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Ministry of Sustanaible
Development and Planning

Vice-Ministry of Environment,
Natural Resources and Forestry Development

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Inter-institutional Council of Climate Change

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INTRODUCTION

The Bolivian National Communication provides a general vision of the actions and policies that Bolivia is carrying out in relation to climate change. These actions are executed under the United Nations Framework Convention on Climate Change (UNFCCC) and specifically under the articles 4 (first paragraph) and 12.1 of this convention, that makes reference to the commitments of the developing countries.

Bolivia signed the UNFCCC in the Earth Summit (United Nations Conference on the Environment and the Development) held in Río de Janeiro in 1992 and ratified it by Law N°1576 on July 25 1994, under ordinance approved by the National Congress and the Executive Power. Later on, in November 1994, the Secretary of the Convention received this ratification.

In 1993, reforms in the Executive Power were set down and in 1997 these reforms were reinforced, giving execution to one of the most important postulates of the Summit of Río, which proposed a commitment to sustainable development in all the countries of the world, according to Agenda 21. In this sense, Bolivia accomplished this precept, creating a governmental body committed to planning development in terms of fighting against poverty (through the generation of employment and economic activity in harmony with natural resources and environmental protection).

In this context, the Ministry of Sustainable Development and Planning and the Vice Ministry of Environment, Natural Resources and Forest Development have been created with the objectives of reinforcing national environmental administration and consolidating patterns of sustainable development. In addition, The National Program of Climate Change (NPCC) was created in 1995 as a branch of the Vice Ministry of Environment, Natural Resources and Forest Development.

With the support of the US Country Studies Program, the NPCC initiated actions in order to fulfill the contracted obligations of the UNFCCC and to develop the first investigations relating to a National Inventory of greenhouse gas emissions of anthropogenic origin (GHG); the analysis of vulnerability and adaptation of forest, agriculture, livestock and water resources to possible climate change and the analysis of mitigation options for greenhouse gas emissions in the energy and not-energy sectors.

In 1996 the PNCC worked on the possibility of developing a National Plan of Action on climate change with cooperation of the U.S. Environmental Protection Agency, through the US Country Studies Program and the National Strategy of Implementation of the UNFCCC, with the support of the of United Nations Program for Development, inside the CC:TRAIN project.

In 1997, the new government restructured the executive power and prioritized activities such as the protection of natural resources and forestry development, supporting the environmental administration and the execution of international agreements.

The new governmental structure has also promoted the cooperation of the government of Holland through the Netherlands Climate Change Studies Assistance Program commissioned by the Netherlands Development Assistance (NEDA). This support is administered by the Institute of Environmental Sciences of the University of Amsterdam, and consists of the development of complementary studies; national inventories; use of new IPCC methodologies; studies of impact on agriculture, forest and water resources to possible climate change, and mitigation studies in the forest and energy sector in order to consolidate the National Communication. The main objective is to develop the First National Bolivian Communication on the Convention of Climate Change with the support of the Global Environmental Facility (GEF) through the Program of Enabling Activities.

Like other developing countries, Bolivia has specific fundamental priorities: to eliminate poverty, to generate employment, to stimulate economic development and to improve health conditions for its inhabitants. Climate change is therefore not a priority, although the characteristics of the country make it considerably vulnerable to this issue.

Its points of vulnerability are mostly related to the large extensions of arid and semi-arid areas, regions exposed to forest deterioration and areas exposed to natural disasters like flooding or desertification. Bolivia is, in addition, a country without a coast and with an extensive and fragile ecosystem that suffers the consequences of technological and industrial development.

The National Communication is based on studies carried out by the PNCC and on the work of universities and institutions related to the investigation. The project outlines the possibility of incorporating certain measures in the energy and non-energy sectors allowing a reduction in GHG emissions. However, this would need the economic support of developed countries inside what the UNFCCC denominates as common but differentiated responsibilities.

This national report also outlines a meticulous analysis of the levels of GHG emissions during 1994, taking as a comparative methodology the IPCC guidelines for 1996. The guides for the preparation of initial communications of the parts are included in the Annex 1 (I Document FCCC/CP/1996/L.12), and it is also part of decision number 10 of the Second Conference of Parts (10/CP2). Finally, the report contains an analysis of national necessities for the implementation of projects, climate scenarios, vulnerability of some ecosystems, mitigation options and measures that could be developed in order to tackle climate change.

This National Communication represents another effort of the Bolivian Government in order to cooperate with the implementation of the Climate Change Convention. It is necessary to mention that these efforts were made in spite of very limited human and economic resources, and restricted scientific and technological means.

This was made to show the international community that Bolivia meets its commitments and it is appropriate that Annex I countries set an example in meeting with their promises under the UNFCCC and reduce their GHG emissions.

Additionally, Bolivia ratified the Kyoto Protocol through its Law No. 1988, dated July 22, 1999, as a demonstration of its willingness to face negative climate change impact. Later on, in November 1999, the Secretary of the Climate Change Convention received this ratification.

NATIONAL COMMUNICATION

EXECUTIVE SUMMARY

1. INTRODUCTION

Bolivia signed the United Nations Framework Convention on Climate Change (UNFCCC) during the Earth Summit (UN Conference on Environment and Development) held in Rio de Janeiro in 1992, and ratified it by Law No.1576, dated July 25, 1994 approved by the Bolivian Congress and the Executive Government. The UNFCCC Secretariat acknowledged and concurred the Bolivian ratification in November 1994.

Bolivia, as a highly vulnerable country, also ratified the Kyoto Protocol through its Law No. 1988, dated July 22, 1999, as a demonstration of its willingness to face negative climate change impact.

The National Climate Change Program (NCCP); that depends on the Vice-Ministry of Environment, Natural Resources, and Forestry Development; was established in 1995 to initiate actions aimed at meeting Bolivian commitments under the UNFCCC, and developing the first research activities to address climate change issues.

In 1996, the NCCP developed a Bolivian National Action Plan on Climate Change; prepared the Greenhouse Gas (GHG) Emission Inventory applying the 1996 revised Intergovernmental Panel on Climate Change (IPCC) Guidelines; and initiated the National Implementation Strategy (NIS) of the UNFCCC.

The Bolivian National Communication, as submitted herewith, contains a detailed analysis of the 1994 GHG emission levels in Bolivia according to the 1996 IPCC Guidelines, following the Initial Communications Guidelines for the Non-Annex I Parties (FCCC/CP/1996/L.12) and the 10th Decision, adopted by the Conference of the Parties (10/CP2).

This Communication includes the analysis of climate scenarios, assessment of some ecosystem vulnerability, mitigation options, adaptation measures that could be adopted to address climate change impact and the analysis of national resources to implement projects.

This National Communication represents another of the government's efforts to comply with its commitments, and its disposition to cooperate with the implementation of the Climate Change Convention.

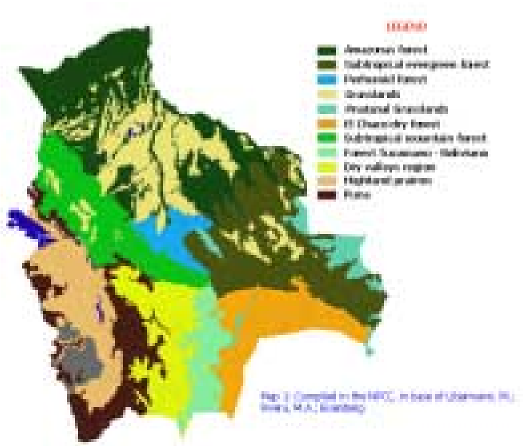
These efforts were made in spite of very limited human and economic resources, and restricted scientific, and technological means, to show to the international community that Bolivia meets its commitments. In this sense, it would be appropriate that Annex I countries set also an example in meeting with their commitments under the UNFCCC, and reduce their GHG emissions.

It is here acknowledged the valuable support and cooperation received in carrying out national studies on climate change from the GEF; UNITAR – UNDP; the Netherlands Government, through the Netherlands Climate Change Studies

Assistance Program, the Netherlands Development Assistance (NEDA) and the Institute for Environmental Studies of the Free University of Amsterdam and the U.S. Country Studies Program.

2. NATIONAL CIRCUMSTANCES

Bolivia is located in central South America, between 57° 26' and 69° 38' W longitude, and between 09° 38' and 22° 53' S latitude covering a geographical area of 1,098,581 km^2. (see map)



Bolivia cause a variety of climates importantly determined by the tropical-humid influences of the Equatorial Amazonian Current and the Southern Current cold-air masses. Additionally, latitude and altitude gradients between east and west have an influence on the climate.

Concerning demography, population density is 7 inhabitants/per km^2. Biodiversity is rich, and represented by 319 mammal species (Beck. S. et al., 1993), 1,274 bird species (UNDP (c), 1996) and approximately 17,000 major plant species.

According to the "Poverty Map" (published by the Economic Policy Analysis Unit -UDAPE, 1995), basic needs for the majority of the Bolivian population are unsatisfied. It is a fact that a significant percentage of the population have no access to basic sanitation services, health and housing facilities and that 94% of rural households are affected by poverty.

In 1994, Bolivian exports consisted mainly of traditional products: mining 36%, hydrocarbon 10%. However, during recent years, the growth in exports of non-traditional products represented 47%, while re-exporting was 7%.

Bolivia's GDP is approximately 8.5 billion US$, with a stable growth rate of 4-5% since 1986. The GDP vegetative growth projection indicates that the GDP would be 9 billion US$ for year 2000, and approximately 42 billion US$ for 2030.

Bolivia has always been a hydrocarbon producer. For this reason, the energy framework in which the country develops is essential for the Bolivian economy, considering that its energy sources consist mainly of fossil fuels. In 1995, the energy production structure was composed of natural gas 64.46%, hydro-energy 5.7%, crude oil 18.89%, and biomass 10.95%.
Other energy sources, such as solar energy and geothermal energy are barely exploited. Energy consumption per sector was: industry 32.94%,

transport 32.41%, residential 27.41%, commercial 7.03%, and agriculture 0.21%.

Bolivia has 18 managed natural protected areas (within the National Protected Areas System, under the IUCN: I and V categories) comprising 13.71% of the national total area.

Within this Protected Areas System, 435,000 ha of land are considered as biosphere reserves, 15 million ha were declared as protected areas, 15 million ha were declared as reserve lands and immobilization reserves set aside for protection under the Agrarian Reform Law (INRA Law, 1997) and 53.45 million ha of land are covered by forests, representing 48.7% of the national total area. Most of these areas are in the northern and eastern plains of Bolivia.

The water resources in many sites of the Amazonian basin are affected by erosion intensified by deforestation processes. Many of the rivers and tributaries flowing by small and medium villages are severely affected by urban contamination, mainly biological waste, due to the lack of effective sewage and waste disposal systems.

Air contamination problems in Bolivia are almost non-existent, except when there are seasonal vegetation burning practices (during July-September) that are traditional for opening new areas for expanding agriculture. This seasonal contamination has become a threat to human health with incidences of respiratory disease, while smoke causes difficulties for airport operations.

3. NATIONAL GHG EMISSION INVENTORIES

In 1994, greenhouse gas (GHG) emissions and removals by sinks were calculated following the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories.

Activities related to land use change and forestry are the most important sources of GHG emissions with 38.61 million tons of CO_2, followed by the energy sector with 7.64 million tons of CO_2 (using the bottom-up approach by source categories), and the industrial processes with 0.393 million tons of CO_2.

Carbon dioxide emissions from land use change and forestry are high due to forest and grassland conversion. This implies that expansion of agriculture frontiers, and spontaneous human settlements are the most important GHG emission generating activities in Bolivia.

CO_2 emissions from changes in forest and other woody biomass stocks were 5.6 million tons; from forest and grassland conversion 32.98 million tons; while abandonment of managed lands produced a removal of 4.54 million tons of carbon dioxide.

Percentages of emissions generated from the energy sector were: transport 29.7%, natural gas flaring in exploitation fields 29.3%, energy industries 18%, manufacturing industries and construction 10.7%, and residential consumption of energy 9.1%.

Methane (CH_4) emissions were 0.653 million tons. This total comprises: energy sector 0.089 million tons, agriculture 0.485 million tons and land use change 0.054 million tons.
Other GHG emission totals were: nitrous oxide (N_2O) 0.0025 million tons, carbon monoxide (CO) 0.857 million tons, nitrogen oxide (NOx) 0.108 million tons, non-methane volatile organic compounds (NMVOCs) 0.058 million tons, sulphur dioxide (SO_2) 0.0055 million tons, and hydrofluorocarbons (HFCs) 0,00001 million tons. Table No. I summarizes figures of the GHG emission inventory for 1994.

Table No. I 1994
GREENHOUSE GAS (GHGs) EMISSIONS INVENTORY - SUMMARY REPORT (Gg)

GREEN HOUSE GAS CATEGORIES	CO_2	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFCs	PFCs	SF_6
SOURCE AND SINK CATEGORIES	EMISSIONS	REMOVALS							P		
TOTAL NATIONAL EMISSIONS AND REMOVALS	46,657.21	4,537.42	653.48	2.53	107.95	857.99	58.15	5.46	0.01	NO	NO
1 Energy	7,646.20		89.05	0.20	37.64	322.43	54.09	5.19			
A Fuel Combustion	7,646.20		7.86	0.20	37.55	322.30	46.11	3.85*			
Energy industries	1,374.75		0.032	0.004	4.139	0.521	0.134	IE			
Manufacturing industries & construction	823.15		0.061	0.004	2.544	0.355	0.076	IE			
Transport	2,269.88		0.428	0.028	24.000	154.676	29.256	IE			
Commercial / Institutional	16.00		0.002	0.024	0.019	0.009	0.001	IE			
Residential	695.76		0.059	0.001	0.590	0.536	0.056	IE			
Agriculture/Forestry/ Fishing	106.75		0.008	0.000	1.930	1.608	0.321	IE			
Mining/ Metallurgy	30.87		0.001	0.000	0.093	0.005	0.002	IE			
Other sectors	86.93		0.028	0.001	0.791	10.247	1.919	IE			
Natural gas flaring in exploitation fields	2,242.11										
Biomass			7.24	0.14	3.44	154.34	14.34				
B Fugitive emissions from fuels			81.19	0.00	0.09	0.13	7.98	1.34			
Oil and natural gas			81.19								
Ozone Precursors and SO2 from oil refining					0.09	0.13	7.98	1.34			
2 Industrial proceses	393.90		0,00	NO	0,00	0.01	3,95	0.27	0.01	NO	NO
A Non-metallic mineral products	393.90				0,00	0,00	0,75	0,23			
B Other processes	NO		0.00	NO	0.00	0.01	3,19	0.04	0.01	NO	NO
3 Solvent use							0.11				
C Chemical products							0,11				
4 Agriculture			489.27	1.73	56.75	57.04					
A Enteric fermentation			462.54								
B Manure management			19,51	0.0149							
C Rice cultivation			5.04								
D Agricultural soils				0.14							
E Prescribed burning of savannas			2.160	0.030	0.970	56.670					
F Field burning of agricultural residues/wastes			0.018	1.543	55.778	0.369					
5 Land use change and forestry	38,617.11	4,537.42	54.67	0.38	13.56	478.51					
A Changes in forest & other woody biomass stocks	5,629.38										
B Forest and grassland conversion	32,987.73		54.67	0.38	13.56	478.51					
C Abandonment of managed lands		4,537.42									
D CO2 emissions & removals from soil	NE	NE									
6 Waste			20.49	0.22							
A Solid waste disposal on land			20.14								
B Waste water management			0.35								
C Other residues				0.22							
International Bunkers	173.57		0.00	0.01	0.87	0.39	0.24	0.06			
International Aviation	173.57		0.00	0.01	0.87	0.39	0.24	0.06			
CO_2 Emissions from Biomass	3,112.38										

* The SO_2 emissions of combustion activities in different sectors are not discriminated against.

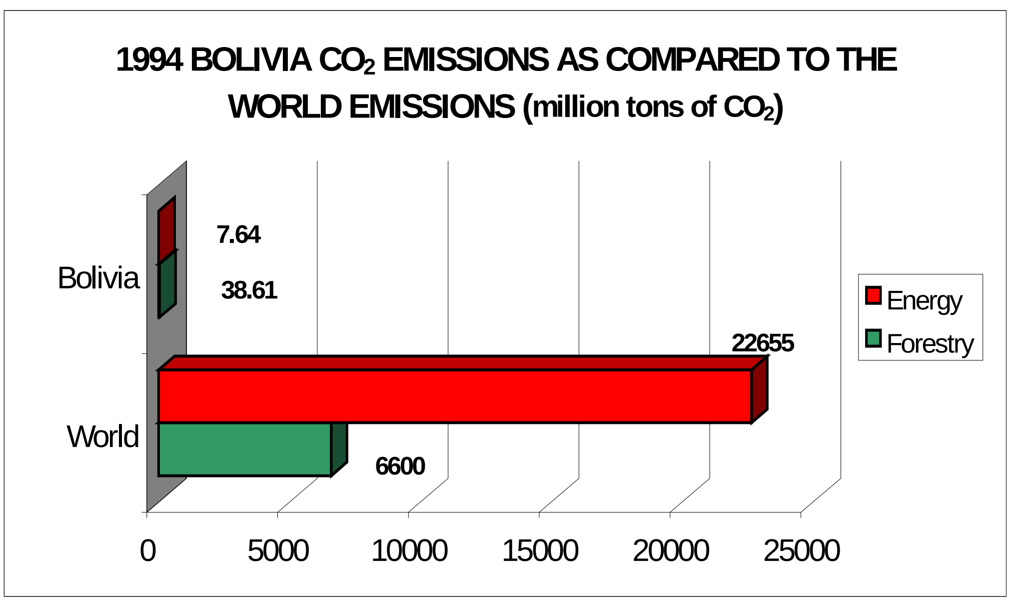
P = Potential emissions with method tier I.
NE = Not Estimated
NO = Not Occurring
IE = Estimated, but included elsewhere

In terms of Global Warming Potential (GWP), in 1994 Bolivia GHG emissions were composed of: carbon dioxide 76.28%, methane 22.44%, and nitrous oxide 1.28%. This relative contribution, as expressed by sectors, was: land use change and forestry 65.21%, energy 15.66%, agriculture 17.68%, waste 0.81%, and industrial processes 0.61%.

Bolivian contributions in 1994 to international bunkers relating to international aviation were estimated as: 173.57 Gg of CO_2, 0.01 Gg of N_2O, 0.87 Gg of NOx, 0.39 Gg of CO, 0.24 Gg of NMVOCs, and 0.06 Gg of SO_2.

The 1994 Bolivian CO_2 emissions from the energy sector were estimated as 7.64 million tons, which scarcely represent 0.033% of total world emissions, estimated as 22,655 million tons for same year (UNDP 1998 Report on Human Development). Bolivian CO2 emissions from land use change and forestry sectors were estimated as 38.61 million tons, representing only 0.58% of total world emissions, which were estimated as 6,600 million tons for the same year (1998 Report by the Tropical Woods International Organization). See comparative illustration below Graph. No. 1:

Graph. No.1

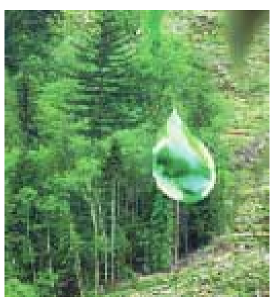


This comparison illustrates that Bolivia is a country under a very incipient process of development. Therefore, Bolivia should not be considered as a "pollutant" country; much less a contributor to the greenhouse effect.

4. VULNERABILITY AND ADAPTATION

Climate Change Scenarios

The analysis done by the National Meteorology and Hydrology Service (SENAMHI, 1998) considered three global climate change scenarios, developed by the IPCC: the IS92a, considered as a reference scenario for the UNFCCC Intergovernmental Negotiating Committee, which estimates a medium range of future emissions by assuming a moderate intervention level towards reducing GHG emissions; the IS92c considered as an optimistic scenario; and the IS92e as a pessimistic scenario.



On the basis of these global scenarios and other assumptions, climate scenarios defined for Bolivia on an analysis time horizon until year 2100, show: a) all scenarios indicate the same temperature increase trends, b) the temperature increase line is almost parallel to the normal curve and c) in some cases models indicated higher temperature increases during the rainy season.

Concerning precipitation, absolute precipitation increase is higher during the rainy season (September to February), while precipitation variation during the dry-season (May to August) is low in absolute terms. Precipitation trends for the north, east, and south-east areas of the country indicate decreases for the dry season.

For the three above mentioned scenarios, national scenarios indicate precipitation decreases for June and July (winter season in Bolivia), which becomes critical as temperature increases. Moreover, these scenarios indicate slight seasonal rainfall extension trends, even until May, and a slight extension of dry season until September and October.

Impacts

As reported in studies developed by the National Climate Change Program (MDSMA,1997), climate changes will cause varied impacts to ecosystems in Bolivia: i.e. 2° C temperature increase and 10% precipitation increase may cause an area increase of tropical moist forest of 65.27%, to the detriment of subtropical moist forest areas up to 59.72%.

This scenario shows an increase in subtropical dry forest of 3.79% (MDSMA, 1997, 1998). In contrast, the area of subtropical moist forest would decrease by 81% under a 2°C temperature increase and a 10% precipitation decrease scenario; while tropical moist forest would remain unchanged, and tropical dry forest area would increase by more than 300%.

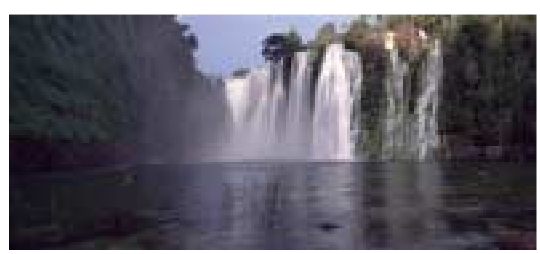
Under the scenario IS92c (optimistic scenario), national scenarios show that until year 2010 changes would occur in cool temperate desert zones, cool temperate thorn steppe, and tropical wet forests; in 2050, no high vulnerable zones are envisaged.

Under the scenario IS92e conditions (pessimistic scenario) national scenarios show that all life zones would be vulnerable to climate changes; zones suffering impacts would be tropical moist forest, warm temperate dry forest, subtropical rain forest, tropical wet forest, subtropical thorn woodland, and cool-temperate desert areas. Changes would oscillate within a range of 100%.

It can be assessed that overall, agricultural regions would be affected by probable climate change. Some zones would be more vulnerable than others; for instance, trends in the inter-Andean valleys indicate decreases in rainfall and increases in the minimum and maximum temperatures, which would affect the crops vegetative life cycle. On the other hand, in high plain or "Altiplano" no variation in rainfall precipitation is envisaged, but there would be an evident increase in minimum temperatures. Similar trends are forecasted for the tropical eastern zones of Bolivia, such as Santa Cruz and Trinidad. However, there might be some trends towards a constant maximum temperature or a very slight decrease.

As regards agricultural ecosystems, studies on vulnerability to climate change indicate that a probable 2° C temperature increase would not seriously damage cultivated areas if this increase goes together with precipitation increases.

In the high plains, these conditions would be favorable for growing crops if provided with adaptation measures such as irrigation systems and improved cultural practices. However, If precipitation decreases occur, even under no temperature increase conditions, negative effects would be critical, not only directly and immediately for agricultural production, but would also cause long term negative consequences, such as irreversible damages to the ecosystem.



Studies on vulnerability of water resources to climate change (NCCP, 1997; San Andres University of La Paz - Hydraulic and Hydrology Institute, 1999), show important variations in the runoff levels, depending on the considered global and national climate scenario (Incremental scenarios, IS92a, IS92c, and IS92e), and studied basins and their location.

This would cause an impact on water resources by affecting forestry, agriculture and consumption systems.

Climate change in Bolivia affects human health directly and indirectly. The most frequent direct effects are: floods (Santa Cruz), landslides (La Paz), forest fires (Guarayos - Santa Cruz) and storms (Cochabamba), all of them increasing population mortality.

Regarding indirect effects, the human health vulnerability study of malaria and leishmaniasis, showed that malaria is sensitive to climate variation and changes (IS92a scenario). Trends show a very high increase between baseline period (1960-1990) and current situation (1991-1999). The biggest incidence (growth) has occurred since March 1993 for P. Falciparum cases and from April 1994 for Plasmodium Vivax cases.

Regarding leishmaniasis, results show a very high vulnerability to climate change which would be accentuated by humidity, and temperature. Leishmaniasis incidence will increase particularly from July to September and the highest effects will be registered in August, according to projections made for 2010.

ADAPTATION

The following adaptation strategies were identified for the forestry sector by the National Climate Change Program (MDSMA,1997):

* Sustainable forest management and use
* Enhancing efficiency of industrialization processes
* Identifying forest tree species that are resistant to climate change
* Reducing habitat fragmentation

Damages by probable climate change in the agriculture sector might become critical if economically important basic crops are negatively affected. The national food security could run the risk of being affected. In 1998, and to prevent such effects, the following adaptation measures were proposed (PNCC, 1998):

- Improvement of soil and water resources management
- Agriculture research
- Interactive technology transfer

Adaptation options for livestock breeding, and pastures are addressed to:

- Identify pastures resistant to climate change
- Introduce improved pastures
- Introduce improved livestock species

- Make changes in the livestock grazing seasons
- Introduce supplementary diets for livestock

Adaptation options for water resources are addressed to:

* Plan and coordinate the use of water resources by basin
* Construct works to arrange water regulation, irrigation and storage.
* Adopt water conservation policies
* Control quality of water
* Implement systems for a controlled and paid water supply
* Adopt contingency plans
* Construct work for inter-basin water transfers
* Forecast systems for flood and droughts
* Educate and train people on water resource management and use.

In the health sector the following adaptation strategies were identified :

- Environmental Care
- Sanitary Education
- Reservoirs Control
- Decreasing vector/human contact
- Epidemic and climate vigilance
- Biological Control
- Chemical Control

5. PROJECTIONS, PLANS AND MEASURES

Energy Sector - Mitigation Options and Costs

GHG emission mitigation measures for the energy sector would be addressed to enhance the energy supply and use improving effectiveness in the energy consumption, using energy sources that are less carbon-intensive and increasing the use of renewable energy.

The mitigation measures identified for the energy sector, in order to contribute the reduction of GHG emission levels, are detailed below:

* Efficiency in the illumination of the residential sector
* Efficiency in biomass use for household stoves
* Efficiency in the residential sector refrigeration
* Increase of natural gas use in the residential sector
* Increase of solar energy use for water heating purposes

* Rural electrification based on renewable energy sources
* Efficiency of public commercial sector illumination
* Efficiency in commercial use of biomass
* Conservation of electric energy in commercial uses
* Conservation of energy in the industrial sector
* Increase of natural gas use in road transport
* Reduction of natural gas flaring in exploitation fields
* Redistribution of expansion options in the electric power generation sector

The implementation of the mentioned measures necessarily requires financial and technical support internationally.

If these mitigation measures are applied, in a modest scenario, non-biogenic CO_2 emissions, as compared to baseline, could be reduced by: 7.03% for year 2005, 5.81% for 2010, 12.75% for 2020, and 15.07% for 2030.

In the same scenario, biogenic CO_2 emissions can be reduced approximately by 2.30% for 2005, 4.07% for 2010, 6.14% for 2020 and 6.96% for 2030.

Similarly, other GHG emission reductions are expected, except CH_4 and N_2O, which would slightly increase. (See Table 1).

Table 2 illustrates the cost analysis for proposed measures.

Table 1. Reduction of GHG Emissions, Mitigation Scenarios as compared to Base line scenarios: 2005-2030 (Gg)

Moderate Scenario

GHG Emissions / Year	2005	2010	2020	2030	Total 2001-2030
Non-biogenic Carbon Dioxide	604.99	632.31	1,854.36	3.076.40	44,386.28
Biogenic Carbon Dioxide	102.93	205.86	414.22	622.59	9,625.09
Methane	6.38	0.67	-1.05	-2.76	35.43
Nitrous Oxide	-0.02	-0.03	-0.06	-0.08	-1.34
Carbon Monoxide	30.39	60.77	154.35	247.94	3,514.85
Nitrogen Oxide	28,95	57.90	661.92	23.34	12,918.19
Volatile Hydrocarbons	0.01	0.03	0.07	0.12	1.69
Sulphur Dioxide	0.02	0.03	0.07	0.11	1.61

Reductions Higher Scenario

GHG Emissions / Year	2005	2010	2020	2030	Total 2001-2030
Non-biogenic Carbon Dioxide	640.75	703.84	2,649.50	4,595.15	61.406.12
Biogenic Carbon Dioxide	130.10	260.20	559.17	858.15	12.913.62
Methane	6.05	0.01	-2.22	-4.44	7.98
Nitrous Oxide	-0.02	-0.04	-0.07	-0.11	-1.74
Carbon Monoxide	39.18	78.35	204.66	330.97	4.650.46
Nitrogen Oxide	29.71	59.41	666.76	32.45	13.027.48
Volatile Hydrocarbons	0.02	0.04	0.08	0.13	1.91
Sulphur Dioxide	0.02	0.04	0.08	0.12	1.83

Source: MDSP- Mitigation Options analysis...

Table 2 - Cost Analysis of CO2 Emissions Reduction: Moderate Scenario

Mitigation Measure	Balanced Energy Savings Cost, US$1990/G/J	1990 Total Cost million US$ (1990)	1990 Benefits million US$ (1990)	Net Present Value, to 2030 million US$	Benefit/ Cost Ratio	Balanced Cost per Emission Reduction US$1990/ t CO2	Balanced Annual Cost US$/yr	Average Emission Reductions 2001-2030 Gg CO2/yr
Efficiency in the illumination of residential sector	14.101	2.90	1.45	1.45	0.5003	5.09	157,540	42.27
Efficiency in biomass use for household stoves	0.197	0.45	9.02	-8.57	19.9790	-5.52*	-931,520	230.43*
Efficiency in the residential sector refrigeration	62.267	51.45	4.81	46.64	0.0935	150.00	5,070,160	4.76
Increase of natural gas use in the residential sector	-	9.00	2.74	6.26	0.3042	20.00	680,600	46.89
Increase of solar energy use for water heating	-	12.06	1.86	10.20	0.1542	70.00 190.00*	1,108,870	22.33 8.18*
Rural electrification based on renewable energy	-	14.96	6.93	8.03	0.4632	100.00	873,130	12.24
Efficiency in public commercial illumination	1.39	0.29	1.35	-1.06	4.6619	-1.00	-115,160	52.01
Efficiency in commercial use of Biomass	0.259 w. 0.389 d	0.22	3.03	-2.80	23.6199	-6.48*	-304,840	64.315*
Conservation of electric energy in commercial uses	13.238	14.06	6.37	7.69	0.4531	5.17	836,700	220.98
Conservation of energy in the industrial sector	4.420 ep 0.518 thp	2.80	4.69	-1.89	1.6750	-1.90 -3.18*	-205,420	147.65 87.74*
Increase of natural gas use in transport	-	59.28	119.06	-59.78	2.0084	-70.00	-6,480,000	120.34
Reduction of natural gas flaring in exploitation fields	-	0.00	18.34	-18.34	-	-9.48	-1,990,000	286.88
Redistribution of Expansion Options of the electric power generation sector	-	19.42	68.38	-48.96	3.5211	-10.00 110.00	-5,320,000	550.60 -67.99*

Notes: * Biogenic CO2
d: dung
ep: electric processes
thp: thermal processes
w : wood

Forestry and Agriculture Sector Mitigation Measures and Cost

The proposed mitigation measures selected for the non-energy sector are addressed to face a process of environmental deterioration, extension of agriculture frontiers and deforestation, as shown in the following:

* Development of tree growing areas
* Natural regeneration of forests
* Alternative options to replace felling and burning practices in agriculture
* Support to implement the new Forestry Law
* Strengthening capacity of Planning
* Protection and monitoring of protected areas

The mitigation measures for the agriculture and livestock sectors are addressed not to reduce the main GHG emissions (CO_2 and CH_4) but to improve agriculture and livestock practices.

* Prevention and control of land degradation
* implementation of agro-forestry systems
* Natural regeneration of pastures
* Improvement of animal breeding techniques

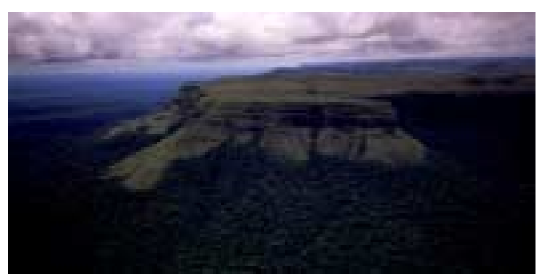
The estimated costs of the mitigation measures proposed for the agriculture and livestock sectors are shown in Table 3.

Table 3 - Total and unitary cost of mitigation measures to reduce GHG emissions in Bolivia (Carbon dioxide and Methane) for the forestry, agriculture and livestock sectors.

Mitigation Measures	Year 2000		Year 2010		Year 2020	
	Total Cost thousands US$	Unit Cost US$/Gg	Total Cost thousands US$	Unit Cost US$/Gg	Total Cost thousands US$	Unit Cost US$/Gg
FORESTRY SECTOR:						
Development of tree growing areas	3,044.00	1,576.80	4,204.00	884.20	5,364.00	624.00
Natural regeneration of forests	4,400.00	6,772.49	6,400.00	1,836.11	8,400.00	1,142.42
Alternative practices to felling & burning agriculture	6,848.57	79,105.18	8,806.42	79,105.18	10,764.27	79,105.18
Support implementation of the new Forestry Law	3,307.50	1,372.68	5,387.56	1,372.68	8,775.78	1.372.68
Strengthening capacity for planning, Protection & monitoring of protected areas	3,492.58	1.220.32	4,693.74	1,220.32	6,308.00	1,220.32
AGRICULTURE SECTOR:						
Prevention & Control of land degradation: - Implementation of agro-forestry systems	2,420.00	29,540.11	6,276.85	10,341.86	16,280.54	8,269.74
- Regeneration of natural pastures	1,210.00	16,714.15	3,138.42	6,154.92	8,140.27	4,949.40
LIVESTOCK SECTOR						
Improve animal production techniques	16,945.00	950.39	19,287.00	954.02	21,629.00	956.89
ANNUAL BUDGET (US$)	41,667.65		58,193.99		85,661.86	

6. COMPLEMENTARY INFORMATION

Bolivia has begun an aggressive approach in order to cooperate in conjunction with the countries of Annex I in the reduction of GHG emissions according to the specifications of the UNFCCC and the Kyoto Protocol. Government politics now involve climate change as an important element of sustainable development.



As stated in this document, Bolivia has established specific institutional structures (lead by its Ministry of Sustainable Development and Planning) to address climate change issues and to develop GHG mitigation scenarios for the energy and forestry sectors.

These actions demonstrate Bolivian willingness to implement the UNFCCC suggestions and it is expected that the international community will acknowledge accordingly.

Based on inter-sectors discussions and achieved consensus on feasible actions and national priorities, a "National Action Plan on Climate Change" was developed to address climate change issues and to contribute to reduction of GHG emissions through international funding. Under the joint implementation pilot phase, some projects were developed in cooperation with UNFCCC Annex I countries investors.

These projects will help to obtain more experience on procedures, monitoring, methodologies, certification and distribution systems regarding certified emission reductions. These experiences will also serve to implement future projects.

Developed countries have the historical obligation to support vulnerable countries like Bolivia to improve climate observation infrastructure (data processing to measure climate change impacts and continued research related to GHG emissions) and to strengthen national capacity building for individuals and institutions.

Such support should serve to implement adaptation projects in the agriculture sector.

NATIONAL STRATEGY

The Government of Bolivia is developing a National Implementation Strategy of the UNFCCC, which is intended to establish a shared outlook among all stake-holders involved in implementation to attain a mission awareness at leading institutional levels and involved partners.

The Bolivian Strategy on Climate Change will be based on the following four areas, designed to follow action - lines within an economic and social development framework:

- Promoting clean development in Bolivia by introducing technological changes in the agriculture, forestry, and industrial sectors, aimed to reduce GHG emissions with a positive impact on development.
- Contributing to carbon management in forests, wetlands and other managed natural ecosystems.
- Increasing effectiveness in energy supply and use to mitigate effects of GHG emissions and risk of contingencies.
- Focus on increased and efficient observations, and understanding of environmental changes in Bolivia to develop effective and timely responses.

Main objectives for the above action areas are:

1. Collaborate in implementing adaptation policies to face climate change impacts, and help for technological and productive transformation of sectors through clean technologies.
2. Increase human security levels regarding human vulnerability, risks and contingencies.
3. Integrate climate change issues into educational systems of society to foster awareness of adaptation.
4. Generate strategic alliances to implement the National Implementation Strategy.

7. FINANCIAL AND TECHNICAL NEEDS

Financial and technological requirements are critical not only for Bolivia, but also for the Latin American region as a whole. Such requirements must be adhered to, to implement strategies and action - lines to face climate change, its causes and implications.

Specific resources are needed to generate small scale climate scenarios to reduce uncertainties originating from climate variations in different regions of Latin America, and particularly Bolivia. Similar requirements are also needed for the studying and assessment of GHG emissions from land use change and forestry, and some areas in the energy sector.

The Clean Development Mechanism represents an important challenge and opportunity for developing countries. However, access to funding for projects related to climate change is still subject to inequalities based on national capacities. Such access needs to be facilitated under the equity and fair management principles within the UNFCCC; and a true and decisive support commitment would be desirable by the international community for strengthening human resources and institutional capacity, development of project portfolios, construction of base line scenarios, certification guidelines, etc.

Finally, an effective support from the UNFCCC Secretariat is essential to provide institutional strengthening of the Bolivian National Climate Change Program. Such support will ensure and consolidate the UNFCCC implementation process in Bolivia.

CHAPTER I

NATIONAL CIRCUMSTANCES

This chapter provides a general vision of the information used in this report, from the fundamental characteristics of Bolivia to the basic data related to its geographical, climatic, economic (energy sources), social (population) and environmental characteristics. We also provide a section associated to development plans, existing politics in the environmental field and to legislatives processes which are currently valid.

Geographical and climatic characteristics

Bolivia is located in central South America, between 57º26 ' and 69º38 ' west longitude and between 9º38 ' and 22º53 ' south latitude. It covers a geographical surface of 1.098.000 Km²

The physical characteristic of this country means a variety of climates, determined by the tropical humid influence of the Amazon Equatorial Current and the Southern Current cold air masses. Additionally, latitudinal and altitudinal gradients between east and west also influence this issue.

MAP 1: SIMPLIFIED MAP OF ECOLOGIGAL - REGIONS IN BOLIVIA

Made by the PNCC based on the maps of: Rivera, M.O.; Libermann, M.; Elemberg and Holdrich´s zones of life

The country is physically divided into three big areas (map 1): The Andean area that occupies a great part of the closed basin of South America, between the Oriental and the Occidental mountain ranges. The average precipitation fluctuates between 400 and 600 mm annually with a gradient in precipitation from the north to the southeast.

The annual average temperature varies from 7 to 10ºC with a gradient in the temperature towards the south. The gradient in precipitation and temperature generates a cold damp climate in the northern high plains and a cold arid climate in the south. Likewise, the gradient of dampness leads to the formation of the big lakes in the north and the salt lakes in the south.

The sub-Andean area includes the geographical regions of Yungas, the Bolivian sub-Andean border, and the dry inter- Andeans valleys; the first one is composed of the humid Yungas [between 700 and 2.000 meters above sea level (m.a.s.l)], the Yungas` cloud forests (between 2.000 and 3.600 m.a.s.l.) and finally, the Tucumano-Bolivian formation, a continuation of the Yungas forests, in the south of the country. The annual average precipitation in this area ranges from 1.200 to 1.700 mm and from 10 to 20ºC. in temperature.

The Bolivian sub- Andean border belongs to the lower part of the Oriental mountain range and reach to the last foothills of the Andean mountain range (between 300 and 2.000 m.a.s.l.). The precipitation level is higher on the eastern side, in the cities of La Paz, Cochabamba and Santa Cruz where it exceeds 3.000 mm, reaching 5.000 mm in exposed areas of humid air masses of the Northeast. In the southern area, that corresponds to the lower ground of the Tucumano-Bolivian forest, precipitation is less (700 to 1500 mm) and the average annual temperature varies from 19ºC to 26ºC, depending on altitude and latitude.

The dry inter- Andean valleys occupy intermediate regions of the Andean mountain range. They are not connected in the north but in the south, they become bigger and more connected. The average annual precipitation range in this area is from 400 to 600 mm with five dry months and an average annual temperature from 15 to 18ºC (SENAHMI. 1998).

The area of the plains involves the big zone of flat and not very bumpy areas to the east of the country. The largest forests and natural savannas belong to this region in which the average annual precipitation ranges from 400 to 2.000 mm. In this area the gradient of precipitation goes towards the south and the average annual temperature reaches 24 and 26ºC.

Seasons are drastically marked by a dry period between May and September when temperatures go down because of the influence of cold winds from the south. Due to geological and hydrological characteristics and to the latitudinal climatic gradient, this region contains different types of forest, from tropical and always green subtropical forests to the dry deciduous forests in the Chaco, the big areas of natural savanna, the pampas created by seasonal flooding, the savannas of flooded systems and the marshy areas.

Macroeconomic aspects

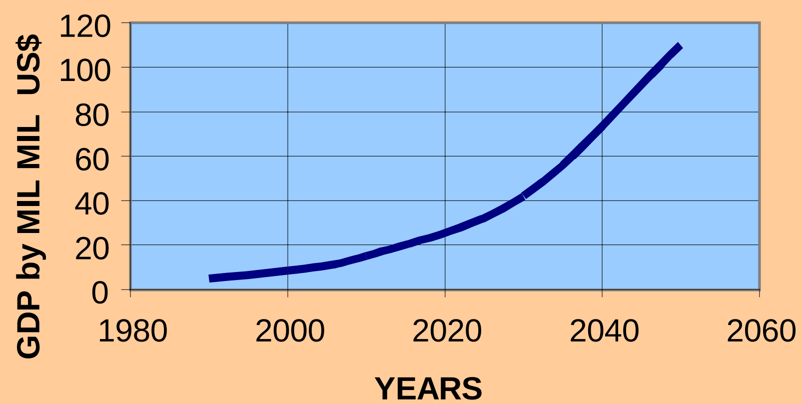
The economic model which has been applied to this country since 1982 responds to the market economy. The new vision of the Bolivian government describes this economic pattern as a Social Economy of Market that makes an effort to improve the distribution mechanisms in order to reverse the conditions of poverty and existing inequality in the country.

Bolivia's GDP is approximately 8.5 billion US$ with stable growth rates of 4 to 5% since 1986.The GDP vegetative growth projections suggested that GDP would reach 9 billion US$ for the year 2000, and approximately 42 billion US$ for 2030 (graph 1).

The inflation rates have been stable since 1986 being around 18%, and it reached 11% in 1995 (PNUD. 1998). In 1997 and 1998, however, the inflation rate was below 5%.

The net reserves of the national bank system grew by 22% between 1997 and 1998 from 2.853 billion US$ to 3.468 billion US$ and the deficit of the public sector is approximately 4% of the GDP (PNUD. 1998).

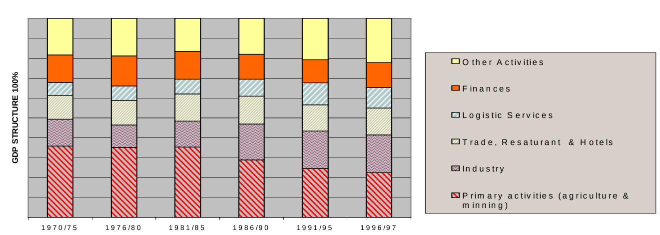
Graph 1: Vegetative growth of the GDP in Bolivia



Source: MDSMA, 1994

The productive sector of the Bolivian economy has had significant changes in the last 30 years and the participation of different sectors in the GDP has also been modified. The primary sectors have reduced their participation. In the period 1970-75 they represented an average of 36%, while for 1996-97 they were 23%.

Graph 2: Composition of the GDP 1970 - 1997



The biggest growth is in the areas of industry, trade, services and logistic services (transport, storage and communication) which shows a tendency towards the tertiary sector for the economy, although 43% of the economically active population still carry out agricultural work.

The activities in the sectors of telecommunications and electricity are growing quickly benefited by capitalization and privatization of the national companies.

The industrial activity is concentrated on small units of manufacturing production and the percentage of existing medium and large industries does not reach 10%.

The primary sectors (mining and agriculture) have notably diminished in the economy in the period 1970–1997 (graph 2). Besides this, a change has taken place in mining practices, strengthening the sector of the auriferous mining as much as in the west of Bolivia as in the rivers of the amazonic basin.

The agricultural sector's contribution to the GDP in 1995 was 15% (G-DRU. 1996) and 11% in 1996 (Department of Information and Statistics. SNAG. 1997. cit. Cruz. D.. 1998). The rates of growth between 1990 and 1993 varied between 4 and 12% (AGRODATA. 1994) and the average rate of growth between 1988 and 1995 reached 3% (G-DRU. 1996).

For the same period, the rates of growth of the agricultural industry (sector mainly concentrated in the area of Santa Cruz) reached 16% with a maximum growth of 48% in the period 1990/91. The contribution of the production of coca to the GDP decreased to -0.6% in the period 1988/95 and a moderate growth was perceived in cattle production and forestry, hunting and fishing activities (1.4 and 1.7% respectively).

In the period 1996/1997 the productive activity diminished its already low rhythm of growth as a consequence of several factors: politics concentrated in the improvement of the macroeconomic feature, attention in improving the external image, incipient politics to stimulate the production industry and lack of modern rules to regulate the market and the competition.

Table No 1: GDP - economic activity and economically active population (PEA)

Branch of Activity	Contribution to the GDP till 1995	Index of growth in the period 1988/95	**Percentage of the PEA (7 years and more)**
Agriculture, cattle raising, hunting and fishing	15%	3%	44%
Mining	6%	7%	2%
Hydrocarbons	4%	3%	------
Manufacturing Industry	17%	4%	10%
Electrical services. Gas and water	2%	8%	0.3%
Construction and public work	3%	6%	------
Trade	9%	5%	------
Transport, storage and communication	9%	6%	10%
Financial services, insurance, property and services to companies.	11%	4%	5%
Social, personal and communal services	4%	4%	0.4%
Restaurants and hotels	3%	5%	approx. 6%
Public administration services	11%	1%	-------

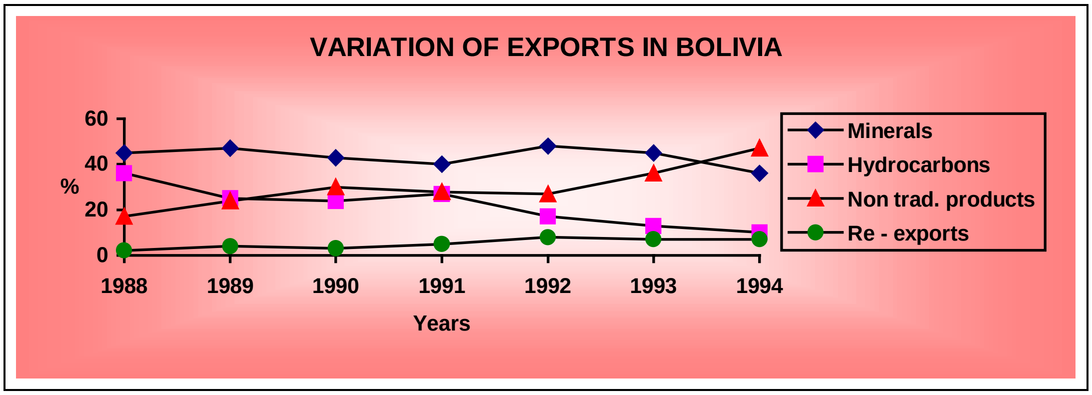
Sources: INE. 1995. Annual statistics. La Paz; INE. 1996. Department of National Finances. La Paz
PEA: Economically Active Population.

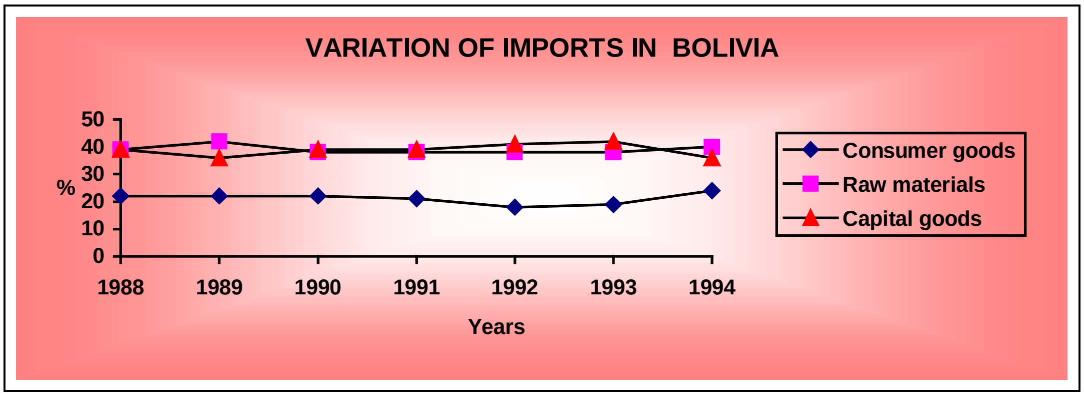
The main Bolivian exports during 1994 were centered around traditional products: mining (36%) and hydrocarbons (10%), though, it is important to underline the growth in the exports of non traditional products (47%) and re-exports (7%) (graph 3).

Bolivia still depends on the exportation of basic products. The percentage of manufactured products for exportation reaches 13% and these are based on natural resources: industrial food, textiles and wood.

The imports are mainly related to technological issues. In 1994 the imports of consumer goods totaled 26%; raw material and intermediate products 44% and capital goods for agriculture, transport and industry were around 40%. (graph 3).

GRAPH 3. VARIATION OF EXPORTS AND IMPORTS

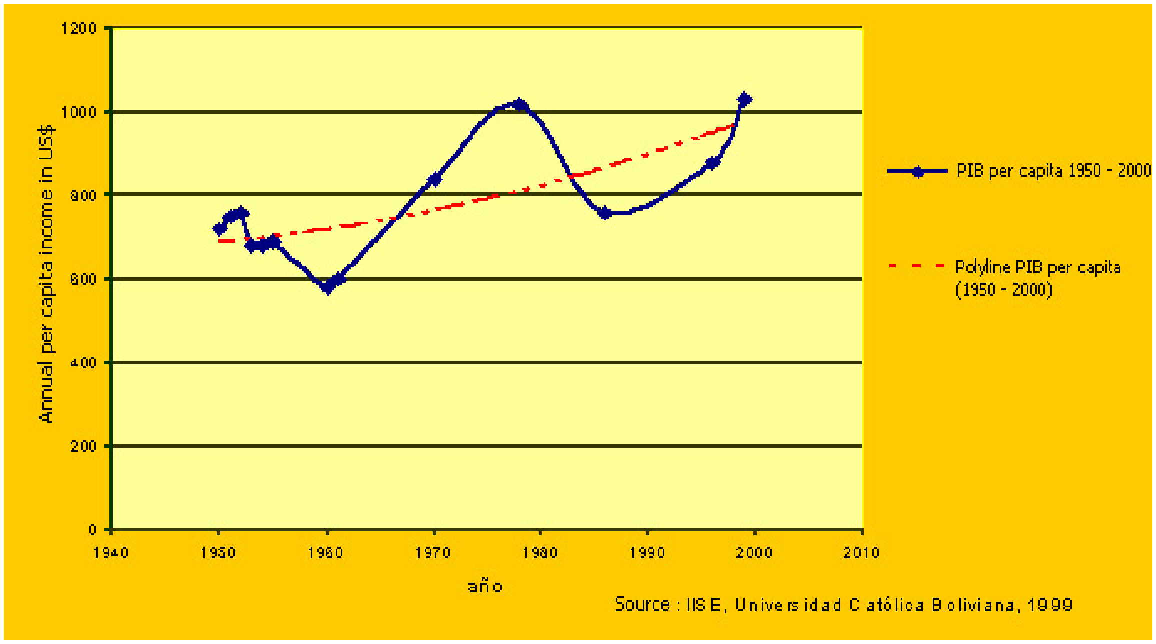




Source: National Institute of Statistic (INE).

Regarding the economic development, the Bolivian economy has had a moderated rise in the last 30 years. The GDP per capita in the 90's was between 750 and 1030 US$ while in the 70's this value was between 900 and 1000 US$.

GRAPH 4 - PER CAPIT GDP IN BOLIVIA



The main structural problems of the Bolivian economy according to the General Plan of Economic and Social Development PGDES 1997 - 2002 are:

- the fragility of the fiscal system as a result of unstable incomes.
- the low internal savings and its consequences in the impossibility to increase investments.
- the weakness of the financial system that still maintains oligopoly characteristics.
- the lack of public resources that do not allow an increase in the levels of human development.
- the undersupplied physical infrastructure that hinders the unfolding of competitive capacity and increments in productivity.
- the deficit in the internal supply of food.
- the stagnation of the traditional exports and the lack of dynamism in the non traditional ones.
- the deficit of the commercial balance that reached 630 million dollars in 1997.

Bolivia has the expectation of becoming the center of geo-political and economic integration in South America. If this happens, this could increase competitiveness in the different regions of the country, whilst confronting the requirements of wider and more demanding markets, increasing diversity and technological levels.

From the point of view of internationalization, Bolivia has low protection tariffs and is a country that encourages foreign investment through different protection norms. The participation of Direct Foreigner Investments totals 7.8% (PNUD. 1998). Between 1992 and 1997, foreign investment grew by 276% so that in 1997 foreign investment reached 636 million dollars, 16% higher than public investment executed in the same period (Escobar. J.. 1999).

On the other hand, Bolivia still has a series of difficulties on international scene. The deficits in the current account exceeds 5% of the GDP and the foreign debt totals 338% of exports and 61.4% of GDP (PNUD. 1998).

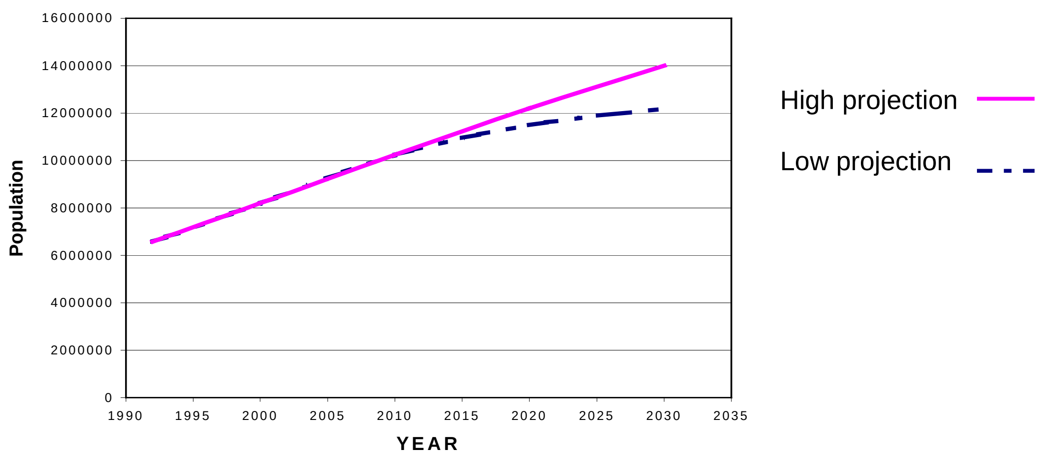
The Bolivian government has promoted, during the last 13 years, different measures in order to increase its competitiveness in the South American context, to raise productivity and to improve the image of Bolivia internationally. Through capitalization, the government has acquired strategic partners to facilitate progression in state companies which is used to assist the social sector, to maintain the natural resources and to make its fiscal duties more effective.

Complementary to these measures, the Bolivian government is taking steps to improve the stock market and to give more security to its operations.   Bases to control the functioning of these markets through the Super-Intendancy of banks, pensions, values and insurance are also being established

Demographic transition and human development

Bolivia has a population of 8 million inhabitants and an annual growth rate of 2.35% (INE. 1995). In general terms and according to the national tendencies related to human development, the birth rates and the national levels of mortality have the tendency to decrease. According to projections made by The National Statistics Institute and the UNFPA, the national population for 2030 will reach 12 to 14 million (graph 5) (IISE. 1999).

Graph 5: Projection of the Bolivian population for 2030



Both, the high and low projections, use decreasing population growth rates. For the year 2010, the estimated values projected by the National Statistics Institute (INE) reach between 2.18%, and 1.98% between the years 2005 - 2010 and almost 1.29% between the years 2025 - 2030. The birth rate also decreased to around 4% for the period 1995 - 2000 and around 2.5% for the period 2025 - 2030 (IISE. 1999).

Urbanization process

Bolivia still has low levels of urbanization in comparison with other countries of South America where urbanization levels reach 78%. According to the Population and Housing Census of 1992 (INE), the urban population is 57.5% while the rural population is 42.5% . (It is actually assumed that urbanization levels are higher but there are no official statistics). On the other hand, levels of urban growth in Bolivia are the highest in South America and reach an average of 4% while the average regional growth reaches 2.5% (PNUD (c). 1996).

According to several sources, population projections estimate that Bolivia's urban population will reach 75% to 80% by the year 2025 which also means a clear tendency towards urbanization of the economy. The Housing Population's Censuses of 1976 and 1992 show a clear process of urbanization and concentration of population in big and intermediate cities.

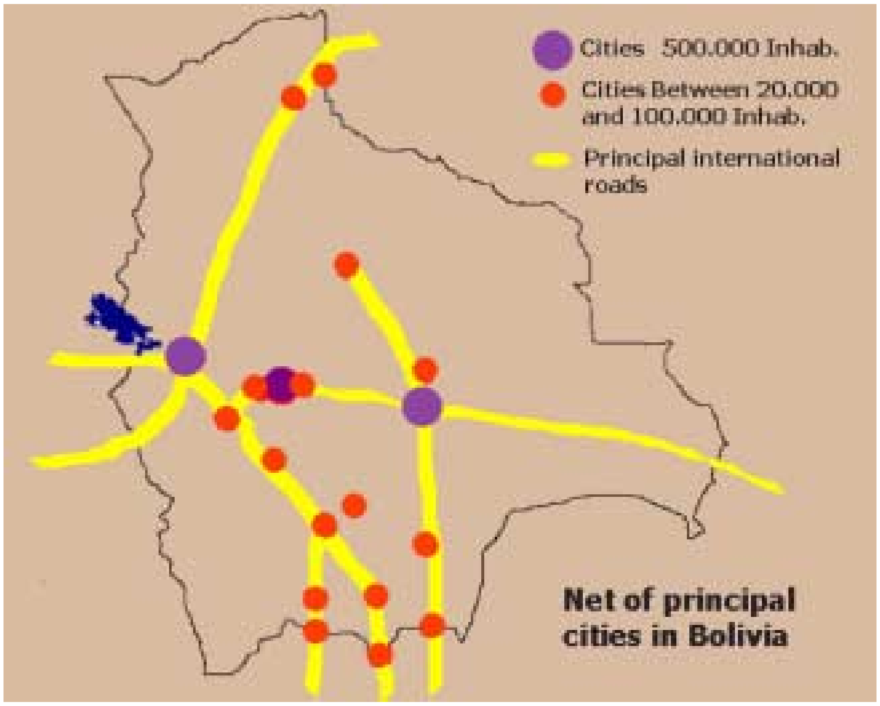
The population of the biggest cities of Bolivia (La Paz, Cochabamba and Santa Cruz) surpasses 500.000 inhabitants. These cities belong to the denominated "Main Axis" in which two thirds of the urban population of the country are firmly settled and where four fifths are economically active.

Other 16 intermediate towns of more than 20.000 inhabitants make up 30% of the country's urban population. These towns have trebled their population in the last 15 years and they show a strong gravitation towards the east of the country. In the valleys the average rates of growth reach 9% while in the high plain the rates of growth are below 3% (PNUD (a). 1998. 159). (Map 2).

Other 104 villages and communities of more than 2.000 inhabitants are distributed all along the national territory in a dispersed way, with a strong gravitation towards the plains. In general, the growth levels are quite low in the valleys and the high plain.

Between 1950 and 1992, 23 towns with more than 5.000 inhabitants were founded in the east, while in the west, including the valleys, just 6 urban centers have been established (Bairon. 1996).

MAP 2: Urban gravitation towards towns bigger than 20.000 inhabitants.



SOURCE: PNCC

According to Bairon (1996) an urban center of 5.000 inhabitants has approximately 1.000 houses, occupies about 80 hectares and requires 1.300 stable jobs of low productivity (75%). The economic importance is related to the size of the population, the degree of its development, the distribution of the educational and health infrastructure and the development of the commercial and transportation areas.

Towns bigger than 5000 inhabitants begin to improve the relationship between the total population and the economically active population, and that is why they show certain growth tendencies in population concentration. On the other hand, the towns of between 2.000 to 5.000 inhabitants tend to maintain their indicators of natural growth (through a balance of birth - mortality) and tend even to lose their economically active population (as normally happens in small communities).

The processes of urbanization and concentration of markets will be accentuated through the support and investment in roads. This will be promoted by the Economic and Social Development Plans (PDDES) in order to consolidate a quick development of 16 intermediate towns of more than 20.000 inhabitants throughout the whole country. This commitment could rapidly generate new dynamics of public and private investment and help to consolidate the state's politics related to a the new territorial and municipal classification. Other 31 intermediate towns of more than 5.000 inhabitants could also have a logistical function in the territories in order to consolidate an urban network in the country.

Human Development

According to Index of Human Development, Bolivia occupies the 116th position with a GDP per capita of 2.612 dollars (PNUD (a). 1998).

This classification confers Bolivia a place between the countries with a medium level of Human Development. The social indicators, however, describe a dramatic situation in the levels of the human development (Bolivia is, in Latin America, the fifth country with the smallest level of human development).

In addition, there is a huge gap between the levels of human development in the cities and in the country. This relation is directly proportional to the number of inhabitants of the cities and villages. The bigger cities are precisely those that have a bigger diversity of markets, infrastructure, transport, communication, energy consumption, a higher per capita consumption and, of course, higher levels of human development.

Since the 70's, cities have obtained evident improvements in their indexes of human development, while in the rural areas the rhythms of change have been slower. The levels of mortality and birth are a good example in making this comparison. In the urban areas the total birth rate is 3.8 children per woman, while in the rural areas it is 6.3 children. Furthermore, the infant mortality rates in the cities is 58 per one thousand, while in the rural areas this index is 98 (Human Develop in Bolivia - 1998).

According to the Map of Poverty (1995), a big part of the population has a lack of essential necessities (appropriate access to basic services, housing and health). In rural areas, poverty affects 94% of the inhabitants.

The same disparities between cities and the countryside can be observed in educational levels. The literacy indexes of children older than 15 in the cities is between 96% and 97% in men and 85% to 92% in women. In the countryside, the indexes of literacy in a similar group (15 years or more) ranges between 72% and 83% for men and 44% to 65% for women (Human Development in Bolivia - 1998).

The global rate of attendance to schools (TBE) totals 83% in the cities while in rural areas barely totals 63%. Likewise, from each 10 youths that have access to the secondary level in the whole country only 5.5% belong to the rural area (Poverty Map. 1995).

The scarce attendance in schools in the rural areas is related to different problems, but the most critical ones are mainly associated to the economic situation of the family (working children) and the deficiencies in the conception of the educational sector. In the whole department of Pando for example, there are 14 secondary schools from which 11 belong to the capital (ZONISIG. 1997).
The concentration of the educational infrastructure in urban areas is similar in the main towns of the country and the same pattern can be detected in the distribution of other services (health, for example).

The places with a big population density have a bigger demographic pressure that optimizes the productive processes through the use of new technologies. This has as a result a much more productive infrastructure, higher levels of technology, better levels of organization and, of course, bigger levels of governmental attendance and support.

In this sense, the development of intermediate cities and towns in the whole country could bring improvements in the distribution of population and could help in reducing the existing inequalities.

Energy profile

Bolivia is a country with an important production of hydrocarbons and the energy sector has a vital importance in the national economy. In 1990, the energy sector produced 45% of the National General Income, 26% of national exports, 35% of public investment and 7% of public debt. The energy sources for energy production in the country are basically fossil fuels. The structure of energy production during 1995 is shown in the following table.

Table N 2: Structure of energy production

Natural gas	64 %
Hydro-energy	6 %
Unrefined petroleum	19 %
Biomass	11%

Source: SNE[1]. cit. Hanna. J.. 1998. 6

Other energy sources such as solar and geothermal are, at this time, barely exploited (Hanna. J.. 1998. 7).

According to the National Program of Climate Change (MDSMA. 1997. cit. Hanna. J. 1998) energy consumption during 1995 had the following composition (table 3):

Table 3: Structure of energy consumption

Industrial	33 %
Transport	32 %
Residential	27 %
Commercial	7 %
Agriculture	0.2 %

Source: SNE. cit. Hanna. J.. 1998. 6

The main energy source used in Bolivia is diesel oil (3.65 million barrels, 17.52% of the national energy consumption during 1995), followed by gasoline (16.5%), firewood

[1] *National Secretary of Energy*

(16%), natural gas (15%), bagasse (9 %), LGP (9 %) and electricity (8 %) (MDSMA. 1998. cit. Hanna. J.. 1998. 7).

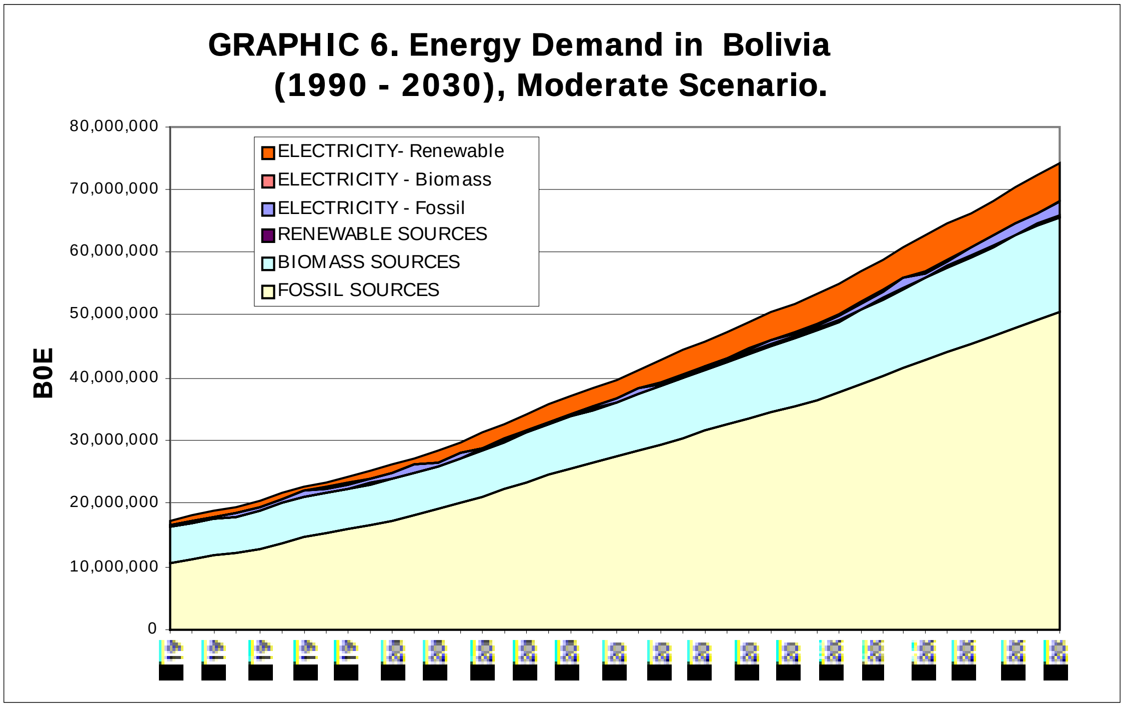
There is an important lack of demand of energy mainly in rural areas (small villages of 2.000 inhabitants). In the countryside, the percentage of people with access to electric energy totals 9% in the high plains (Altiplano), 29% in the valleys and 0.02% in the lowlands (INE. 1996).

In towns with more than 20.000 inhabitants this percentage increases to 60% on average, totaling 90% in the most important cities and in the big mining centers with more than 5.000 inhabitants which are benefited by the National Interconnected System (ibid).

During 1995, the installed capacity for electric generation (in equipments basically) was 802.2 MW (National Secretary of Energy. cit. Hanna. J.. 1998. 7) and an amplification of this capacity to 547.4 MW was projected until the year 2005 through the National Interconnected System (MDSMA. 1997. cit. Hanna. J.. 1998).

The Program of Rural Electrification (preliminary version) contemplates for the next years approximately 500 projects of rural electrification that would benefit 100.000 homes (20% of the rural population). From this total, 52% of the projects would work with renewable energy sources (hydroelectric and wind); 36% with the amplification of electricity networks and finally, 12% with biomass, generation of diesel and generation of natural gas.

The projection of energy demand for fossil fuels, use of biomass and renewable energy is shown in the graph 6. It is possible to appreciate that the demand process through renewable energy is very small compared to fossil energy.



Source: PNCC, 1999.

Environmental profile

Bolivia is a country with a demographic density that totals 7 inhabitants per square kilometer. It has an important biodiversity: 319 species of mammals (Beck. S.. et al. 1993), 1.274 species of birds (PNUD (c). 1996) and approximately 17.000 species of plants. These values are shown in table 4.

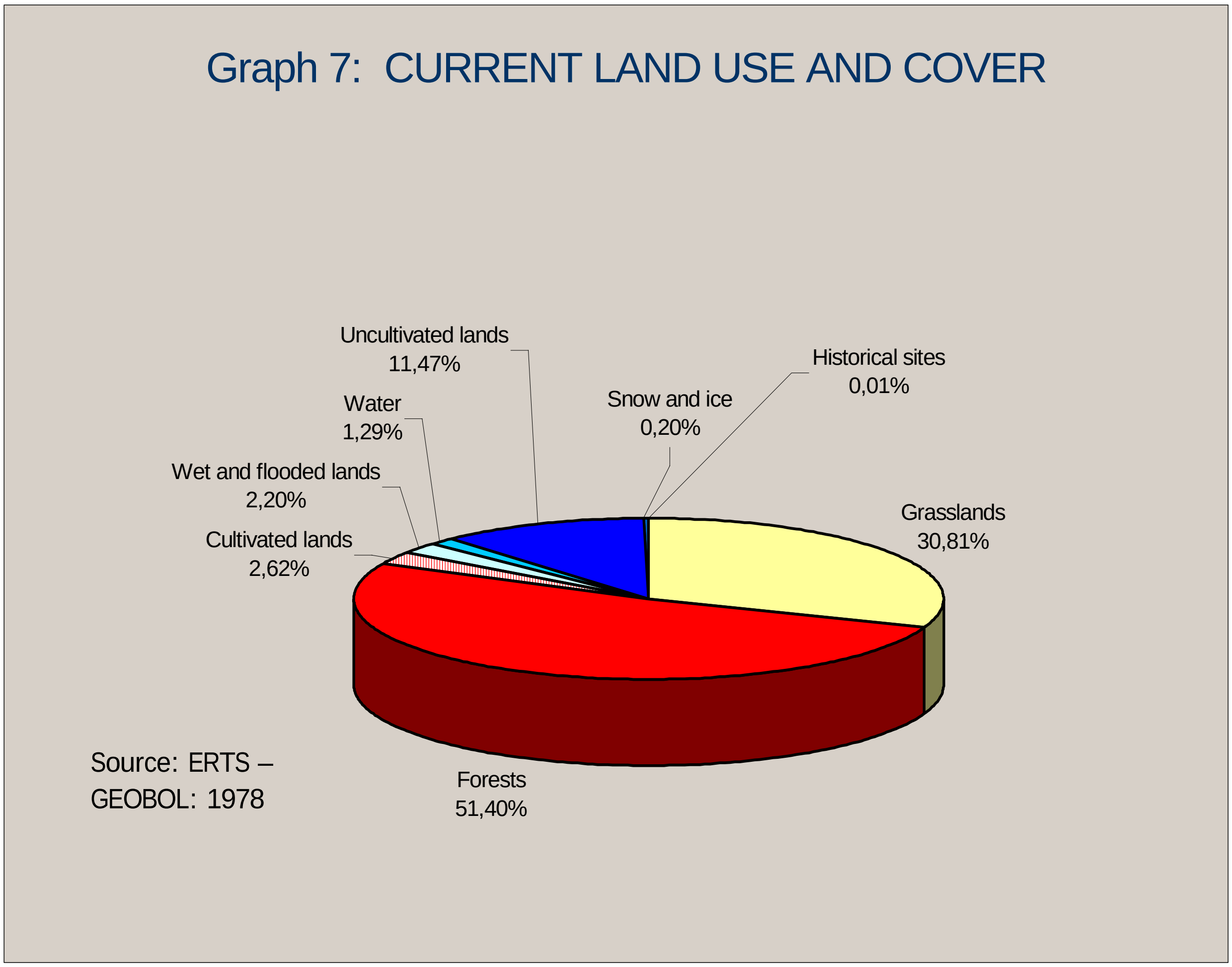
Table 4: Biodiversity in Bolivia

	TOTAL	Number of endemic species	Threatened
PLANTS			
Angiosperms	17.000	4.000	43
Gymnosperms	16	4	0
Pteridophytes	1.300	-	-
Bryophytes	1.200	-	-
ANIMALS			
Mammals	319	19	38
Birds	1.274	17	82
Reptiles	220	17	10
Amphibians	112	23	2
Fishes	500	10	8

Sources: Beck 1993; Ergueta y Morales (eds.). 1996 cit. PNUD (a). 1998; PNUD (c) 1996

Bolivia has 18 regions included in the National System of Protected Areas (SNAP). These areas total 13.71% of the national territory and include varied geographical regions: mountains, valleys, systems of lagoons and subtropical and tropical forests.

The system of protected areas has 435.000 hectares of biosphere reserve, 15.06 million hectares declared protected areas and 15 million hectares declared reserves of immobilization (SNAP, 2000; INRA. 1997). The graph 7 synthesizes the current land use and cover in Bolivia.



Forests occupy 51.4 million hectares (Source: Forest Map of Bolivia, 1995) which is 48.7% of the total surface of the country. The distribution of forests in Bolivia corresponds to the following scheme:

Amazonia	22.18 millions of hectares
Chiquitanía	7.49 millions of hectares
Chaco	10.07 millions of hectares
Andes	13.45 millions of hectares

The average deforestation rate between 1971 and 1987 was 140,000 hectares per year. According to the "FAO Production Yearbook" 21.2 million hectares of forest were devastated in this period. The current deforestation rate is 150,000 hectares per year while other sources mention an annual growth of 6% in agricultural activities that deteriorate the forest.

During 1994/95, the cultivated surface in Bolivia was 1,646,691, 1.65% of the total surface of the country (INE. 1995). This percentage increased to 1.82% in the period 1996/97 (Cruz. D.. 1998. 10) and decreased to 1.67% in 1997/1998. The biggest increase was registered in the sector of industrial cultivation where an average growth of 16.47% was estimated between 1988 and 1995 GDP (G-DRU. 1994).

According to the National Institute of Agrarian Reform (INRA), between 1953 and 1993 44 million hectares were distributed for agricultural uses (42% of the total surface of the country). Apparently, these lands are not completely cultivated.

The Ministry of Sustainable Development (MDSMA. 1997) has the following proposal for land use:

Intensive agriculture	3.7%
Extensive agriculture	22.7%
Extensive cattle raising	25.8%
Pasturing	2.8%
Forest	21.9%
Restricted areas	12.4%
Protected areas	8.7%
Bodies of water	1.0%

This distribution would allow to dedicate 52.8% of the surface of the country to agricultural uses. From this percentage, 25.8% would be dedicated to livestock, mainly in the natural savannas (which should be managed appropriately), 3.7% to intensive agricultural uses, 8% to protected areas (National System of Protected Areas) and 12% to restricted areas (protection of forests and basins) (INRA 1997. MDSMA 1997).

In Bolivia, according to the second National Agricultural Census, there are 314,600 agricultural units with 22.6 million available hectares. On the other hand, sources like CEDLA (cit. Peace. D.. 1998) estimate the existence of 550,000 peasants dedicated to agriculture, 50,000 agricultural companies and 45,000 families that belong to ethnic groups with specific knowledge of forest management (Peace. D.. 1998). These groups are mainly set down in the high plains, the valleys and the colonized lands of La Paz, Cochabamba, Santa Cruz and Tarija.

The expansion of the agricultural frontier (strongly concentrated in the department of Santa Cruz and associated to the transformation of forests) is mostly related to the industrial cultivation of soya, rice, wheat, maize and sugar cane.

The emergence of new development points in the departments of Beni, Pando, the north of La Paz and in the area of the Chaco (Chuquisaca and Tarija) have also as a result transformed forests in order to use them for cultivation and cattle raising.

Similarly, this typical pattern of agricultural use can be seen in the east of the country where it is difficult to adapt this type of extensive agriculture to land use plans (PLUS).

A third area of expansion in the agricultural frontier is the zone of Chapare where, through the denominated "alternative development", the plantations of coca leaves are been substituted by the production of banana, pineapples and other crops.

In the western part of the country, agriculture is characterized by the work of small units of producers. In most of the cases, this is a subsistence agriculture with insufficient produce to be exchanged in the markets.

Fortunately, in many cases, the productive capacities in the high plains and in the valleys are being increased through the implementation of irrigated areas, the genetic improvement of seeds, the improvement of animal health and the implementation of systems of productive complementarities developed among regions. These projects were, till now, in an experimental phase (studies and isolated experiences) and that is why they do not currently reach the size to assure the feeding of the population and to increase competitiveness in markets.

59.2% of the land in the country is affected by water erosion (SNRNMA. 1995). In the Andean region, particularly in the inter-Andean dry valleys, 4.6% of the territory is constituted of sandbanks with strong desertification tendencies by wind erosion. In the region of the Chaco, the influence of the wind usually transforms million of hectares into dunes (Bojanic. 1997).

In the high plains and the valleys, the intense use of the land and its inappropriate management and conservation, is responsible for the loss of fertility and intense erosion processes.

Land erosion is one of the main ecological problems of Bolivia and it has been estimated that 275,544 km2 of the total surface of the country suffers from strong problems of erosion. This quantity is equivalent to 61% of the arid, semi-arid and dry sub tropical regions of Bolivia) (Source : Land Conservation Office, 1996).

In the subtropical regions and in the plains of the east and the south of the country, the inadequate administration of the natural resources (flora and fauna) is also causing land erosion, mainly in areas affected by spontaneous colonization.

The excessive pressure on the ground, its salination through watering practices (Gandarillas. H.. 1997) and the inadequate ways of land use (mainly in the integrated areas of Santa Cruz but also in other colonization areas) is deteriorating large extensions of agriculture areas. The maintaining of this tendency would rapidly decrease the areas for agricultural potential (2.6% according to ERTS–GEOBOL. 1978) (Bojanic. 1997).
The water resources in several points of the Amazon are also affected by erosion, intensified by the effects of deforestation.

On the other hand, many streams and rivers crossing small and medium populated centers (which do not have effective sewer system and collect waste) suffer the results of urban contamination (mainly biological).

In this sense, the INRA law determines protective basins for preserving against water erosion. Similarly, the Bolivian government is working on a legislation that could implement the application of environment laws and water laws in small towns considering, at the same time, the basic necessities of these settlements.

However, the contamination of water resources is even worse in the big cities and in places of agricultural and mining production. In this sense, independent studies have been carried out for the water resources of the Altiplanic basin, for rivers of the La Plata basin (strongly polluted by mining activity), for some Amazon rivers that suffer strong contamination caused by agriculture (sugar cane, especially) and for the basin of the La Paz River, where different mining areas are established. Fast flowing rivers such as the Pilcomayo and the Desaguadero have also suffered the effects of mining activities, or the effects of harvest, as is the case of the Piraí river, in Santa Cruz.

Referring to the air, it is possible to say that Bolivia does not suffer huge problems of air contamination. There are, in certain moths of the year, cultural practices or festivities (San Juan's date especially) when the permissible limit of pollution in the cities is exceeded (Pinto. M.R.; Zaballa. M. com. per.).

Another source of air contamination is the burning of vegetation (chaqueo) between July and September, when smoke hinders airplanes from landing and constitutes a health threat, causing breathing diseases.

Contamination caused by the sublimation of heavy metals happens mainly in places of mining exploitation (the exploitation of gold causes mercury sublimations, for example). Considerable concentrations of heavy metals have also been reported in some urban places, lead and cadmium mainly.

Environmental legislation

During the last 10 years, the Bolivian government has been promulgating different laws in order to control the use of natural resources and to promote the environmental defense. At the moment, the major part of this legislation is still being discussed. The Environmental Law (Law 1333. **of April 27 1992) is the first legal reference regarding the environment and its protection.**

This law was finally approved in December 1995 and has been lately complemented by laws like the Water Law, the Forest Law, the Law of Biological Diversity and the Law of Land and Land Use. The points developed by the Environmental Law refer to renewable and non-renewable resources, health and environment, environmental education, science and technology. The functions and responsibilities of ministries, prefectures and municipalities are also delineated in their regulations. The Environmental Law takes into account the following components:

Prevention and environmental control

The procedures regarding the evaluation of environmental impact are delineated by the National Evaluation System of Environmental Impact (SNEIA) and by the National System of Environmental Control and Quality (SNCCCA). Their functions are related to environmental protection and surveillance, environmental audits and administrative sanctions.

Atmospheric contamination

Parameters for the administration of air quality and the environmental regulation for enterprises are established in this area. Topics regarding the control of atmospheric contamination (noise, polluting emissions and quality of fuels), urban and industrial planning and surveillance mechanisms (sanctions and others) are also delineated.

Water contamination

This area includes topics like: regulation parameters for potable water supply (municipal and cooperative); regulations for waste water, permissible parameters and concepts for the legislation of water discharges, regulations for the control and evaluation of water quality, surveillance mechanisms and sanctions, evaluation of water treatment, conservation of underground water and contamination of basins.

Activities regarding dangerous substances

This area, created as part of the Program of Inter-sector Action against dangerous substances, includes different topics related to this issue: registration, licensing, handling, generation, treatment, selection, gathering, transport, storage and confiscation.

Complementary legal references

The Forest Law (Law 1700. **of December 21 1996) has the objectives of regulating the sustainable use and the protection of forests and land. Besides, it guarantees the conservation of the ecosystem in facilitating the access for the population to natural resources.**

The following are some of the forest law regulations:

- Regulations regarding forest concessions.
- Regulations regarding management plans.
- Regulations regarding land use
- Incentives for the rehabilitation of degraded lands.

The National Law of Agrarian Reforms (Law INRA 1715 **of October, 18, 1996) has the following functions: to establish the organic structure and attributions of the Service of Agrarian Reform; to define the distribution of land; to guarantee the land ownership, to regulate the reparation of agrarian property, to regulate the executive and judicial instances in agrarian matters.**

The Law of Wild Life in National Parks, Hunting and Fishing (Law 12301. **of March 14 1975) and the Law of Biological Diversity Conservation have the objective of**

regulating the protection of wild flora and fauna inside protected areas. This law will be soon substitute by the Law of Biological Diversity Conservation.

Finally, the Law of Popular Participation (Law Not. **1551. of April 20 1994) promotes the strengthening of small towns and municipalities in order to increase the participation of people in the taking of decisions.** It promotes, on one hand, a natural administrative division inside the municipalities through the formation of the Territorial Organizations of Base (popular organizations that have the right to control and supervise the municipal administration). On the other hand, it countersigns the functions and municipal rights settled by the Organic Law of Municipalities.

The chart No 5 synthesizes national circumstances through different indicators.

Chart No 5. NATIONAL INDICATORS

APPROACH	1990	1994	SOURCE
Population	6,179,952 inhab.	6,718,281 inhab.	INE - National census of population and housing 1992, Page 8
Rate of population growth		2,35	INE - National census of Population and Housing 1992
Population density		6,7 inhab /km2	
Index of Human Development		0.593	Human development 1994
Birth Rate		4,6	INE - National census of population and housing 1992
Mortality Rate		9,7	INE - National census of population and housing 1992
Infant Mortality Rate (per thousand)		75	INE - National census of population and housing 1992
Economically Active population		3,9 my inhab.	INE - National census of population and housing 1992
Population in extreme poverty (1992) **Moderate poverty (1992)** **Threshold poverty (1992)**	2,109,870 inhab. (36.8%) 1,964,271 inhab. (33 %) 787,907 inhab. (13.4 %)		Poverty Map, January 1995 UDAPSO, INE, UPP,UDAPE. (Chart 1.1)
Life expectancy (years)	56.84 years	59.33 years	INE - Population estimates and projections 1950-2050, Pag 16, (Chart 8.)
Illiteracy Rate	20 %	21.92 % (1992)	INE - National census of population and housing 1992, Page 29. socio-demographic indicators by counties, INE 1995.
Relevant areas (km2) Arable land Permanent cultivation Forests Other land	 20,400 km2 2,380 km2 556,080 km2 238,920 km2	 22,000 km2 2,820 km2 553,920 km2 242,240 km2	Annual Production FAO Vol.47 1993, page 9, Chart 1.
GDP ($us 1990) T/C: 3.17 UDAPE, VOL.5 p. 310, I chart 4.5.1	4,871,651 $us.	5,688,515 $us.	Annual statistics for the Rural Sector 1995-1996. P. 17, chart 1.
GDP PER CAPIT ($US. 1990)	0.788 $us.	0.846 $us.	Own elaboration (based on GDP and population values).
Industry in GDP (%)	16.96 %	16.74 %	Annual statistics 1995, INE, Pag 171; chart 4.01.03.
Services in GDP (%)	14.49 %	13.72 %	Annual statistics 1995, INE, Pag 171; I square 4.01.03.
Agriculture in GDP (%)	15.35 %	15.18 %	Annual statistics 1995, INE, Pag 171; I square 4.01.03.
Ground used for agriculture purposes (km2)	20,066 km2		Annual statistics for the Rural sector. DRU 1994. pag 125, chart 116.
Livestock population	5,543,385 animals	5,912,050 animals	Annual statistics for the Rural sector. DRU 1995-1996. pag 75, chart 20.
Forest area (km2)	549,684 km2	545,684 km2	Bolivian Forestry map -1995
Annual deforestation rate		168.012 have	Bolivia Forestry map - 1995
CO2 emissions per capita		0.006 Gg/ person.	PNCC - energy and non energy sectors

CHAPTER II

NATIONAL GREENHOUSE GAS INVENTORY

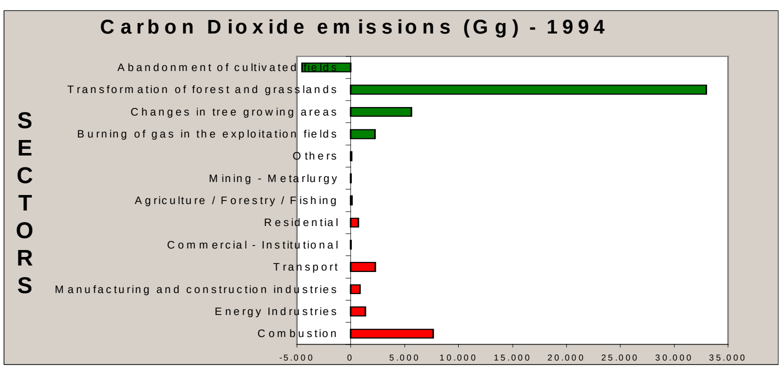
SUMMARY

The greenhouse gas emissions and their removal for the year 1994 have been calculated using the methodology published in 1996 by the Intergovernmental Panel of Climate Change (IPCC) for the elaboration of GHG National Inventories.

The activities related to land use change and forestry, are the most important source of greenhouse gas emissions, contributing to the total CO2 emissions with 38.61 millions of tons. This is followed by the energy sector with 7.64 millions of tons of CO2 and the industrial sector with 0.393 millions of tons of CO2.

Land use change and forestry are the major producers of carbon dioxide in Bolivia. These activities are mostly related to the transformation of forests and prairies and with the increase of agricultural frontiers caused by spontaneous colonization. The CO2 emissions related to the change in forests and other tree growing areas are 5.6 million tons; the ones related to the transformation of forests and prairies to 32.98 million tons and the emissions related to the abandonment of cultivated lands are 4.54 million tons.

In the energy sector, transport contributes to GHG emissions with 29.7% of the total followed by the burning of gas in the exploitation fields (29.3%), the energy industries (18%), the manufacturing industry (10.7%) and the residential use of energy (9.1%).



The methane (CH4) emissions stands at a total of 0.653 million tons from which 0.089 million tons correspond to the energy sector, 0.5 million to the agriculture sector (basically to the area of enteric fermentation) and 0.05 million tons to land use change. The nitrous oxide (N2O) emitted stands at 0.003 million tons, the carbon monoxide (CO) at 0.86 million tons, the nitrogen oxide (NOX) at 0.11 million tons and the volatile organic compounds different from the methane (COVNM) at 0.06 million tons. The sulphur dioxide (SO2) emitted reaches to 0.005 million tons and the hydro-fluorocarbonates (HFCs) to 0.00001 million tons.

It is important to point out that the emissions related to international aviation are 0.17 million tons of CO_2. (international bunkers).

The following diagram summarizes all the components of the GHG emissions inventory for 1994.

National Inventory of Greenhouse Gas Emissions 1994 - General Summary Gg											
CATEGORY AND SOURCES OF GREENHOUSE GAS EMISSIONS	Emissions de CO_2	Remissions de CO_2	CH_4	N_2O	NO_x	CO	COVNM	SO_2	HCFs	PFCs	SF_6
									P		
Total National Emissions	46,657.21	4,537.42	653.48	2.53	107.95	857.98	58.15	5.46	0.01	NO	NO
1 Energy	7,646.20		89.05	0.20	37.64	322.43	54.09	5.19			
A Combustion activities	7,646.20		7.86	0.20	37.55	322.30	46.11	3.85*			
Reference Method	*8,385.74*										
Method by Source	7,646.20		7.86	0.20	37.55	322.30	46.11	IOP			
1 Energy Industries	1,374.75		0.03	0.00	4.14	0.52	0.13	IOP			
2 Manufacturing and construction	823.15		0.06	0.00	2.54	0.36	0.08	IOP			
3 Transport	2,269.88		0.43	0.03	24.00	154.68	29.26	IOP			
4 Cmmercl / Institutional	16.00		0.00	0.02	0.02	0.01	0.00	IOP			
5 Residential	695.76		0.06	0.00	0.59	0.54	0.06	IOP			
6 Agricult. / Fishing / Forestry	106.75		0.01	0.00	1.93	1.61	0.32	IOP			
7 Mining/ Metallurgic	30.87		0.00	0.00	0.09	0.01	0.00	IOP			
8 Other Sectors	86.93		0.03	0.00	0.79	10.25	1.92	IOP			
9 Burning of Natural Gas	2,242.11										
10 Use of tree growing			7.24	0.14	3.44	154.34	14.34				
B Fugitive Emissions			81.19	0.00	0.09	0.13	7.98	1.34			
1 Gas and Oil			81.19								
2 Precursors of SO_2 produced by Oil					0.09	0.13	7.98	1.34			
2 Industrial Process	393.90		0.00	NO	0.00	0.01	3.95	0.27	0.01	NO	NO
A Non metallic mineral products	393.90				0.00	0.00	0.75	0.23			
B Other	NO		0.00	NO	0.00	0.01	3.19	0.04	0.01	NO	NO
3 Use of solvents and others							0.11				
A Chemical Products							0.11				
4 Agriculture			489.27	1.73	56.75	57.04					
A Enteric fermentation			462.54								
B Use of manure			19.51	0.01							
C Rice cultivation			5.04								
D Agriculture				0.14							
E Burn prescribed savannas			2.16	0.03	0.97	56.67					
F Burning of agricultural residues			0.02	1.54	55.78	0.37					
5 Land use change and forestry	38,617.11	4,537.42	54.67	0.38	13.56	478.51					
A Changes in forests and tree growing areas	5,629.38										
B Forests and grasslands	32,987.73		54.67	0.38	13.56	478.51					
C Cultivated fields abandoned		4,537.42									
D Emissions and absorp. of CO_2 in the fields	NE	NE									
6 Residues			20.49	0.22							
A Disposition of solid residues			20.14								
B Wastewater treatment			0.35								
C Emissions of N_2O from human excrement				0.22							
Informative Sources											
International Bunkers	173.57		0.00	0.01	0.87	0.39	0.24	0.06			
Aviation	173.57		0.00	0.01	0.87	0.39	0.24	0.06			
CO2 emissions related to tree growing areas	3,112.38										

* Emissions of SO_2 related to activities of combustion in the sectors that have not been included.

P = Potential emissions based on the method of Grade I

NE = Non estimated

IOP = Estim. emissions included somewhere else

NO = National non existent emissions

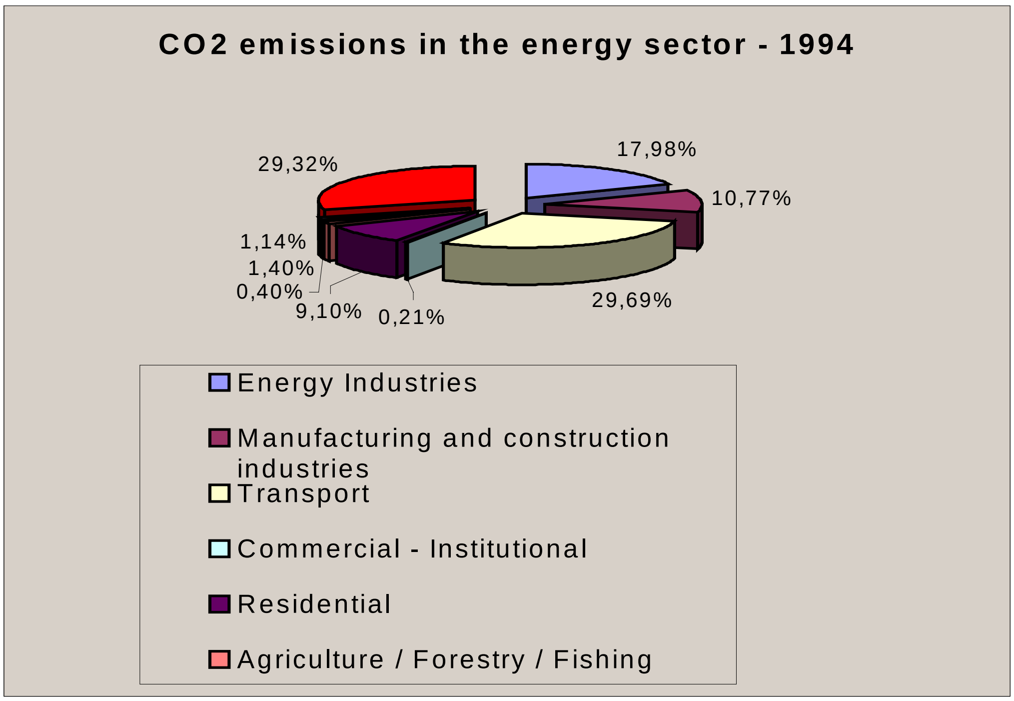
INTRODUCTION

This chapter provides a summary of the National Inventory of Greenhouse Gas Emissions during 1994. The gases under consideration are the following: CO2, CH4, N2O, NOx, CO and COVNM.

The emissions were estimated according to the “IPCC Revised Guidelines for National Gas Inventories” (IPCC,1996) following the procedure of “bottom up” for the energy sector.

CO2 EMISSIONS

The chart 2.1 represents the total CO_2 emissions that took place in Bolivia during 1994. The quantity ascends to 46,657.21 Gg and the data was calculated with the methodology set down by the IPCC guide lines - 1996. The removal is 4,537.42 Gg. Commercial, metallurgy



Source: NPCC.

Chart 2.1. Total CO_2 emissions in Bolivia - 1994. (Gg)

Sources	CO2
	1994
TOTAL ENERGY	**7646,19**
Combustion Activities	7646,19
Energy Industries	1374,75
Manufacturing and construction industries	823,15
Transport	2269,87
Commercial - Institutional	16,00
Residential	695,76
Agriculture / forestry / fishing	106,75
Mining / metalurgy	30,87
Others	86,93
Gas burning in the oil fields	2242,11
Fugitive emissions	**0,00**
Gas and oil	0,00
Products used in the oil refining	0,00
Mineral Carbon	0,00
Industrial Process	**393,90**
Mineral non metallic products	393,90
Land use changes	**38617,11**
Changes in the forest and other woody biomass	5629,38
Conversion of forests and grasslands	32987,73
Cultivated fields that are abandoned	**-4537,43**
TOTAL CO2 EMISSIONS	**46657,20**

CO2 emissions in the energy sector

The combustion of fossil fuels is the second source of CO_2 emissions in Bolivia. The estimated emissions are based on the energy balance provided by the Vice-Ministry of Energy and Hydrocarbons. The statistical information has been provided by the National Oil Company (YPFB) and by the National Company of Electricity. Complementary information has been supplied by the Ministry of Economic Development, the National Police, General Customs, private import companies and the Air Administration Services (AASANA). The chart 2.2 represents a summary of the energy balance for 1994 and the corresponding level of carbon dioxide emissions.

The chart 2.3 represents the emission factors (which were based on the IPCC recommendations and in values which are characteristic of the country) used in the different fuels. Bolivia has determined the values of the factors related to the theoretical emission for the fuels that are sold inside the national territory, considering the net heating powers and the chemical composition of the fuels.

Chart 2.2 Energy Balance and it's relationship with the CO_2 emissions

Combustion Activities	Year 1994	
	PJ	CO2 (Gg)
1. Energy Industries	**26,72**	**1374,75**
Oil derivatives	2,62	173,45
G Natural gas	24,10	1201,30
2. Manufacturing Industries	**15,26**	**823,15**
D Oil derivatives	5,12	316,12
G Natural gas	10,14	507,03
3. Transport	**34,82**	**2269,87**
D Oil derivatives	34,73	2265,54
G Natural gas	0,09	4,33
4. Commercial/Institutional	**0,26**	**16,00**
D Oil derivatives	0,12	7,84
G Natural gas	0,14	8,16
5. Residential	**11,13**	**695,76**
D Oil derivatives	0,69	45,73
G Natural gas	10,44	650,03
6. Agriculture and Forestry	**1,61**	**106,75**
7. Minning and metallurgy	**0,47**	**30,87**
8. Others	**1,32**	**86,93**
9. Burning of gas in the oil fields		**2242,10**
10. Biomass (*)	**34,43**	**3112,38**
Total CO2 emissions		**7646,18**

(*) This is a referential value normally considered in "use of soil"

Chart 2.3 Emission Factors used to estimate the CO2 emissions

Type of fuel	Emission factors (Gg/Tj)
	1994(*)
Natural Gas	0,01365
Diesel	0,01826
Gasoline	0,0174
Kerosene	0,01826
GLP	0,01715
Fuel Oil	0,01826
Avgas	0,01996
Jet fuel	0,01985

(*) Based on inferior heating powers. YPFB

In the energy sector, transport is the main source of CO_2 emissions contributing to the total with 29.7%. Significant levels have been recorded from the burning of gas in the fields of exploitation (29.3%), the energy industry (18%), the manufacturing industry (10.7%) and finally, the residential use of energy (9.1%). The emissions related to aviation were calculated using the method "Tier 2" recommended by the IPCC Revised Guides - 1996.

CO2 emissions in the industrial sector

Cement production in Bolivia is the industrial process that contributes the most to the CO_2 emission since the country does not have a significant industrial park to process the greenhouse gas emissions.

The information used in this section is based on data provided by the National Institute of Statistic (INE), the Vice-Ministry of Industry and Trade and the Coordinator of Industries.

The chart 2.4 represents the cement and lime production during 1994 and its corresponding CO2 emissions. The used emission factor was the one recommended by the IPCC Methodology Guides for the developing countries (0.4985 tCO2/t cement production and 0.79 tCO2/t caustic lime).

Chart 2.4. **CO_2 emissions in the industrial sector**

Industrial Process	Production (t)	Emission (Gg)
	1994	1994
Cement	774041	386
Lime	10000	7,9
Total		393,9

CO2 emissions for land use change and forestry

The lack of employment, the limited alimentary production and the necessity to produce fuel, determines, in Bolivia, human actions that alter the biosphere, contributing to greenhouse gas emissions (carbon dioxide mainly). The annual levels of deforestation in Bolivia have been increasing since the 80's and the reforestation measures do not have an impact that could oppose this process.

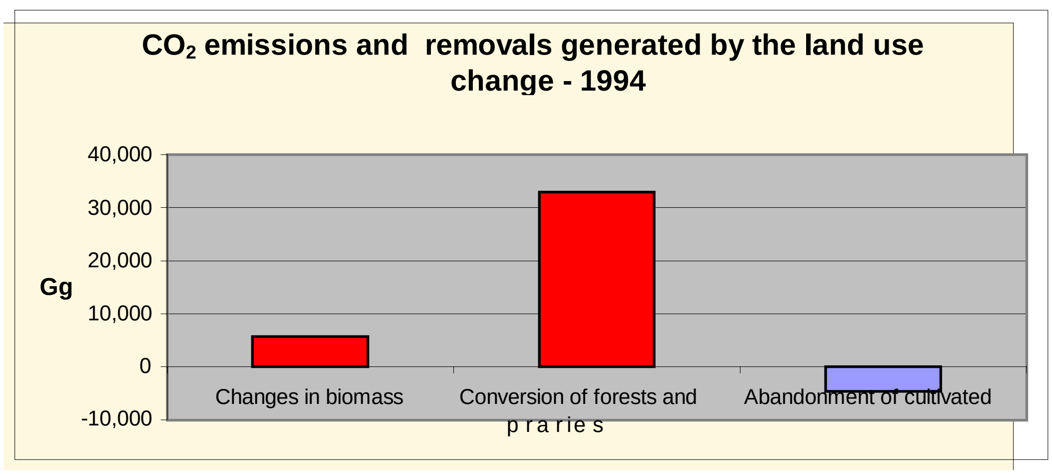
Land use change is definitively the most important producer of CO_2 in Bolivia. Changes in forest and other tree growing areas are also considered in the transformation of forests and grassland and the abandonment of cultivated lands. The chart 2.5 summarizes the emission levels for this activity that produces 82.76% of the total national CO_2 emissions (38,617.11 Gg during 1994).

Chart 2.5 CO_2 emissions caused by land use change

Activity	Change in the forest	Transformation of praries	Abandonment of lands	Total emissions(Gg)
	1994	1994	1994	1994
CO2 emissions (Gg)	5629,38	32987,73	-4537,43	38617,11

The use of the factor "oxidation of the biomass" proposed by the IPCC (0.9) has been substituted in this analysis by the value 0.27 proposed by Fearnside (1992) for Amazonia. The IPCC applies this to already cleared areas. This is not the case in the tropical and subtropical regions of Bolivia where the land has been previously burned (chaqueo) in order to plant seeds.

The issue related to "wastes and residues" does not register CO_2 emissions because there aren't any incinerators for solid residues in Bolivia.



CH_4 EMISSIONS

The investigation of the CH_4 emissions was fundamentally based on the IPCC revised methodology guides (IPCC,1996). The considered emission factors were also the ones suggested by the IPCC guides for the developing countries (enteric fermentation of the domestic livestock and their manure). However, in the specific case of the bovine livestock, the emission factors were determined by the food consumption and energy requirements, discriminating against the milk producing livestock, the non milk producing livestock and the young animals, in consideration of the national particularities (IPCC, 1996b). The factor of biomass oxidation used was 0.27.

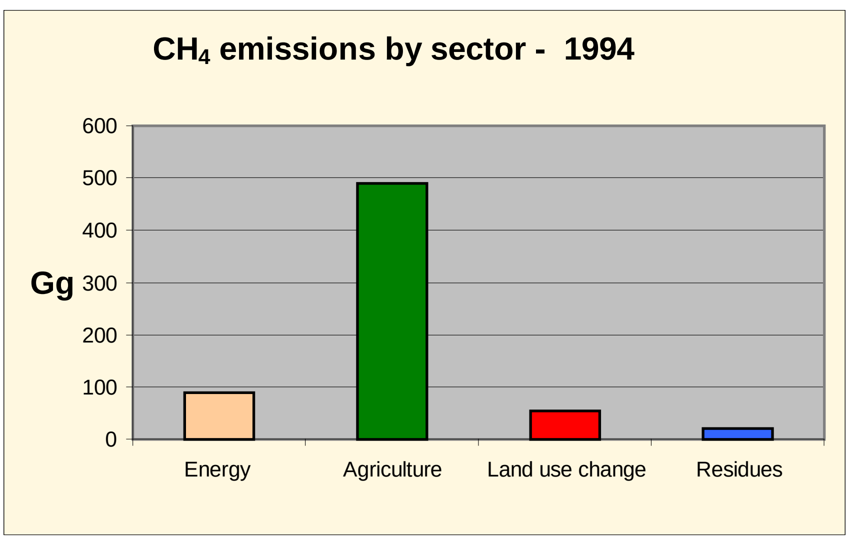
The CH_4 emission factors suggested by the IPCC methodology Guides (1996), were also used to determine the rice production, the burning of prescribed savannas, the burning of agricultural waste, the transformation of forests and grasslands and the handling of solid residues and wastewater.

In the chart 2.6 it is possible to observe the methane emissions produced in Bolivia by all sectors during 1994. In the whole country, emissions reached 653.48 Gg.

It is also possible to realize that during 1994 the agricultural sector was the biggest methane producer (489.27 Gg) followed by the energy sector (89.05 Gg), the land use change and forestry (54.67 Gg) and the sector of residues and wastewater (20.49 Gg).

Chart 2.6 CH_4 emissions sources in Bolivia (Gg) - 1994

SOURCES	CH4 emissions (Gg)
	1994
ENERGY - TOTALS	**89,05**
Combustion activities	**7,858139**
Stationary sources	0,190539
Mobile sources	0,4276
Biomass	7,24
Fugitive emissions	**81,19**
Gas and oil	81,19
AGRICULTURE - TOTALS	**489,27**
Enteric fermentation and manure	482,05
Rice cultivation	5,04
Burning of prescribed savannas	2,16
Burning of agricultural residues	0,018
LAND USE CHANGE	**54,67**
Conversion of forest and grasslands	54,67
RESIDUES	**20,49**
Solid residues	20,14
Wastewater	0,35
TOTAL	**653,48**



N_2O EMISSIONS

The emissions of nitrous oxide are not completely developed and well-known in comparison with other greenhouse gases. This situation is more critical in Bolivia where there are no solid investigation bases due to a series of factors, among them, the economic limitations.

The chart 2.7 presents the N_2O emissions for all the different sources during 1994. Apart from the energy sector, the emission sources of this gas are the burning of savannas, the burning of agricultural waste, the management of manure, the transformation of forests and grasslands and the management of residues. In general, the N_2O emission levels are quite low (2.53 Gg). The investigations of the N_2O emissions were based on the IPCC emission factors and on the methodology outlined by the IPCC (IPCC,1996).

Chart 2.7 N_2O emissions by sources (Gg) - 1994

Sources	Emisiones de N2O(Gg)
	1994
ENERGY - TOTALS	**0,20**
Combustion Activities	**0,2**
Stationary sources	0,03221
Mobile sources	0,02779
Biomass	0,14
Fugitive emissions	**0**
Natural gas and oil	0
AGRICULTURE	**1,728**
Manure management	0,0149
Agricultural fields	0,14
Burning of savannas	0,03
Burning of agricultural residues	1,543
LAND USE CHANGE	**0,38**
Conversion of forest and grasslands	0,38
RESIDUES	**0,22**
Other residues	0,22
TOTAL	**2,528**

OTHER GASES

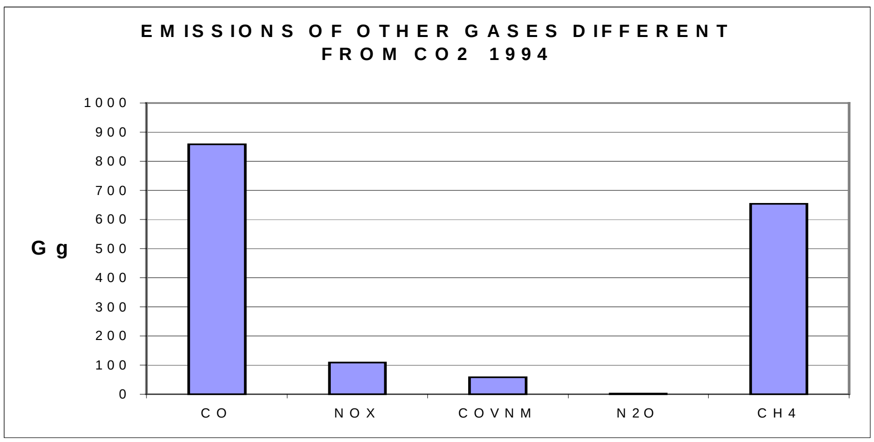
The chart 2.8 shows the emissions of the nitrogen oxides (NOx), carbon monoxide of (CO) and non-methane volatile organic compounds (COVNM) during 1994. The total NOx emissions during 1994 reached 107.95 Gg and the main producer of this gas was the energy sector (37.64 Gg), followed by the agricultural sector (56.75 Gg) and the land use change sector (13.56 Gg).

The CO emissions during 1994 were 857.99 Gg. From this total, 322.43 Gg were generated by the energy sector, 57.04 Gg by the agriculture and 478.51 Gg by the land use change and forestry.

Finally, the total COVNM emissions for 1994 reached 58.15 Gg. The main producer of this gas was transport (29.26 Gg), followed by the industrial processes sector (3.95 Gg) and the use of solvents (0.11 Gg). The emission factors used in this investigation were the ones recommended by the IPCC revised methodology guides (IPCC 1996).

Chart 2.8 COVNM, CO and NOx (Gg) emissions - 1994

COVNM emissions	**58,15**
Energy	54,09
Industrial processes	3,95
Use of solvents	0,11
CO emissions	**857,99**
Stationary sources	13,28
Mobile sources	154,68
Biomass	154,34
Fugitive emmisions	0,13
Industrial processes	0,01
Burning of prescribed savannas	56,67
Burning of agricultural residues	0,37
Transform. of forest and grasslands	478,51
Nox emissions	**107,95**
Stationary sources	10,11
Mobile sources	24,00
Biomass	3,44
Fugitive emmisions	0,09
Burning of prescribed savannas	0,97
Burning of agricultural residues	55,78
Transform. of forest and grasslands	13,56



The sulphur dioxide (SO_2), especially generated in the energy sector, was emitted in a very reduced quantity during 1994 totaling 5.46 Gg. The energy sector contributes to the emission of this gas with 5.19 Gg and the industrial processes with 0.27 Gg. Finally, the emission of hydro-fluorocarbons (HFCs), mainly produced by industrial processes, hardly totals 0.01 Gg.

GLOBAL WARMING POTENTIAL

Carbon dioxide was definitively the major greenhouse gas produced in Bolivia during 1994. The emissions of this gas reached 46,657.21 Gg, a considerable amount when compared to 653.48 Gg of CH_4; 2.53 Gg of N_2O; 857.99 Gg of CO and 107.95 Gg of NOx.

In terms of Global Warming Potential (GWP), the carbon dioxide emissions represent 76.28% of the national emissions (chart 2.9) followed by methane (22.44%) and nitrous oxide (1.28%).

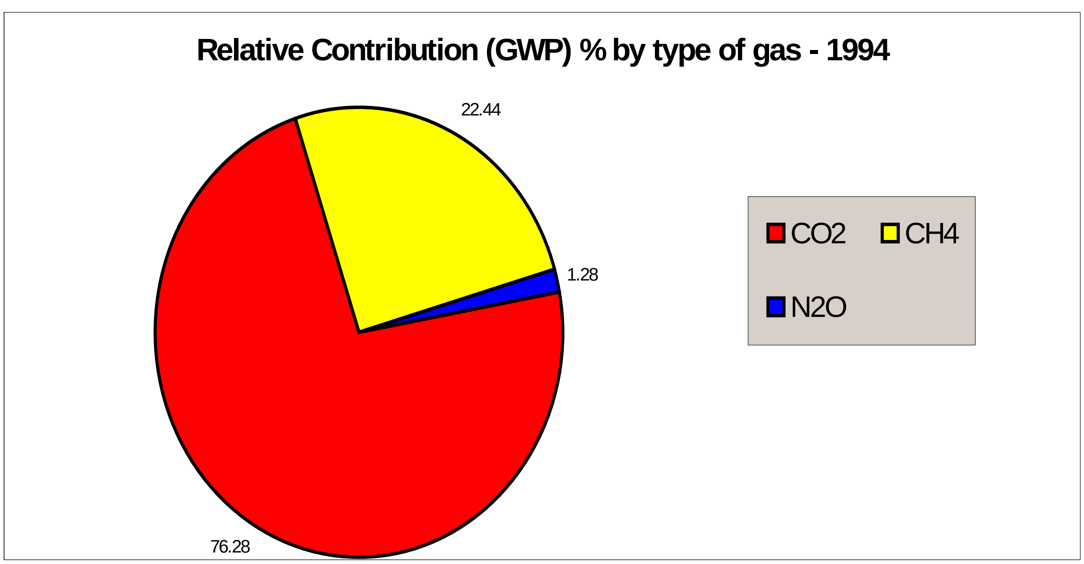
Chart 2.9. ACCUMULATIVE EFFECT OF GREENHOUSE GAS EMISSIONS - BOLIVIA, 1994.

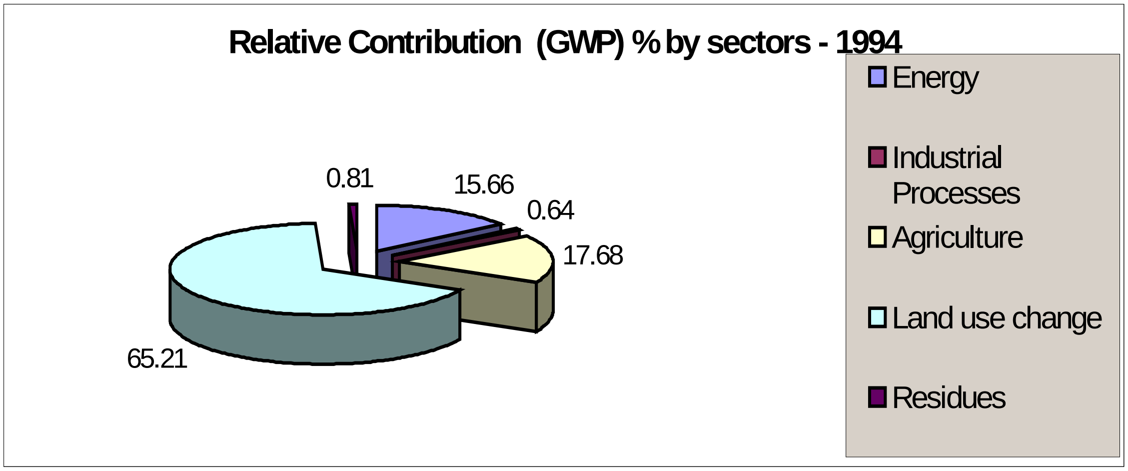
Gases	EMISSIONS (Gg) Molecular weight	GWP 100 years horizon	Warming Potential	RELATIVE CONTRIBUTION (%)
Carbon Dioxide (CO2)	**46.657,21**	**1,00**	**46.657,21**	**76,28**
Combustion	7.646,20		7.646,20	12,50
Fugitive emissions	0,00		0,00	0,00
Industrial processes	393,90		393,90	0,64
Land use change and forestry	38.617,11		38.617,11	63,14
Methane (CH4)	**653,48**	**21,00**	**13.723,08**	**22,44**
Combustion	7,86		165,06	0,27
Fugitive emissions	81,19		1.704,99	2,79
Agriculture	489,27		10.274,67	16,80
Land use change and forestry	54,67		1.148,07	1,88
Residues	20,49		430,29	0,70
Nitrous Oxide (N2O)	**2,530**	**310,00**	**784,30**	**1,28**
Combustion	0,200		62,000	0,10
Agriculture	1,730		536,300	0,88
Land use change and forestry	0,380		117,800	0,19
Residues	0,220		68,200	0,11
Total			**61.164,59**	**100,00**

The chart 2.10 represents the relative contribution of each sector to the Global Warming Potential. During 1994, the land use change and forestry sectors were the major contributors to the Global Warming Potential with 65.21% followed by the energy sector (15.66%), agriculture (17.68%), residues (0.81%) and the industrial sector (0.64%).

Chart 2.10 Global Warming Potential by Sector - 1994.

	Emissions by sector (1994 / GWP)				
Sector	**GAS**	**Emission**	**GWPs**	**CO_2**	**Relative**
		(Gg)		**Equivalent**	**Contribution**
				(Gg)	**(%)**
Energy	CO_2	7,646.20	1	7,646.20	12.50
	CH_4	89.05	21	1,870.05	3.06
	N_2O	0.20	310	62.00	0.10
	Total			**9,578.25**	**15.66**
Industrial processes	CO_2	393.90	1	393.90	0.64
	CH_4		21		
	N_2O		310		
	Total			**393.90**	**0.64**
Agriculture	CO_2		1		
	CH_4	489.27	21	10,274.67	16.83
	N_2O	1.73	310	536.30	0.88
	Total			**10,810.97**	**17.68**
Land use change	CO_2	38,617.11	1	38,617.11	63.14
	CH_4	54.67	21	1,148.07	1.88
	N_2O	0.38	310	117.80	0.19
	Total			**39,882.98**	**65.21**
Waste	CO_2		1		
	CH_4	20.49	21	429.03	0.70
	N_2O	0.220	310	68.20	0.11
	Total			**497.23**	**0.81**
TOTAL				**61,163.33**	**100.00**

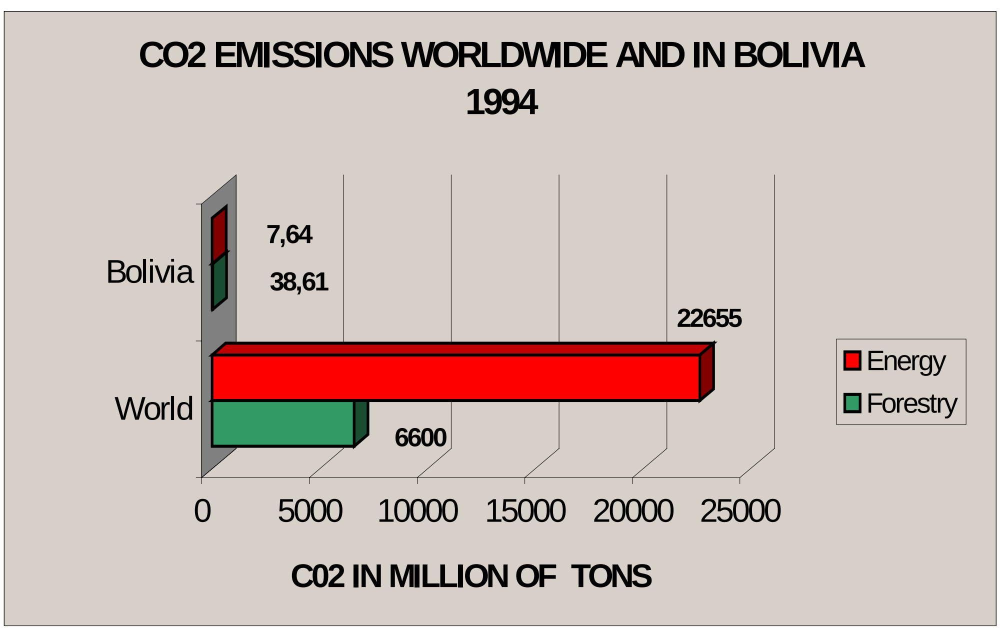




Regarding the international bunkers related to worldwide aviation, Bolivia during 1994 has contributed to 173.57 Gg of CO_2, 0.01 Gg of N_2O, 0.87 Gg NOx, 0.39 Gg of CO, 0.24 Gg of COVNM and 0.06 Gg of SO_2.

In 1994 national CO_2 emissions for the energy sector reached 7.64 million tons, an amount that hardly represents 0.033% of total world emissions that totaled 22,655 million tons according to the Report on Human Development published by the UNDP in 1998.

The world CO_2 emissions in the forestry sector reached 6,600 million tons (International Organization of tropical Wood, 1998). In comparison, CO2 emissions of Bolivia reached 38.61 million tons; 0.58% of world emissions.



Bolivia is a country with an incipient process of industrial development which means that it cannot be considered as a polluting country that makes an important contribution to greenhouse gas emissions.

UNCERTAINTIES

The analysis of errors developed by the greenhouse gas emissions inventory has considered each of the analyzed gases in connection with the emission source.

The uncertainties of the emission factors were analyzed in conjunction with IPCC Guidelines in cases in which the emission factors suggested by the IPCC guidelines were used. For the cases in which Bolivia's emission factors were taken, the analysis was developed by an expert.

The uncertainties in data for each component were estimated considering not only the values established by the guidelines but also the methodology used to estimate the basic data and the level of consistency of the information sources.

The chart 2.11 synthesizes the level of uncertainty related to the type of gas and the emission source.

CHART 2.11 GLOBAL UNCERTAINTIES OF THE EMISSIONS INVENTORY

GA	SOURCE	Emission factor Ue	activity data Ua	Uncertainty Ut
CO2	Energy	**5%**	**8%**	**9%**
CO2	Industrial processes	**7% (to)**	**2%**	**7%**
CO2	Land use change	**29%**	**20%**	**35.2%**
CH4	Burning of biomass	**50%(a)**	**20%**	**53.8%**
CH4	Manure management	**21%**	**10%**	**23%**
CH4	Enteric Fermentation	**17%**	**10%**	**20%**

(a) Value of uncertainty given by the IPCC Guidelines.

CHAPTER III

VULNERABILITY AND ADAPTATION

The analysis of the ecosystem's vulnerability to climate change is a very important issue, especially in highly exposed countries like Bolivia. The analysis of vulnerability and adaptation allows, amongst other things, to outline different options in order to face the implications of climate change and to quantify them in investment terms.

The identification of adaptation measures also provides the possibility to categorize and to evaluate technologies, practices and politics in order to face climate change. The integration of climate changes in the socio-economic development and in the handling of governmental and no-governmental programs is another advantage of this work.

During the last years, vulnerability studies were developed in Bolivia in different topics: agriculture, water resources, forests, cattle raising, pastures and human health. These analyses were accomplished through the elaboration of regional climate and change scenarios based on economic tendencies.

Climate scenarios

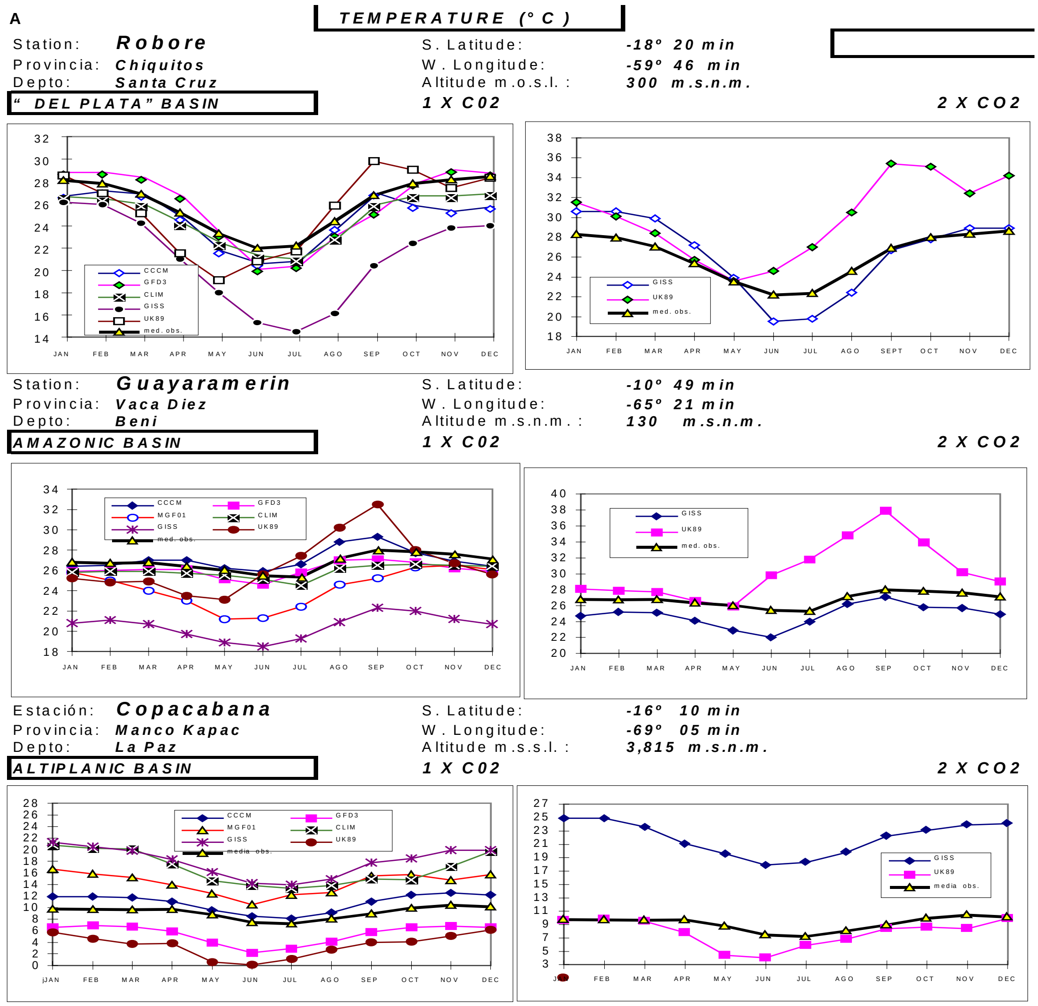
The development of studies related to the impact of climate change makes it necessary to create space and temporal representations of the future climate. These representations are the denominated climate change scenarios which should not be understood as a kind of weather forecast but as circumstances used to establish tendencies and approaches.

The use of General Circulation Models (GCM) have certain limitations basically related to the space resolution of the grids on which the simulations are carried out.

A first study carried out in Bolivia (PNCC, 1997) analyzed the General Circulation Models (MGC) that could approach better climate conditions of the country. The data provided by the GCM (1xCO2) for the main hydrographic basins of the country (Amazon, del Plata and Altiplánica) was compared with a series of 20 to 30 years obtained in 28 meteorological stations. The results showed that the GISS (Goddard Institute Space Studies) and to the UK89 (United Kingdom) were the General Circulation Models with the best adaptation conditions (graphic 3.1).

The initial results showed, in average terms, that the future climate scenario, in the eventuality of a doubling of the carbonic anhydride (2xCO2) would produce increases in the temperature of among 1 to 4ºC and precipitation changes that, in some cases, would imply a decrease of 15% and in others an increase of 20%.

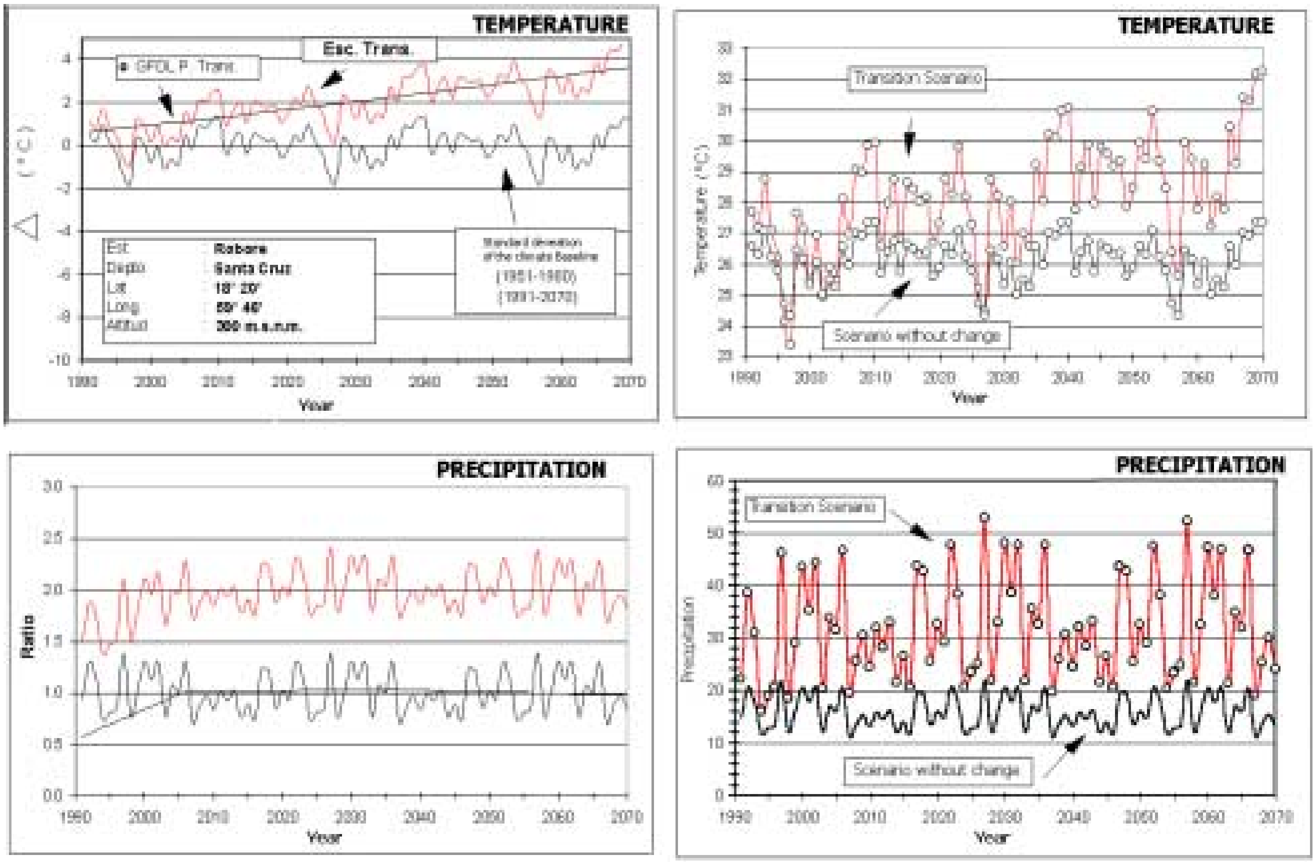
Graph 3.1. Temperature variations between an average situation (1 x CO_2) and an eventual CO_2 doubling using different General Circulation Models.



Source PNCC.

The transitory scenarios were also analyzed for the three hydrographic basins. The transitory scenario selected was the GFDL (Geophysical Flows Dynamics Laboratory). In this case, it was possible to appreciate increases of temperature (3ºC) in the three basins and increases and reductions of the precipitation levels that oscillated between 5% and 30%. Graph 3.2.

Graph 3.2 Temperature and precipitation variations based on the GFDL.



Source PNCC.

A second study related to climate change scenarios was produced by the National Service of Meteorology and Hydrology (SENAHMI 1998) for the period 2000 – 2100 using the Hadley Center HADCM2 general circulation model implemented by the United Kingdom Meteorological Office (UKHI) and the Goddard Institute of Space Studies (GISSEQ).

The SENAMHI combined the programs MAGICC (Model for the Assessment of Greenhouse gas Induced Climate Change) and the SCENGEN (Scenario Generator) in order to estimate the greenhouse gas concentrations and the global temperature changes between 1990 and 2100. The second study was related to a combination of the MAGGIC and the MCG results.

The work carried out by the SENAHMI contemplates three global scenarios of climate change: IS92a that considers as a reference scenario the one established by the Negotiations Committee of the UNFCC and that estimates a halving of future emissions (assuming a modest degree of intervention to reduce GHG emissions); IS92c[1] (optimistic scenario) and the IS92e (pessimistic scenario), respectively.
Taking into account the spatial resolution (5° of the cells), the pattern generalizes the initial climate conditions and the scenarios also contributing to the general data regarding the pattern resolution. Under these conditions the country is divided into five areas, trying to standardize the results of the simulation with the characteristic of temperature and precipitation existing in the different regions (Map Nº3).

Map No.3: Climate areas for the use of General Circulation Models

The temperature has a tendency to increase in the dry months (May, June, July, August). For the year 2030 it could increase to 1.7 °C (the charts 3.1 and 3.2 show the base scenario IS92a). This scenario shows bigger increases in the lower latitudes (near to the Equator). In the humid months the increase of temperature is smaller (1.4°C) and the new distribution of the temperature is almost parallel to the normal one.
The precipitation increases in absolute terms during the humid months (September, October, November, December, January, February). This increase reaches up to 27 mm per month between December and March. In the dry months, the increase percentage is bigger (up to 22% in the area number VI that is occupied by a great part of the subtropical forests and the Chaco's plains). However, in absolute terms, this increase hardly reaches 7mm per month. The distribution curve for the different scenarios proposed by the SENAHMI (1998) presents absolute increases in the humid months and small increases in the dry months.

[1] *The IS92c scenario makes the following considerations: population will increase to 6.4 billion by the year 2100; the economic growth will reach 2.0% by the year 2025 and 1.2% by the year 2100; the global consumption of energy will reach 8.000 EJ of conventional oil and 7.300 EJ of natural gas. The cost of nuclear energy will diminish by year to 0.4%. Both models consider the existence of control measures through international agreements in order to reduce the gas emissions in the developing countries since the second half of the century. The IS92e scenario considers that the increase of population will reach 11,3 billions by 2100, that the economic growth will reach 3.5% between 1990 and 2025 and 3.0% by 2100 and that the increase of fossil energy will reach 30%.*

Chart 3.1: Increase of temperature in the different General Circulation Models (HADCM2, UKHI, GISSEQ) for the scenario IS92A in relation to the normal scenarios (1961-1990)

Year	2030	2050	2100
AREA I			
Dry months	1,1 -1,7 ºC	1,2 - 1,9 ºC	2,2 - 3,6 ºC
Humid months	0,8 -1,4 ºC	1 - 2 ºC	1,9 - 3,8 ºC
AREA II			
Dry months	0,8 - 1,3 ºC	1,3 - 1,9 ºC	2,3 - 3,5 ºC
Humid months	0,8 - 1,3 ºC	1,2 - 1,9 ºC	2,5 - 3,5 ºC
AREA IV			
Dry months	0,9 - 1,5 ºC	1,3 - 2,2 ºC	1,4 - 3,9 ºC
Humid months	0,9 - 1,4 ºC	0,8 - 2 ºC	1,4 - 3,8 ºC
AREA V			
Dry months	0,8 - 1,3 ºC	1,4 - 1,9 ºC	2,3 - 3,5 ºC
Humid months	0,8 - 1,4 ºC	1,3 - 2 ºC	2 - 4 ºC

Chart 3.2. Increase of precipitation in the different General Circulation Models (HADCM2, UKHI, GISSEQ) for the scenario IS92A[2] in relation to the normal scenarios (1961-1990)

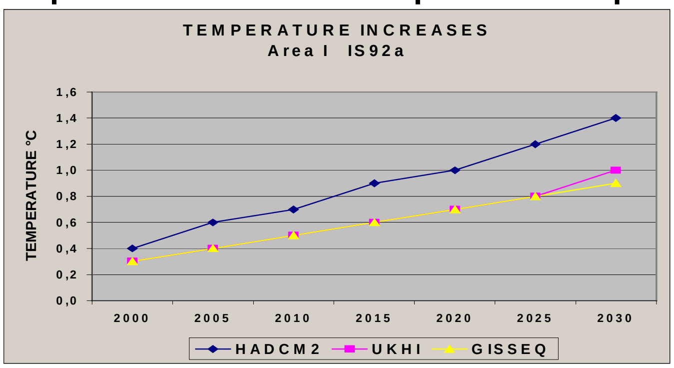
Year	2030		2050		2100	
AREA I						
Dry months	(-3) –12%	(-2) –11mm	(-6) - 14%	(-4) - 15mm	(-10) - 57%	(-4,6) - 31 mm
Humid months	1 - 3%	5 - 27 mm	3 - 6%	5 - 41mm	4 - 26%	7 - 76 mm
AREA II						
Dry months	4 - 13%	0,2 - 1,4 mm	4- 20%	0,2 - 2,1mm	14 - 54%	0,7 - 5,9 mm
Humid months	4 - 15%	5,3 - 27mm	7 -22%	8 - 26mm	13 -37%	15 - 43 mm
AREA IV						
Dry months	(-4) - 22%	(-0,9) - 7,1mm	(-5) - 24%	(-1,3) - 14 mm	(-13) - 45%	(-2,5) - 26 mm
Humid months	1 - 15%	2 - 27mm	5 - 22%	10 - 41 mm	10 - 41%	20 - 71 mm
AREA V						
Dry months	0-20%	0 - 4mm	0 - 20%	0 - 1mm	0 - 51%	0 - 10,5 mm
Humid months	0 - 7%	0 - 12mm	0 - 10%	0 - 19 mm	0 - 19%	0 - 35 mm

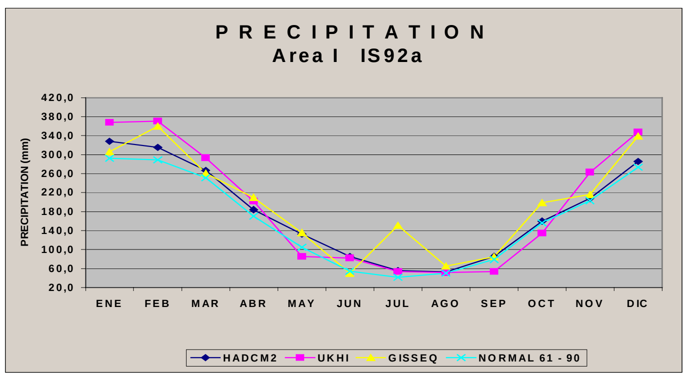
[2] *The IS92a scenario makes the following considerations: the population will increase to 11.3 billion by the year 2100; the economic growth will reach 2.9% by 2025 and 2,3% by 2100; the cost of the solar energy will decrease to 0,075 Kw/h and the price of oil will reach 70 $US /barrel.*

The increase of precipitation will be bigger in the lower latitudes and this is why precipitation increases are expected in the Amazon region and in the northern part of the high plains. In other latitudes of the national territory the precipitation will also increase but in a smaller quantity. For the region of the Bolivian Chaco, some models estimate an increase of up to 20% in the dry months and 12% in the humid months, which means increases from 4 to 12mm per month in absolute terms. Some other models used by the SENAHMI estimate, however, that the precipitation increases are not very probable in this area.

Some of the models used by the SENAHMI estimate negative results in the precipitation patterns in a big part of the Amazon and the subtropical plains of Santa Cruz (areas I and IV), especially in the dry months (graphics 3.3 and 3.4).

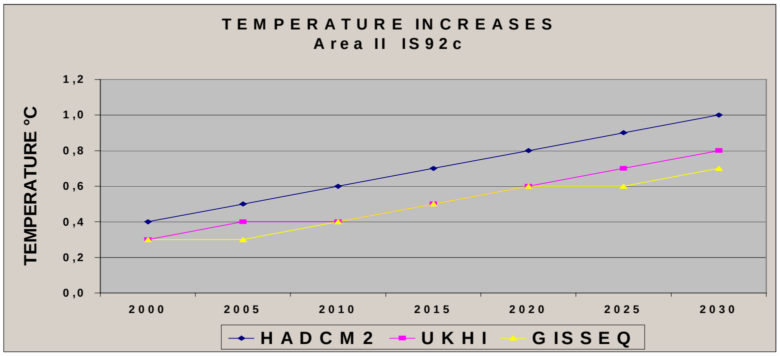
Graph 3.3. Variations of temperature and precipitation in the scenario IS92a

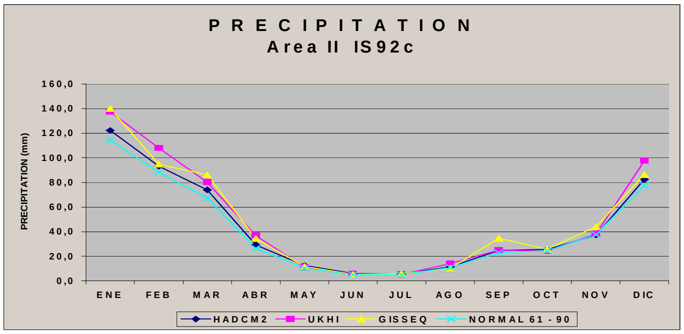




Source: SENAMHI, 1999

Graph 3.4. Variations of temperature and precipitation in the scenario IS92c





Source: SENAMHI, 1999.

Chart 3.5: Increase of temperature in the different General Circulation Models (HADCM2. UKHI. GISSEQ) for the scenario IS92E in relation to the normal scenarios (1961-1990).

	2030	2050	2100
AREA I			
Dry months	0.9 TO 1.9 °C	1.4 TO 3.0 °C	2.8 TO 6.1 °C
Humid months	0.8 TO 1.5 °C	1.5 TO 2.3 °C	2.5 TO 4.7 °C
AREA II			
Dry months	0.9 TO 1.4 °C	1.4 TO 2.3 °C	2.8 TO 4.6 °C
Humid months	0.8 TO 1.4 °C	1.3 TO 2.3 °C	2.7 TO 4.6 °C
AREA IV			
Dry months	1.0 TO 1.6 °C	1.5 TO 2.5 °C	3.1 - 5.1 °C
Humid months	0.6 TO 1.5 °C	0.9 TO 2.4 °C	1.9 - 4.9 °C
AREA V			
Dry months	0.9 TO 1.4 °C	1.5 TO 2.3 °C	3.0 TO 4.6 °C
Humid months	0.8 TO 1.6 °C	1.3 TO 2.6 °C	3.1 TO 5.2 °C

Chart 3.6: Increase of the precipitation in the different General Circulation Models (HADCM2. UKHI. GISSEQ) for the scenario IS92E in relation to the normal scenarios (1961-1990).

	2030		2050		2100	
AREA I						
Dry months	(-8) to 17%	(-8) to 13 mm	(-13) to 18%	(-13) to 19 mm	(-26) to 75%	(-27) to 41 mm
Humid months	(-14) to 11%	(-10) to 31 mm	(-20) to 16%	(-17) to 47 mm	(-35) to 33%	(-30) to 100 mm
AREA II						
Dry months	4 to 22%	0.2 to 2.4 mm	6 to 34%	0.3 to 3.8 mm	12 to 68%	0.6 to 7.7 mm
Humid months	5 - 16%	6 - 19 mm	7 to 25%	9 to 30 mm	10 to 57%	12 to 62 mm
AREA IV						
Dry months	(-5) to 19%	(-1) to 11 mm	(-7) to 30%	(-1.5) to 17 mm	(-14) to 61%	(-3.3) to 35 mm
Humid months	(-12) to 17%	(-5) to 30 mm	(-18) to 27%	(-8) to 48 mm	(-62) to 55%	(-30) to 98 mm
AREA V						
Dry months	(-13) to 21%	(-0.6) at 4.2mm	(-19) to 33%	(-0.9) to 7 mm	(-63) to 68%	(-1.8) to 14 mm
Humid months	(-8) to 22%	(-3) at 30mm	(-13) to 34%	(-4.4) to 63 mm	(-25) to 69%	(-9) to 127 mm

For bigger increases in temperature, the models begin to have adjustment and stability problems which is evident in the scenario IS92E for the years 2050 - 2100. However, for other scenarios, the values described by the models co-inside with the general tendencies of temperature and precipitation change.

All the scenarios show the same patterns in the increase of temperatures but this increase is almost parallel to the normal curve. In some cases, the models show bigger increases of temperature in the humid months.

For the precipitation changes, the absolute increase is also bigger in the humid months while in the dry months the variations are lower in absolute terms.

The patterns in the dry months estimate a decrease (negative values) in the precipitation values, mainly in the areas I, IV and V. The three established scenarios (IS92A, IS93C and IS92e) show decreases of precipitation in the months of June and July. This situation becomes worse due to temperature increases.

The three scenarios show a light tendency to change the months of precipitation to May and to extend the dry period until September or October. However, the scenario IS92E shows a tendency to decrease precipitation in the humid months (September and October) even in the areas I, IV and V.

It is difficult to carry out a comparison between both studies (PNCC, 1997 and SENAMHI, 1998) basically because there are different starting points. However, in general terms, similar patterns of behavior can be appreciated in the results.

The Amazon basin of the country, situated in the area IV, would present increases of temperature and precipitation reduction in the dry months. The basin of La Plata, situated in the area V, would also suffer an increase in temperature. The major differences in the investigation are related to the precipitation data regarding this area where one of the studies estimates precipitation reductions while the other one (SENAMHI) estimates increases.

Finally, in the high plain basin (Cuenca Altiplánica), the studies coincide, pointing out increases in temperature and precipitation in the rainy season.

The results of the investigation allow the conclusion that the application of the General Circulation Models with scale of grid 5º latitude - 5º longitude, do not provide great value information in the particular case of Bolivia where the topographical, physic and climate characteristics are very variable. In this sense, it is definitively necessary to develop new studies and methods in order to evaluate climate behavior more precisely.

Vulnerability and human adaptation

Gradually, there is more and more concern regarding the relationship of climate change with other processes of global change: air pollution, water contamination, fragmentation of the natural habitat, distortion of the hydrological cycle, decreasing biodiversity, agricultural and shepherding practices, urbanization, human migration, demographic growth, exhaustion of natural resources, introduction of species, etc.

At this time, it is impossible to predict the global climate change as a result of human activity. However, changes will occur and those that manage ecosystems for the production or reproduction of their cultures will have to adjust their strategies. It should be emphasized that the scientific community find bigger problems in the inadequate handling of ecosystems that in climate change.

A first step towards a qualitative approach to the vulnerability problem is that the regional changes in the habitability patterns can exacerbate the production mechanisms harming the poor population even more, especially those that depend strongly on agriculture. For this point the fragility of the productive apparatus should also be considered as it could be severely damaged by extreme events (droughts, floods, hailstorms, etc.).

However, the major uncertainty about the adaptability of societies to climate change seems to be related to the uncertainties regarding future technological change (patterns of industrial development and consumption and technological improvements that could help the mitigation or the adaptation for climate change). According to the U.S. Global Change Research Program (1995), technological innovations can improve greatly or exacerbate the mitigation and adaptation processes.

When revising the theme of human security during the development process and, specifically, during the process of adaptation to climate change, the roll played by the human capacities in the consolidation of the social and economic scenarios becomes more and more evident. These capacities influence the assumption of collective decisions delineating social processes and delineating goals and objectives.

In this sense, the social vulnerability is also associated to the incapability of managing the codes of modernity through communication and information, to the lack of capacities to demand and to propose norms to live more adequately, to the lack of social mobility and to the precariousness of people's economies.

In Bolivia, the Index of Social Vulnerability (ISV[3]) shows an accented rural poverty and huge inequalities in villages and cities with a large bio-geographic and ethnic diversity (Human Development in Bolivia. 1998. 35 - 39). It is also interesting to highlight the existent correlation (86.5%) between the Index of Social Vulnerability and the index of poverty (Human Development in Bolivia 1998. 38).

According to the ISV, almost 20% of the counties located in the biggest parts of the inter-Andean dry valleys have serious levels of vulnerability and risk. Only 10% of the counties located in this area have low levels of vulnerability (major towns and urbanized places). 70% of counties show medium levels of vulnerability especially in villages located in the eastern part of the country where there is a smaller population density (Human Development in Bolivia 1998. 39. 197-199).

Finally, it is important to underline the fact that the Index of Social Vulnerability is able to give an approximate idea of the people who are socially vulnerable to climate change and does not include environmental indicators in order to describe the deterioration of the productive bases (erosion, desertification, contamination) or other kinds of risks in the case of extreme events.

During the Intergovernmental Panel on Climate Change (IPCC), several authors concluded that the best way to obtain social adaptation for climate change is to strengthen the human capacities of people with the greatest necessities.

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3 The Index of Social Vulnerability (IVS) has been developed in Bolivia as a complementary study to those promoted by the UNPD in order to perceive the human security and the quality of life in the development processes. Five issues have been identify in order to describe the vulnerability of people to the pressures of the development : culture, habitat, education, economy and politics.

The urbanized areas are also an issue of interest when talking about vulnerability in regard to climate change, basically because there is a big dependence on resources regarding the productive periphery. Climate change could not only affect the provision of water and agricultural products, but collapse the markets and affect human migration.

The government of Bolivia outlines inside it's socio-economic politics the "fight against the poverty", as part of a strategy that points to the generation of social participation in order to produce economic resources that would be re-invested in human development.

The decentralization process is an important part of this strategy, basically because it is accompanied by mechanisms that tend to invigorate the municipal initiatives and to provide to the local authorities with the possibility of deciding the route of their self development, and to react with their own resources to emergencies and eventualities.

This process must be accompanied, anyway, by central mechanisms that could support technological changes through the investigation and the extension of technologies. The central systems should also promote surveillance mechanisms in order to maintain through different components an inter-connected system of civil defense.

Vulnerability of ecosystems

Bolivia is a country with a huge geographic diversity which is also expressed in the variety of climates and in it's orographic, geologic and hydrologic characteristics. The eastern side of the country is covered by big extensions of forests; from humid tropical in the north (among the parallel 9º and 12º of south latitude) to the subtropical dry forests in the Chaco (southeast of the country).

The forests are partially fragmented with big savannas and pampas that cover the entirety of the department of Beni, the northern side of the department of La Paz and the northern area of the department of Santa Cruz. In these areas there is also an important concentration of agricultural and cattle raising activities and human establishments distributed in an homogeneous way in the whole plain area of the country and especially concentrated in the area of Santa Cruz.

The Andean mountain range is also composed of different ecological levels, from formations of humid and subtropical forests of mountain (Tucumano-Bolivian formation) to cloud forests and high-Andean levels. The inter- Andean valleys are rather dry with scarce forests wastes. The valleys, dispersed along the whole Western Mountain Range are privileged places for agricultural production that keep the highest population densities in the country.

The western side of the country is composed of high plains, semi-arid to the north and arid towards the southeast. The north of the high plains, with a hydrological regime that favors agricultural production, maintains high population densities and intense economic activity.

In general terms, Bolivia does not have many investigations regarding the vulnerability of ecosystems to climate change and there are hardly any studies related to climate change scenarios carried out by the National Program of Climate Change in cooperation with the EPA US Country Studies and the Dutch Cooperation (MDSMA. 1997). This first experience is hardly the beginning of a large series of investigations that need to focus on detailed studies that could finally end in specific mitigation and adaptation measures.

The impact of climate change on savannas and grasslands has, as a result, changes in the precipitation patterns and increases in the frequency and intensity of fires. These changes will rapidly affect the composition of species favoring the incursion of grasses, and non palatable species (WWW. 1994. 43-47). Climate change also threatens to change the floor composition of the different regions and to increase desertification tendencies.

In the mountain ecosystems climate change is already perceptible in the global reduction of glaciers. A study carried out in Chacaltaya demonstrates that this glacier could disappear in the next 20 to 40 years (ORSTOM. 1998). The mountain ecosystems tend to receive less snow and to diminish their balance of water causing alterations that threaten the subsistence of some alpine and sub-alpine species.

Ecosystems like the cloud forests can also be very sensitive to climate change and the species that live in this area could be strongly affected by the increase in the temperature in their attempt to move to new ecological levels.

A climate scenario of tropical mountain could change by 38.6% in case of an increase of temperature of 2.5ºC and a precipitation increase of 10%. Scenarios with more temperature increases could even provide changes of 53% (WWF. 1994. 16).

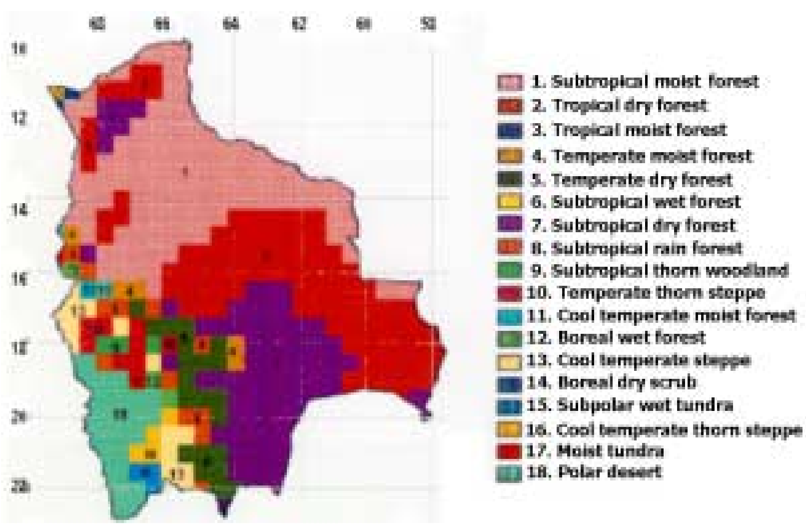
The first studies carried out in Bolivia show a big risk in many ecosystems, especially in those that have strong changes in their thermal and hydrological aspects. In this sense, it is important to continue the investigations and to revise the results of climate scenarios systematically.

Vulnerability of forests

The strong fragmentation of tropical forest generates “islands” with dissimilar types of floor and climate in which different species have difficulties in surviving emigration or adapting to new conditions of life (WWW. 1994. 49). In the scientific community, there is a big concern regarding risks that climate change implies to these types of ecosystems.

The National Program of Climate Change made an initial analysis regarding the impact of climate changes on the forest (PNCC, 1997). The study was based on incremental scenarios (simultaneous variation of temperature and precipitation) and included a doubling of CO_2 which applies to the Map of Life Zones of Holdrige[4]. (map No.4).

Map No 4 : Life Zones in the Holdrige Model



4 *The Holdridge Model is a representation in which the length of vegetation is combined with different climate variables: bio-temperature, average precipitation per year and evapotranspiration potential; creating a triangular system of coordination in which the zones of life can be determined through a series of hexagons. The model uses conventional data related to temperature and precipitation with a resolution of 0.5°x0.5° (longitude x latitude) for a normal situation of (1xCO2). Through this model and using the information provided by the different meteorological stations of the country, it was possible to obtain a precise distribution and classification of the vegetation considering the correspondent longitude and latitude and specifying the new scenarios. This classification has been translated into maps that allow the visualization of the kind of forests existent in different zones.*

Source: Institute of ecology (UMSA).

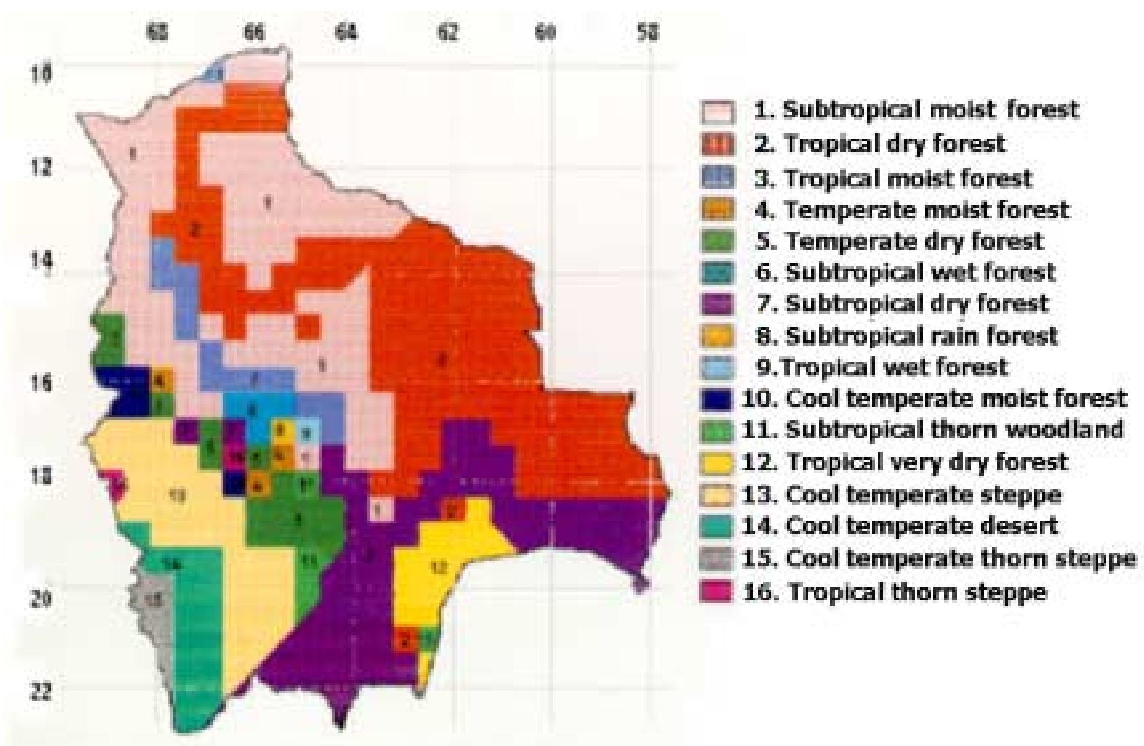
According to the National Program of Climate Changes (MDSMA. 1997.), an increase of 2ºC in temperature combined with an increase of 10% in precipitation, would cause an increase of tropical humid forest in 65.27% in detriment to the subtropical humid forest (59.72%). A similar scenario could also cause an increase of the subtropical dry forest in 3.79% (MDSMA. 1997. 88). In case of a decrease in precipitation (10%) combined with an increase in temperature (2ºC), a decrease of the subtropical humid forest is forecast as 81%. The tropical humid forest would not suffer any change but the tropical dry forest would increase by more than 300%.

The Institute of Ecology of the Universidad Mayor de San Andrés (UMSA) also establishes an analysis of change in the areas of life (Holdridge) taking into account the scenarios IS92a, IS92c and IS92e.

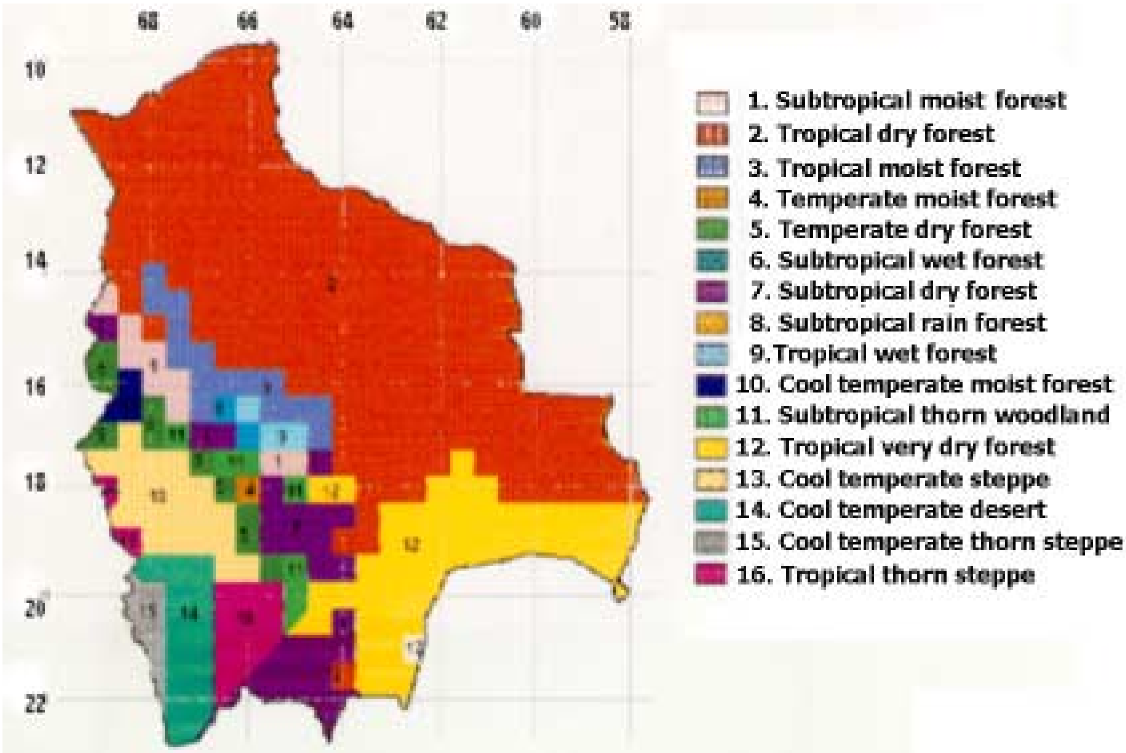
In the specific case of the IS92a base scenario, the study shows that the tropical humid forest and the cold temperate desert will be the less vulnerable areas and that the cold temperate thorny steppe will be the area of major vulnerability. Later on, areas like the subtropical pluvial forest could also be affected. (map No.5)

Map No 5: Variation in the areas of life in the Holdridge Model - Base scenario (IS92a).

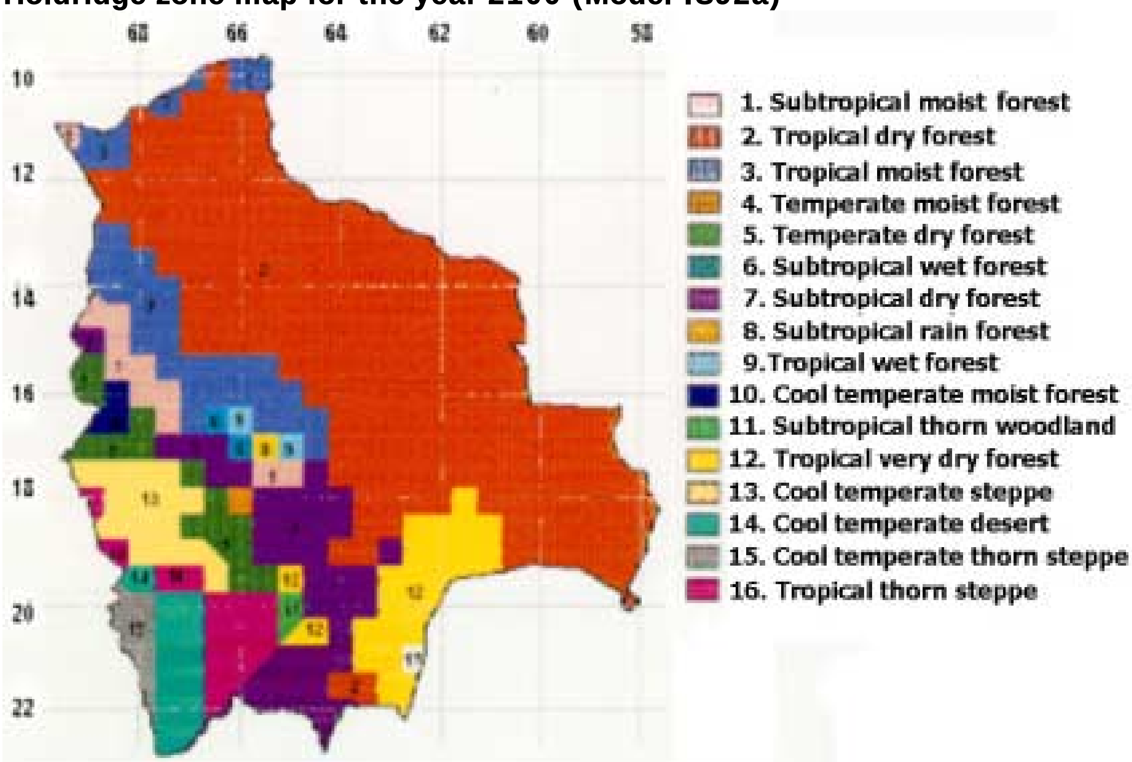
Holdridge zone map for the year 2010 (Model IS92a)



Holdridge zone map for the year 2030 (Model IS92a)



Holdridge zone map for the year 2100 (Model IS92a)



Source: Institute of Ecology (UMSA).

In the IS92c scenario (optimistic scenario) the changes forecast for the year 2010 would especially affect areas like the temperate cold desert, the cold spiny steppe and the tropical humid forest. However, for 2050, this scenario does not forecast any areas of high vulnerability.

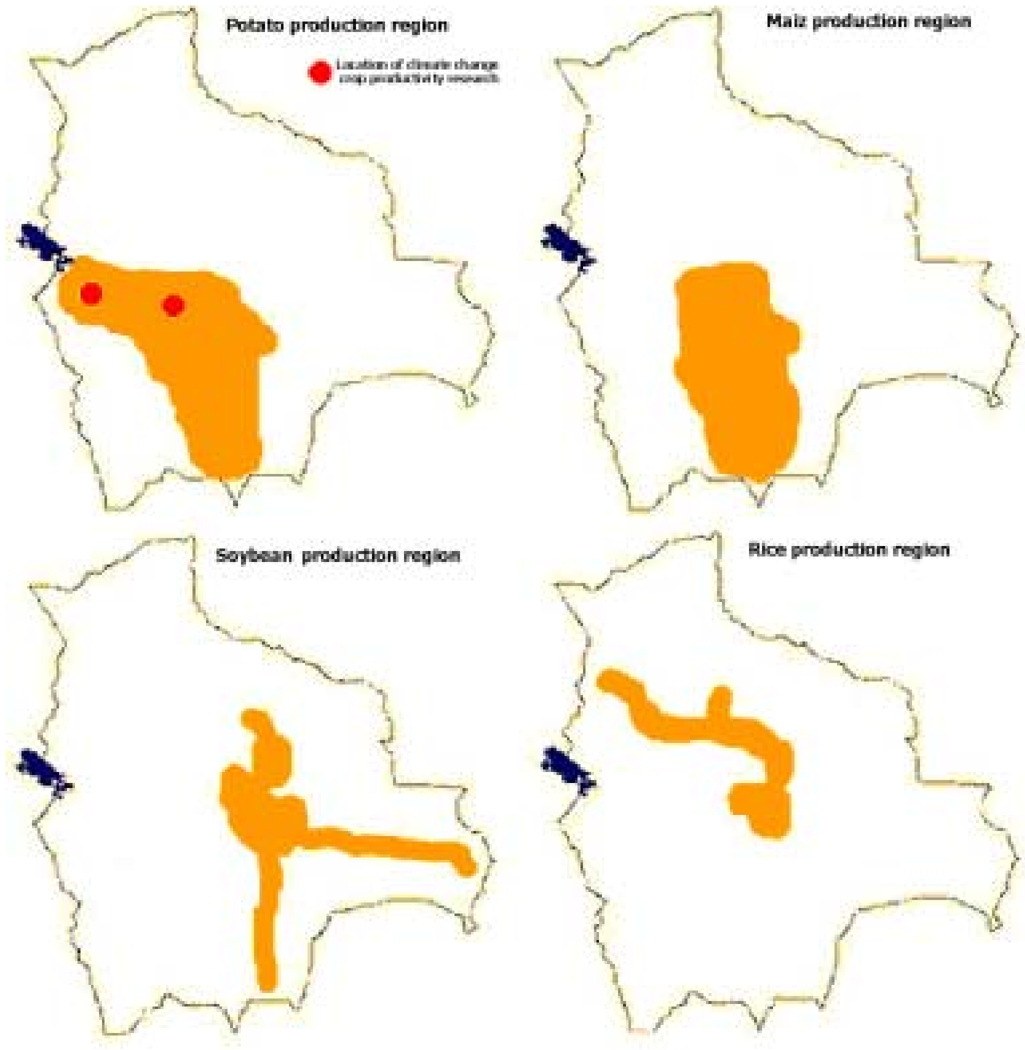
In the IS92e scenario (pessimistic) practically all the life zones seem to be vulnerable to climate change: the tropical humid forest, the temperate dry forest, the subtropical pluvial forest, the humid tropical forest, the subtropical spiny mount and the cold temperate desert where changes of almost 100% can be forecasted.

Vulnerability of the agricultural sector

The whole agricultural regions of the country would be affected by a probable climate change and certain areas can be considered more vulnerable than others, especially because of the risks of transformation in the vegetative cycle of cultivation. In the inter-Andean valleys, for example, there is tendency for a reduction in pluvial precipitation and an increase in the minimum and maximum temperatures. The high plain does not show variations in pluvial precipitation in this forecast, but a clear decrease in the minimum temperatures. In the tropical areas of Santa Cruz and Trinidad (east of the country), the maximum temperatures tend to be constant or to suffer a slight decrease.

The vulnerability studies related to climate change in the agricultural ecosystems of Bolivia show that an hypothetical elevation of the temperature (up to 2° C), could cause a serious damage to the ecosystem. If this hypothetical temperature increase were accompanied by increases of precipitation (even in the high plain area) it would favor the development of cultivation, eespecially if these changes are complemented by adaptation options like the incorporation of watering systems and improvements of cultural activities. Finally, a decrease in the precipitation without increases of temperature would cause catastrophic effects, not only in a direct and immediate way but also with long term serious consequences in an irreversible deterioration of the ecosystem.

Map No 6 : Map of the different cultivations by region: potatoes, maize, soya and rice.



Source: National Program of Climate Change

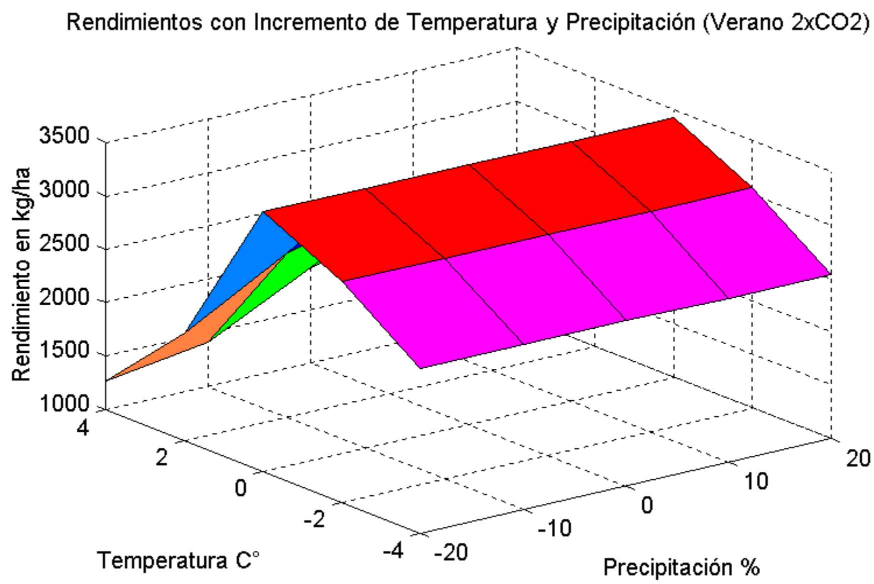
Specific studies related to the vulnerability of certain cultivations regarding climate change in Bolivia have been developed in the country by the National Program of Climate Change (PNCC 1997) and the Institute of Agricultural Investigations (UMSA, 1999).

The cultivation of irrigated maize (zea mays) in the valleys presents a high physiologic sensitivity to climate change. A clear decrease in the production is forecast under 14 climate scenarios using different General Circulation Models. In the GISS and the UK89 the decrease was estimated as being 25% in spite of an increase of carbon dioxide. The cultivation of non-irrigated maize showed different results. In this case the production increases up to 50% in all climate scenarios in which an augment of temperature, precipitation and doubling of carbon dioxide was shown.

The cultivation of soya (glycine max) in the tropical area of the country, and in the integrated area of Santa Cruz specifically, also presented physiologic sensitivity to climate change. For winter, under the IS92a scenario proposed by the IPCC, the vulnerability analysis showed reductions in production of 3.3% and 9.8% for the first and second decade respectively. However, a doubling of CO2 in the mentioned scenario would increase the production to 59% and 58% for the first and the second decade.

During summer a decrease in the production (18.6% and 19.6%) is forecasted for the first and second decade. A doubling of CO2 would produce increases of 13% and 12% for the first and the second decade respectively.

Graph N° 3.5: Soya production with variation of temperature and precipitation. Summer (2xCO2)



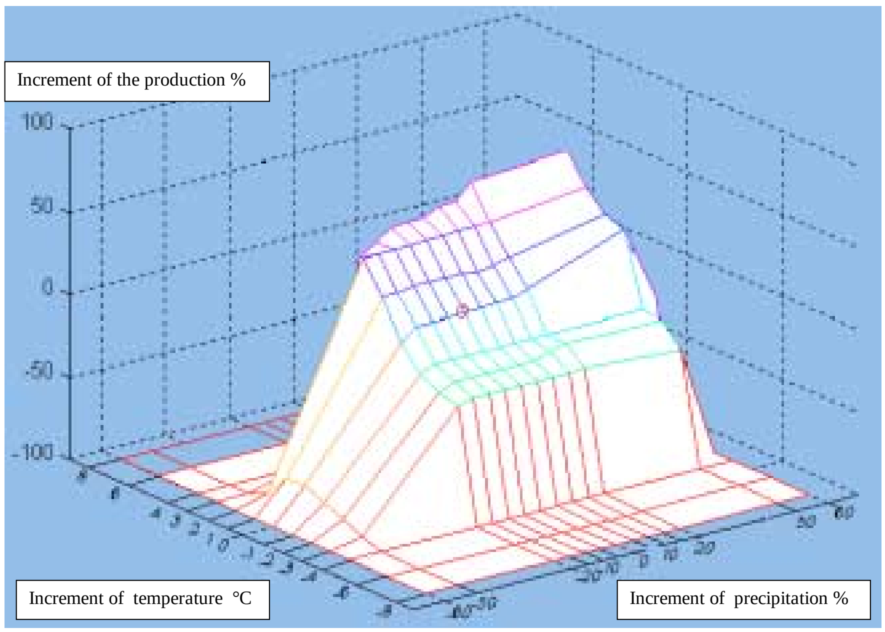
Source: Institute of Agricultural Investigations (UMSA).

In Bolivia's tropical area, the studies of vulnerability have shown that the cultivation of rice (oryza sativa) would suffer a slight influence due to climate change. Under climate scenarios generated by the Model GISS and UK89, the difference in the production represented no more than 2%. The incremental climate scenarios have shown that a reduction in precipitation of 20% plus an increase of temperature of 3°C could cause a decrease of 15% in the production of this crop. A doubling of the carbon dioxide is not relevant for this crop if there is reasonable precipitation level, even in cases of substantial elevations in temperature. In this case, the increase in production does not exceed 5%.

Regarding the potato crop (solanum tuberosum), the studies have shown the sensitivity of this product to climate change in the high plains (Altiplano) as much as in the valleys (Graph 3.6).

Under the optimistic and pessimistic scenarios generated by MAGICC, the production of potato is increased between 4.6% and 1.7% every 10 years. The production increases additionally between 6.6% and 4.6% in case of a CO2 doubling to 660 ppm.

Graph 3.6: Potato production (%) related to variation in temperature and precipitation.



Source: Institute of Agricultural Investigations (UMSA).

Vulnerability of livestock and grasslands

The results of the vulnerability studies carried out by the National Program of Climate Changes established that the bovine livestock and grasslands would be affected by probable climate changes.

The increases or decreases in weight of bovine livestock in climate scenarios that do not suffer a doubling of CO_2 (330 ppm CO2) are not very significant but the doubling of CO2 in the incremental scenarios causes a considerable decrease in the weight of the bovine livestock.

This decrease is also related to the origin of the livestock and the studied area. The Creole livestock that belong to the areas of Beni (Estación Espíritu) and Santa Cruz (Estación Saavedra) lose an average of 12% and 9% of their weight respectively. The zebu livestock in the same regions lose between 15% and 11% of their weight.

These results basically show that the Creole livestock are better adapted to climate change than the zebu livestock, especially if we consider parameters as fertility, longevity and resistance to disease.

The incremental scenarios with double CO_2 concentration and increases of temperature that exceed 4°C cause very significant loss of weight in the animals (16% in the Creole livestock and 19% in the zebu livestock in the area of Beni). In the area of Santa Cruz, these rates reach 14% for the Creole livestock and 8% for the zebu. In the case of an additional decrease in the precipitation levels, these weight losses could total 20% in the Creole livestock and 13% in the zebu.

The grass production would also be affected by climate change and it has been observed, that the production is increased where there are increases in precipitation and temperature. The productions tends to be bigger in incremental scenarios of +2°C and +10 % precipitation but, in general, the levels of increase are basically related to the grass type and the region. The biggest increase was observed in the case of the Kudzu (pueraria phaseoloides roxh) in the area of Beni and the smallest increase in the short grain rice (leersia hexandra swartz) in the area of Santa Cruz.

Vulnerability of water resources

The changes in the supply of water due to modifications in the patterns of rain and temperature can severely affect tropical forests. In some places, the decrease in ground dampness could reduce forests and increase savannas, mainly in places where the supply of water is marginal (high reliability). In areas where high levels of precipitation are forecast there are important risks of erosion due to the inability of forests to satisfy the required evaporation (Cannell. M.G.R.. et al. 1995).

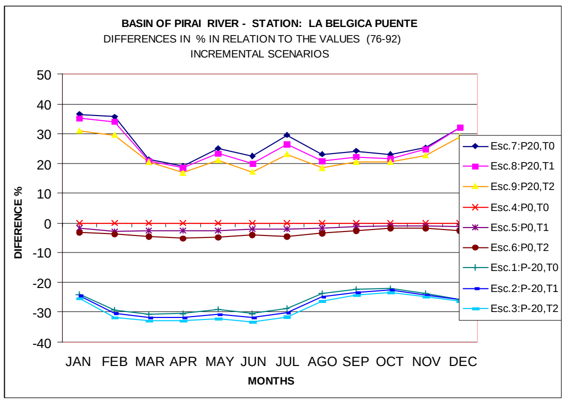
Increases in temperature of up to 1.4 °C and an increase in precipitation could also overload the ecosystem affecting the hydrological pattern in the region of the Chaco (south of the country) affecting the damp soils of the region and its fauna.

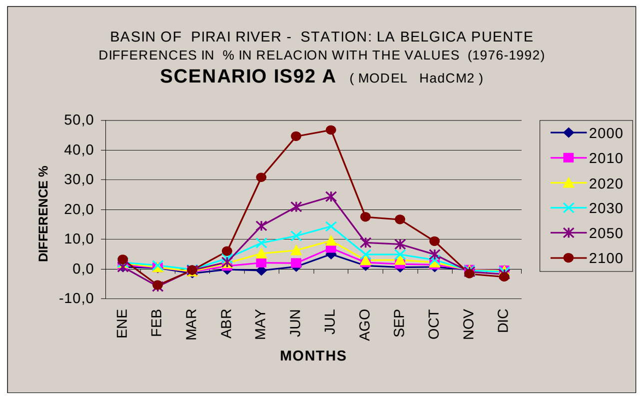
On the other hand, basins like the endorreica, that show an integral deficit in the hydrological balance, could benefit in the case of an increase in precipitation in the northern part of the high plain. This fact, however, must be observed and documented through new studies.

The increment in the temperature increases the evaporation / transpiration levels (even if we take into account the high values of solar radiation in the basin). At the same time, changes in the hydrological patterns can have effects on the level of water erosion and in places where the evaporation / transpiration is stronger, the effects of climate change could even cause high salination levels and aridity of the ground increasing the level of wind erosion (medium reliability).

Studies related to the vulnerability of water resources to climate change (PNCC 1997, Institute of Hydraulics and Hydrology UMSA, 1999), demonstrate important variations in the levels of leakage which change according to the considered climate scenario (incremental, IS92A, IS92c and IS92e) and according to the basin under analysis and the location. (Graph 3.6)

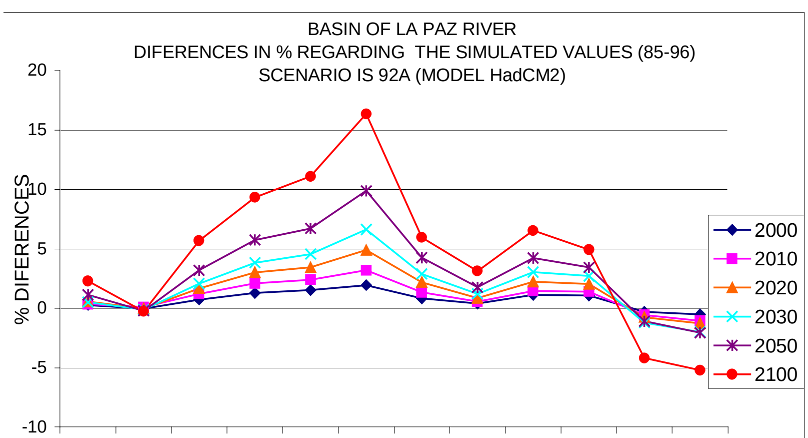
Graph 3.6 Water level variation regarding the "base period" over several years. Incremental scenario and scenario IS92a. **Basin of Pirai River.**



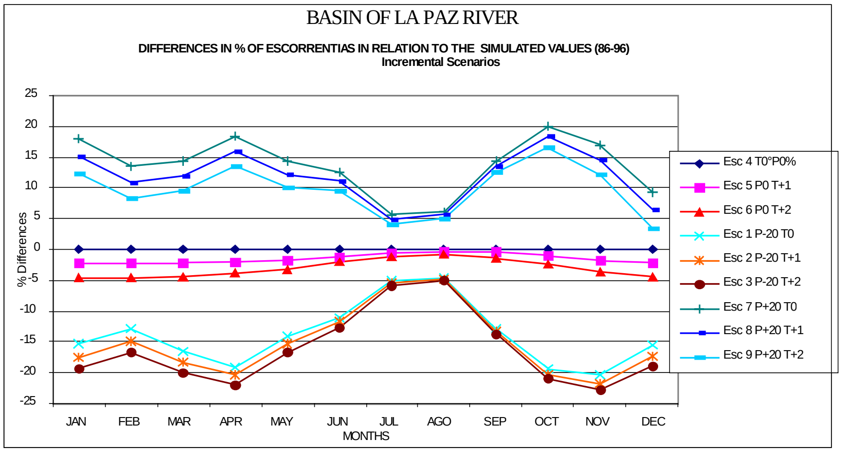


Source: Institute of Hydraulics and Hydrology (UMSA).

Graph 3.7 Water level variation in the basin of La Paz river (incremental scenario and scenario IS92a).



Source: Institute of Hydraulics and Hydrology (UMSA).



We can conclude that the basin of the La Paz river (west of the country) is vulnerable to the problems of supply and demand and also vulnerable to flooding and erosion caused by precipitation of high intensity (Graph 3.7). The basin of the Pirai river (to the east) is only vulnerable to floods.

The first studies point out that the different basins would be vulnerable in the eventuality of climate change, especially in the period of growth (this fact does not take into account the future demand of water resources).

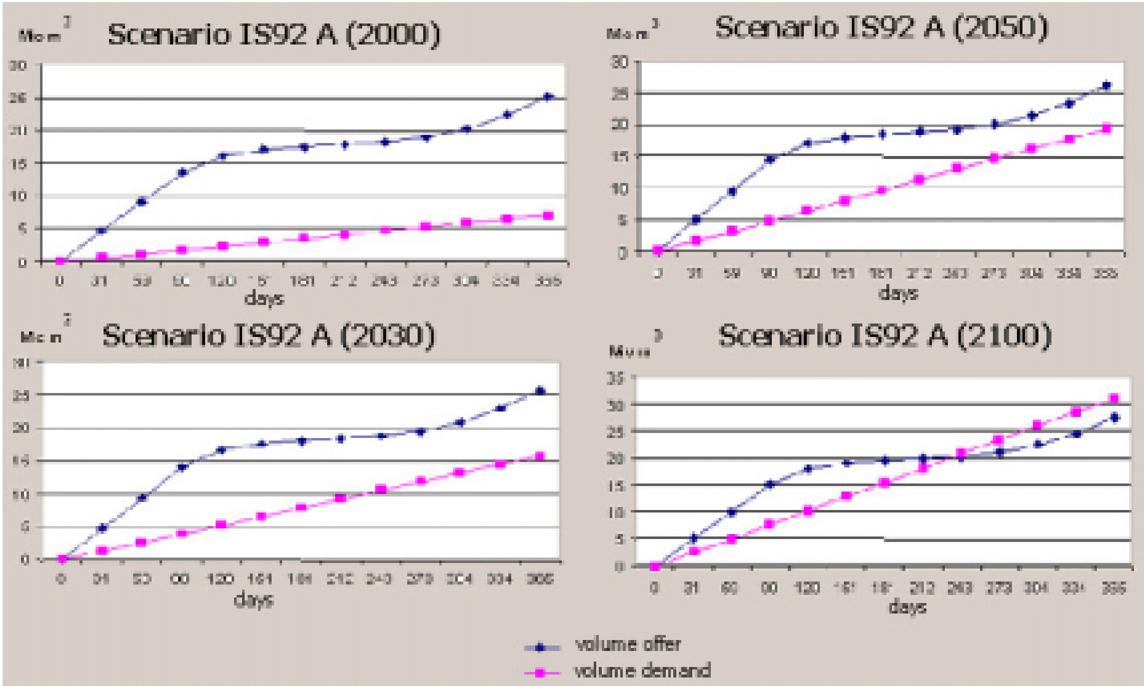
Considering the relationship between the population growth, the increase of the Gross National Product, the increase of the alimentary demand and the industrial growth with the demands of water for consumption, irrigation and industry; it is possible to deduce that the only hope for obtaining sources of water is based on climate change and it is natural to infer that a negative impact caused by climate change will affect the volumes on offer in the future.

In the vulnerability studies projections have been made regarding relationship between the supply and demand of water in the different basins, in order to have a valid indicator of the vulnerability of this resource.

In the sub-basin of the Hampaturi that belongs to the basin of the La Paz river, studies show difficulties in satisfying the demand for water of a growing population. By the year 2030, the capacity for satisfying demand would be insufficient and it would be necessary to have a higher capacity (4 Hm3) in order to assure consumption demands.

For the year 2050, the situation would be critical since the capacity to satisfy demand in a regular way, and without interruptions, would require a supply of 5 Hm3. Finally, in 2100, demand would definitively exceed the supply of water since the required annual volumes would exceed all supply possibilities. The variation among supply and demand can be appreciated in the graph. Nº 3.8.

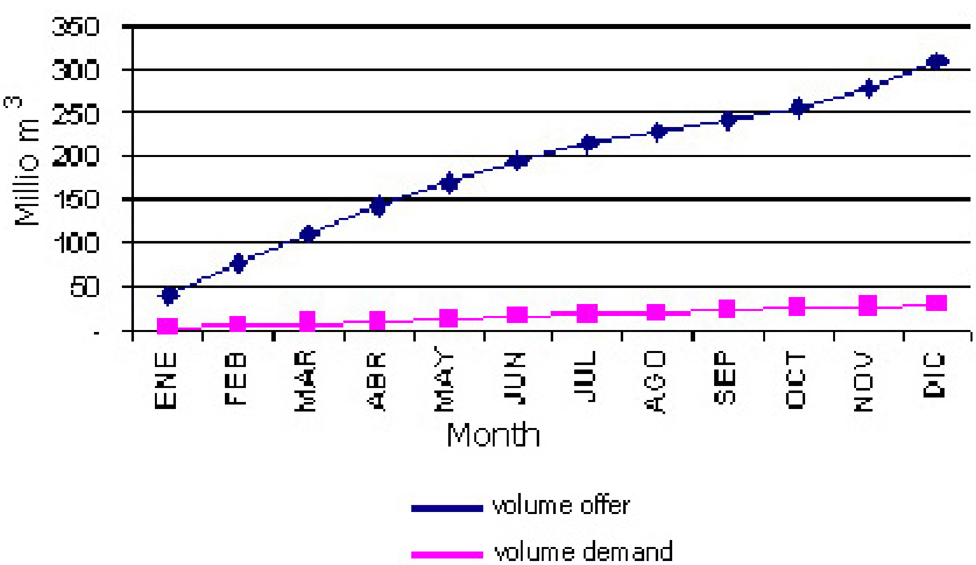
GRAPH 3.8 – VOLUMES OF DEMAND AND SUPPLY IN THE HAMPATURI BASIN



Source: Institute of Hydraulics and Hydrology (UMSA).

In other basins, the increase in the course of the rivers could cause floods as shown in the basin of the Piraí river. In this case the supply would exceed demand. (Graphic No.3.9.)

GRAPH 3.9 BASIN OF THE PIRAI RIVER – “LA BELGICA” SCENARIO IS92c - 2100



Source: Institute of Hydraulics and Hydrology (UMSA).

All these changes could favor or disfavor the handling of water resources in the future. However, the difficulty of projecting an annual variability is a limit to the interpretation of the vulnerability in the basins in case of extreme events.

We can also conclude that the results obtained in the basin of the Hampaturi river are a good example for generalizing the situation in the high plain, a region basically characterized by an accented deficit of water resources.

In a similar way, the results obtained in the basin of the Piraí river, can also be extrapolated to other flat regions in the east of the country where the supply would exceed the prospective demand, and where the characteristics of the land are also susceptible to changing the course of rivers, causing overflows in periods of excessive water.

Vulnerability of human health

The increases of temperature and the variability in climate change (which are the first indicators of the world climate change[5]) are making clearer their sanitary effects, which can be observed in the incidence of emergent and re-emergent illnesses

The effects on the human health (classified as direct and indirect), can easily be detected: the floods in Santa Cruz, landslides in La Paz, fires in Guarayos - Santa Cruz and storms in Cochabamba are examples of how natural disasters can directly influence increases in mortality[6]. There are also damages that do not affect the population directly, but in an indirect way. The quantitative increase of transmitters, for example, amplify the risks of illness in the inhabitants of the affected areas.

Considering the national sanitary profile, where there are important transmitted pathologies, it was necessary to study the influence of climate changes on human health and that is why different topics related to this issue were studied: a) climate and it's variability b) the subsequent ecological changes, c) the dynamics of human illnesses, d) human habitat, and e) the socioeconomic profile of the area (in order to have a complete panorama of climate change impact on human health).

Region I, composed of the departments of Pando, Beni and the north of La Paz, was chosen by the National Program of Climate Change, in order to study malaria (originating from the plasmodium falciparum and the plasmodium vivax) and leshmaniasis; two typical illnesses of that region that would allow us to investigate the effects of climate change on human health. A correlation between the I.P.A [7] index and leishmaniasis was made for the municipalities.

[5] *Climate Change and Human Health WHO, WMO, UNEP*
[6] *Illness and death*
[7] *The Parasites Annual Index measures the level of risk for each thousand inhabitants exposed to contract malaria.*

The methodological work was supported by the use of databases consistent in annual and monthly reports of the total malaria and leishmaniasis cases[8] registered since 1959 to 1998. Climate data [9] was obtained from the National Service of Meteorology and Hydrology (SENAMHI) [10] and from (AASANA) (1960 to 1998). The work was carried out on the IS92a climate scenario, the base line was 1961-1990 and the period 1991-1999 called "current climate", was used in order to adjust the models [11] and to analyze the current and future climate variability. Finally, the correlation between climate and sanitation was interpreted using the Ortiz[12] method.

The investigation had the following results:

- There is a maintenance of the medium climate conditions in the area of transition for the "base line" and for the "current climate". However, there is an increase in temperature in winter and this pattern is projected from the "current climate" until the 2010 scenario.

- Malaria is sensitive to the variations and changes of climate patterns and shows marked differences between the "base line" period of the "current situation".

- Cases originating from the plasmodium vivax in the period 1990–1999 show an increase of incidence between April and June with an important peak in May. The uni-modal character of the plasmodium is demonstrated in the graph. 3.10.

- The malaria originated by the plasmodium falciparum is bimodal[13] (as appreciated in the graph 3.10) and it has two incremental periods that go from March to June and from October to November with periods of remission in the rest of the year. The cases originated by the plasmodium falciparum are particularly important because the illness produced by this agent has a high mortality.

- Climate can favor the development of malaria by 27% on average (11.3% for the plamodium vivax and 43.6% for the plasmodium falciparum) if it is combined with other decisive conditions. An increase in the incidence of this illness has also been observed since March 1993 in the case of the plasmodium falciparum and since April 1994 for the plasmodium vivax.

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[8] Data related to malaria and leishmaniasis was obtained from the National System of Health Information (SNIS) and from the National Program of Malaria and Leishmaniasis (Ministry of Health and Social Forecast).

[9] Medium temperature (TM), Minimum media temperature (TN), Maximum media temperature (TX), Relative humidity (HR), Pluvial precipitation (PP) and Oscillation of 11 meteorological stations (OSC).

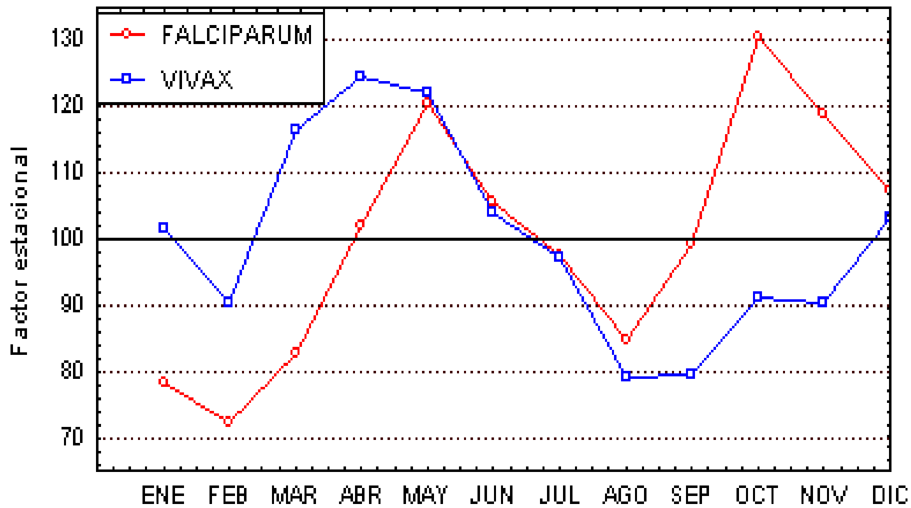
[10] The data obtained from this institution is incomplete and that is why the series had to be completed and a coherent analysis had to be made.

[11] Paolo Ortiz (1998) Havana – Cuba.

[12] Ortiz Model (1998)[12], is based on the use of empirical-statistical models in order to describe and forecast illnesses considering the influence of climate.

[13] Current Climate

Graph No. 3.10 SEASONAL MOVEMENT OF MALARIA CASES PRODUCED BY THE P. FALCIPARUM AND P. VIVAX - REGION I (1990–1999).



Source PNCC.

- In the studied region, malaria originating from plasmodium vivax (according to the IS92a scenario) will show a clear effect on the seasonal variation for the year 2010 and a clear accentuation (a pick) in the months of April and May. These results are in agreement with the current climate conditions (see graphic No.3.11).
- According to the projections made for 2010, the malaria originating from plasmodium falciparum (scenario IS92a) will intensify and the seasonal pattern will vary becoming tri-modal. A maintenance of the pick April–May is forecast but a first pick in January is also forecast as a displacement of the third pick of October-November to August – September (see graphic No. 3.12). In other words, the disease will not only intensify but will vary it's seasonal patterns as a consequence of the variations in climate.

Graphic No.3.11.BEHAVIOUR OF CASES PRODUCED BY THE P. VIVAX IN THE "BASE LINE" , "CURRENT SITUATION" AND PROJECTION FOR 2010

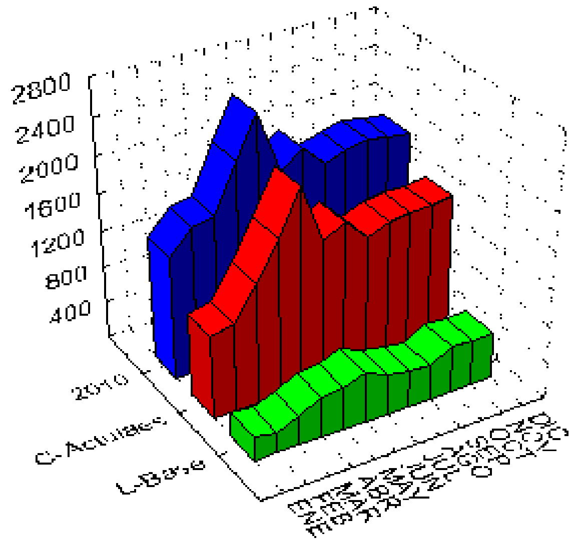
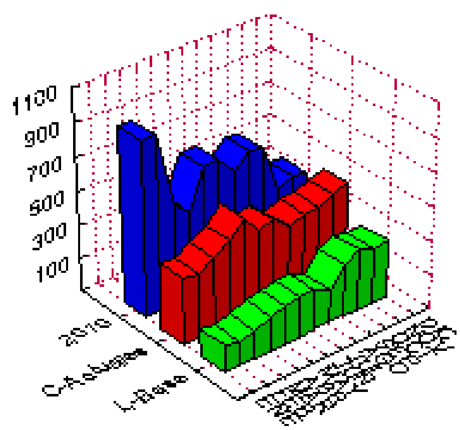


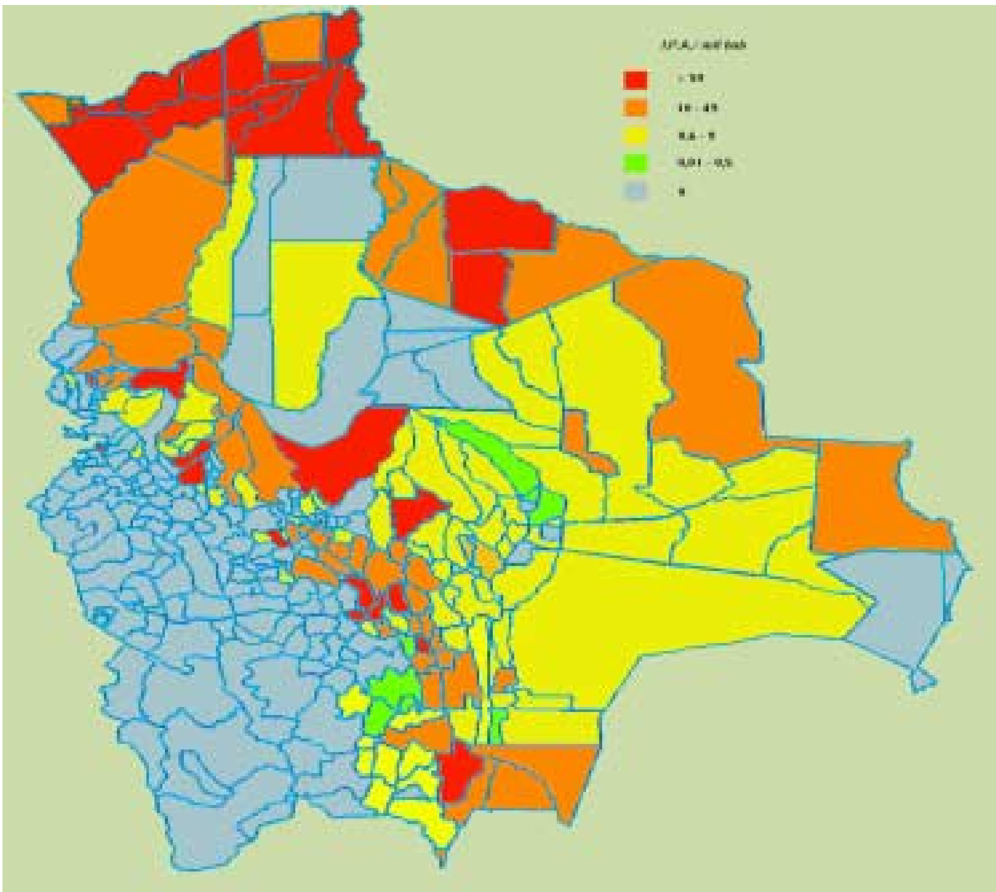
Fig. No. 3.12. BEHAVIOR OF THE PRODUCED CASES FOR P. FALCIPARUM BASE LINE AND CURRENT SITUATION - PROJECTION FOR 2010



- The high rates of migration to the cities that belong to the studied Region (Guayaramerín and Riberalta), which have the highest Annual Parasitic Indexes (I.P.A), constitute an important risk factor in the incidence of malaria in the region, where there is a high dissemination probability to the rest of the country through temporary migrants.

- The analysis of the endemic and the hyper-endemic malaria is a problem relating to almost 100% of the municipalities of the 7 departments of Bolivia, especially to those regions characterized by high humidity. This can happen even when the temperatures are not too high, as in the case of the sub-Andean area of Bolivia where hyper-endemic municipalities have been discovered (map No.7).

Map No.7 PARASITE ANNUAL INDEX FOR MALARIA IN THE DIFFERENT MUNICIPALITIES - BOLIVIA 1998



Source: PNCC - Elaboration based on data provided by the MSPPS

- One of the most astonishing results of this investigation was being able to find a hyper-endemic region at 4000 meters above sea level of the sea. Puerto Pérez, situated in the Department of La Paz, has a Parasite Annual Index of 152.94 /1000 inhabitants. This is a topic that should be deeply investigated in the future.

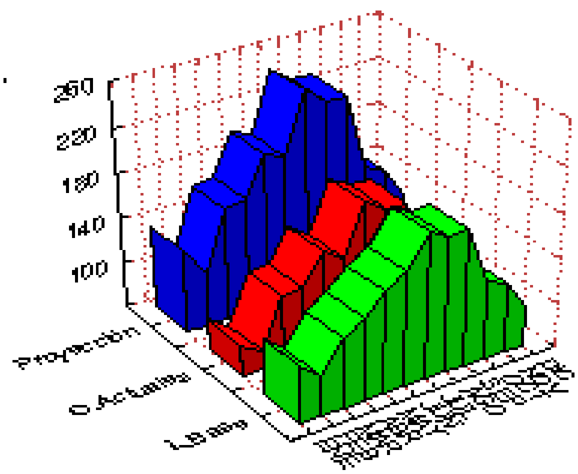
- The regions with high incidence of malaria (hyper-endemic) are characterized by high humidity, important pluvial precipitations, existence of different sources of stagnant water that favor the development of malaria and a temperature that does not have to be necessarily high[14]. This result is correlated to climate variables established in the Index of Bultó.

[14] It is important to notice that the minimum temperature in which the parasites and vectors can survive are as low as 20º C. This data is supported by the temperatures registered all along the sub-Andean zone of Bolivia where hyper-endemic zones have been found.

- The colonization of tropical areas by inhabitants, that proceed from the high plains is another risk factor for diseases transmitted by vectors. This is because people that arrive to those areas are adapted to another atmosphere and therefore to other epidemic profiles.

- The displacement of the tropical humid forest and the subtropical humid forest to the tropical dry forest, provides an appropriate habitat for vectors that transmit malaria. This increases their geographical expansion in outlying areas.

GRAPH 3.13 - BEHAVIOR OF CASES PRODUCED BY LEISHMANIASIS
(BASE LINE - CURRENT SITUATION AND PROJECTION FOR 2010)



With relation to leishmaniasis, the study detected the following results:

- The picks of leishmaniasis coincide clearly with the periods of the year in which the studied Region [15] receives a big quantity of occasional emigrants due to crops and land clearing work. Leishmaniasis, in this sense, should be considered as an occupational illness. The phlebotomus attacks very close to the ground so, activities like the felling of trees, clearing of cultivation land and shepherding increase the possibilities of risk.

- The results of the investigation (see graphic No 3.13.) demonstrate that leishmaniasis has a high vulnerability to climate change (especially increases in humidity and temperature). Incidences of leishmaniasis are accentuated from July to September and the highest pick is registered in August (when the region becomes hotter) according to the projections carried out for 2010.

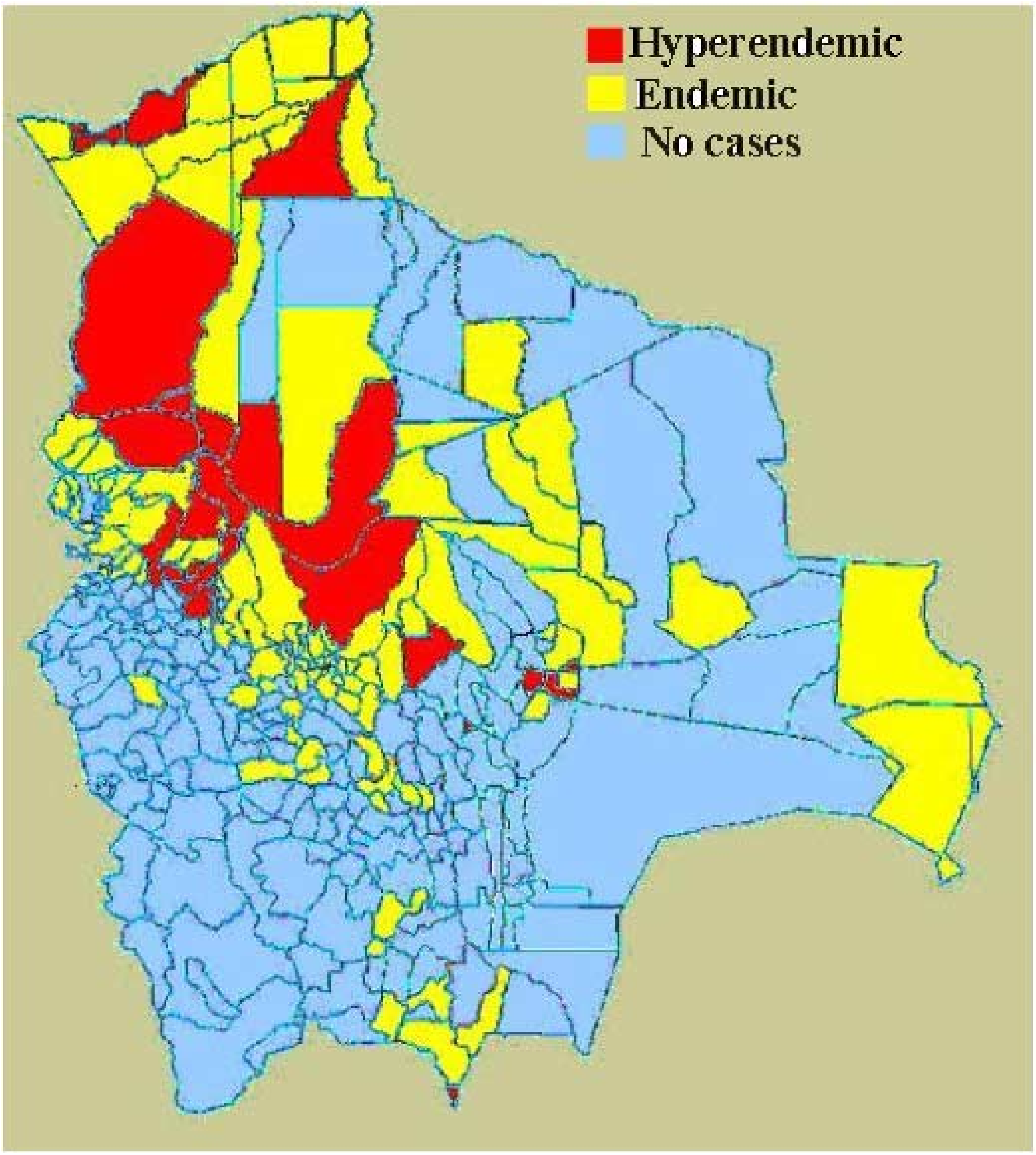
- The analysis of endemic levels of leishmaniasis shows a strong influence on the municipalities located in the regions of Yungas, the humid areas of the sub-Andean region, the flooded savannas of Beni, the damp temperate forests of Santa Cruz and the very damp temperate forests located in the south of Tarija.

[15] March – April and August - September

- There is an important correlation between the cases of leishmaniasis and the towns located along the highways that cross the country, especially in the routes that belong to the north and the northeast of the country.

- There is a high correlation between the indexes of poverty and the municipalities affected by leishmaniasis (see map No.8.). It is possible to suggest, in this sense, that poverty generates lower immunity levels which is a serious risk factor in the development of this disease, particularly in cases of visceral leishmaniasis.

Map No.8. LEISHMANIASIS AT MUNICIPAL LEVEL - BOLIVIA 1998.



Source: PNCC - Elaboration based on data provided by the MSPPS

- The increase in temperature and pluvial precipitation (damp) in the studied region tends to increase the number of vectors, the geographical extension of their habitat and, of course, the cases of malaria and leishmaniasis. This occurs in traditional and new areas of vector occupation, where the incidence of cases will be particularly important due to the low immunity developed by the inhabitants.

- Even when climate must be considered as a whole, it is important to say that the pluvial precipitation, followed by the relative dampness and the minimum temperature, are climate factors with high influence on the vulnerability of human health (as in malaria cases).

"El Niño" Southern Oscillation

Like many other countries, Bolivia has also experienced the effects produced by "El Niño" . Since 1983, the country has suffered increases in drought and floods. In this sense, it is possible to affirm that climate change is causing an important incidence in the effects of "El Niño" since it has been occurring with more frequency and higher incidence in the last years.

In the last decade, extensive areas of valleys and high plains in Bolivia have suffered droughts that have caused the loss of enormous resources (crops and livestock). At the same time, the regions that belong to the east of the country have suffered floods with the consequent loss of crops, livestock and inhabitants' forced migration.

It was also shown that "El Niño" was accompanied by increases in precipitation in the east and droughts in the west. In some cases, "El Niño" also was responsible for escalation in hailstorms in the inter-Andean valleys.

Other marginal effects of this phenomenon are related to extreme winds (that, in some cases, do not belong to the circle of the tropical hurricanes) and fires in places with a tendency to droughts which cause serious damages in the forests (medium reliability). The cyclonal season of the eastern Pacific (from June to November) must also be mentioned as a threat affecting the heating of the sea, the pockets of air and the action of "El Niño". The cycle is extended from January to May, generating a cyclonal season of 12 months.

ADAPTATION

Adaptation measures for the forest sector

The National Program of Climate Change, that belongs to the Environment, Natural Resources and Forestry Development Vice-ministry (MDSMA. 1997, MDSP.2000) has set down, in it's initial studies, the following strategic features in the forest sector:

- Sustainable use of forest
- Improvement in the inhabitant's quality of life

- Elevation of efficiency in the industrialization processes
- Development and growth of the sector

The mentioned features need the following adaptation measures:

- To identify species that can tolerate climate change.
- To reduce fragmentation of habitat.

The National Program of Climate Change (MDSP. 1998) also includes the possibility of improving forest use as a measure of adaptation to climate change.

Other specific measures relating to the reduction of emissions have been considered as mitigation measures. Some of these measures include technological changes or modifications of cultural practices.

Adaptation measures in the agricultural sector

Different adaptation measures have been outlined by the National Program of Climate Change (PNCC,1998) in order to prevent and reduce the negative effects of probable climate change, especially on crops which have economic importance and relate to the population's alimentary security.

- Management of land and water
- Agricultural investigation
- Interactive transfer of technology

These measures maintain a narrow relationship with the government's Economic and Social Development General Plan, where it has been written that “preservation of the national dignity and sovereignty relates to consolidation of alimentary security through the development of an agricultural-alimentary system that could become a fundamental axis in the fight against poverty".

In the grassland and livestock sectors, the following adaptation measures were proposed:

- identification of resistant grassland
- introduction of native grassland
- introduction of new livestock
- migration
- changes in the shepherding cycles
- supplementary diets.

Adaptation measures for water resources

The studies of sensitivity carried out by the National Program of Climate Change (MDSMA. 1997) do not only propose different measures of adaptation but they also revise the effectiveness of them. The following is a list of adaptation measures proposed in this area:

- Coordinated planning of the use of water in the different basins
- Construction of regulation, irrigation and storage works
- Adoption of conservation politics
- Control of water quality
- Systems of controlled and remunerated supplies
- Adoption of contingency plans
- Operations that could allow the transfer of water to intermediate basins
- Systems for forecasting floods and droughts
- Training and education in the management and consumption of water.

Measures of prevention and adaptation for human health

Different adaptation measures were identified in order to tackle the impacts of climate change on human health:

- Care of the environment
- Chemical control
- Reservoir control
- Biological control
- Reduction of the vector contact
- Community participation
- Epidemiological / climate surveillance
- Sanitary education

The implementation of these measures require the fulfillment of the following lines of action:

- To deepen the knowledge regarding the impact of climate change on human health.
- To carry out studies on human health vulnerability to climate change.
- To spread the knowledge of different sanitary projections in relation to climate scenarios proposed for the Region I.
- To study the application of new control measures and vectoral elimination (the biological control, for example).
- To incorporate in the Health Subsystem Information the monitoring of certain environmental parameters (climatological and entomological)
- To set down a system of epidemic surveillance that incorporates vectoral and climatological parameters.
- To motivate the varied groups related to health (municipal and departmental health organizations), to incorporate aspects of the impact of climate change on human health, to their politics, strategies, operative plans and activities.
- To develop plans and actions between all the groups suggested in order to allow the Ministries of Sustainable Development and the Ministry of Health and Social Forecast, to develop programs of prevention in endemic areas, regions

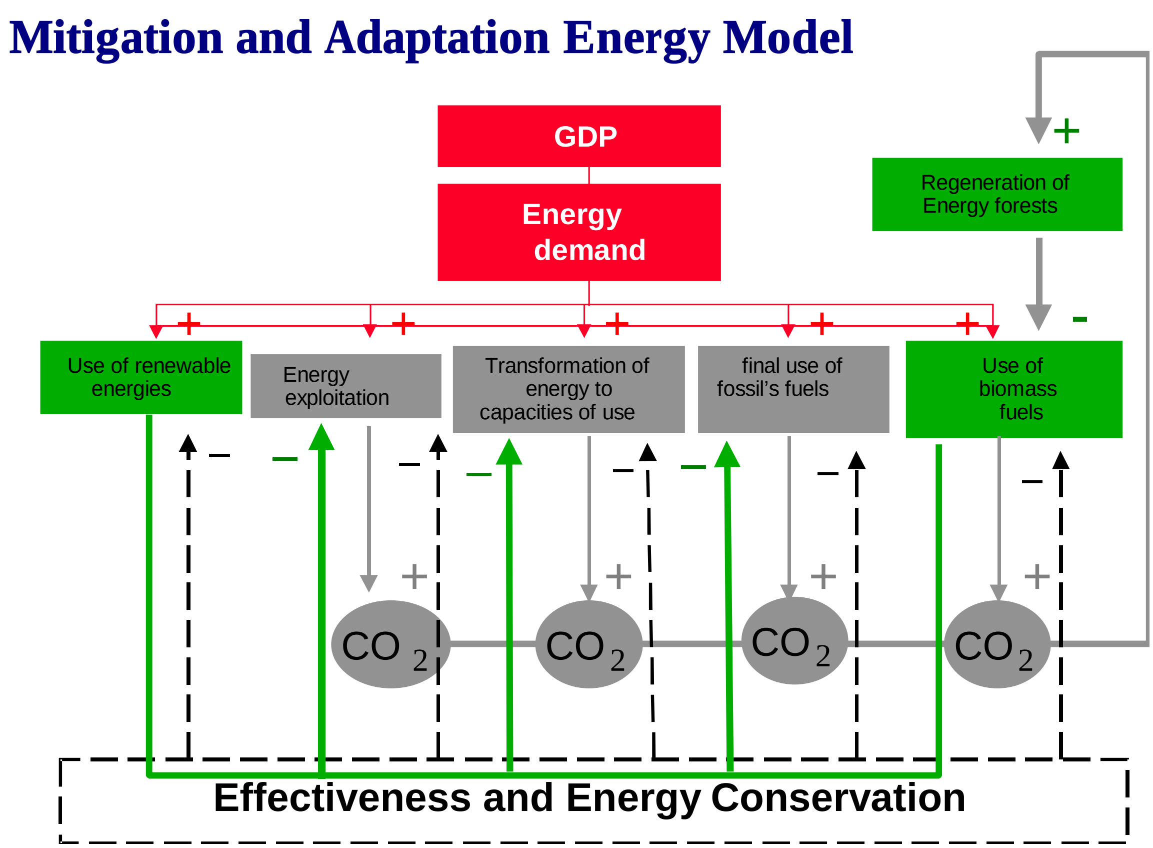
dedicated to colonization and in places where development projects are being held.

- To carry out studies of cost-efficiency and cost-benefit for each method of vectoral control
- To prioritize the areas of malaria and leishmaniasis, identifying the predominant vectoral species.
- To prioritize community participation in the control of malaria and leishmaniasis at municipal level.
- To carry out entomological studies in the vectoral habitat in order to characterize and identify these areas, to determine the best biological agent for their control.
- To improve the level of education (especially for operative personnel) in subjects related to climate influence, the vector's behavior and the population's dynamics.

- To strengthen local and departmental health networks in order to carry out united actions, to respond with efficiency to the direct (droughts, floods, storms, etc.) and indirect (increase in health service demand) effects of climate change.

CHAPTER IV

PROJECTIONS, PLANS AND MEASURES



Mitigation options and their cost

The mitigation of greenhouse gas emissions in the energy sector are delineated by three points which basically relate to improving supply, energy uses: (1) Improving the effectiveness of energy consumption, (2) Converting to energy sources with less carbon, and (3) increasing the use of renewable energy.

ANALYSIS OF MITIGATION IN THE ENERGY SECTOR

The main long term environmental challenge for the energy sector is the achievement of sustainable development which is necessarily related to the reduction of greenhouse gas emissions. The accomplishment of this goal relies on the implementation of actions relating to the efficient and rational use of energy, use of renewable energy sources and the substitution of fossil sources and biomass by sources with a smaller content of carbon.

It should be recognized that the efficient use of energy gives direct economic benefits mainly because increasing energy efficiency is less costly than supplying energy. In this way, demand can be satisfied in a rational way with minor capital investment.

In addition, the reduction in the use of fossil fuels (through their efficient use) and the employing of renewable energy (fuels) with smaller contents of carbon, benefits highly the environment and impacts greatly socially .

BASE SCENARIOS

The absence of official publications, long term prospective studies related to macroeconomic indicators and studies of development scenarios in the energy sector, (prospective or planning ones) do not allow the construction of scenarios with any long term certainty.

The mitigation analysis has defined two socioeconomic scenarios of development (one modest and the other, extreme). These scenarios were based on the historical behavior of the GDP and in the official forecasts regarding development. These two scenarios have established a reliable range in which the tendencies of the energy sector and their sub-sectors could be forecasted according to the designed structure. The limit of the constructed scenarios is the year 2030 and the base year is 1990 (following the recommendations of the IPCC in the elaboration of National Inventories for greenhouse gas emissions).

Chart 5.1. Rates of growth of the Gross Domestic Product (GDP)

Modest and Extreme scenarios.

Modest

ACTIVITY	1991-1997	1997	1998	1999	2000	2001	2002	2003-2010	2011-2020	2021-2030
AGRICULTURE, FORESTRY, HUNTING, FISHING	3.8%	5.3%	3.3%	3.7%	4.3%	4.9%	5.5%	5.0%	4.5%	4.0%
PETROLIUM AND NATURAL GAS	1.3%	-9.2%	4.5%	5.0%	7.0%	7.0%	7.0%	6.5%	5.0%	4.5%
METALICS AND NON METALIC MINERALS	2.3%	1.6%	-3.6%	6.0%	7.6%	14.9%	6.3%	6.3%	5.0%	4.0%
MANUFACTURING INDUSTRIES	4.3%	4.4%	4.5%	4.5%	4.5%	4.5%	4.8%	6.8%	5.1%	4.5%
ELECTRICITY, GAS AND WATER	8.9%	6.4%	8.0%	10.0%	10.5%	11.0%	11.0%	11.0%	9.0%	7.6%
CONSTRUCTION OF PUBLIC INFRASTRUCTURE	4.0%	7.1%	5.5%	6.0%	5.0%	5.5%	5.5%	6.5%	5.0%	4.0%
COMMERCIAL	7.0%	5.4%	4.5%	5.0%	4.5%	5.0%	5.0%	6.0%	5.0%	4.5%
TRANSPORT, STORAGE AND COMMUNICATIONS	4.1%	5.6%	6.0%	6.5%	7.0%	7.5%	7.5%	7.0%	5.5%	5.0%
FINANCES	6.4%	12.3%	9.5%	8.0%	7.0%	6.5%	6.5%	6.5%	5.0%	4.5%
PUBLIC ADMINISTRATION	2.4%	2.7%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
OTHER SERVICES	1.1%	4.0%	4.0%	3.0%	4.0%	4.0%	4.5%	5.5%	5.0%	4.5%
INDIRECT TAXES	*5.0%*	*4.0%*	*5.1%*	*2.9%*	*4.2%*	*4.2%*	*4.1%*	*4.8%*	*4.0%*	*3.6%*
GDP	**5.6%**	**4.1%**	**4.5%**	**4.9%**	**5.2%**	**5.8%**	**5.5%**	**6.0%**	**5.0%**	**4.5%**

Extreme

ACTIVITY	1991-1997	1997	1998	1999	2000	2001	2002	2003-2010	2011-2020	2021-2030
AGRICULTURE, FORESTRY, HUNTING, FISHING	3.8%	5.3%	4.0%	4.2%	4.8%	6.0%	6.0%	5.5%	5.0%	4.5%
PETROLIUM AND NATURAL GAS	1.3%	-9.2%	4.5%	5.0%	9.2%	7.0%	7.0%	7.0%	6.5%	5.0%
METALIC AND NON METALIC MINERALS	2.3%	1.6%	-3.6%	6.0%	7.6%	14.9%	6.3%	6.3%	5.0%	4.5%
MANUFACTURING INDUSTRIES	4.3%	4.4%	4.5%	5.0%	5.3%	5.8%	6.5%	7.5%	7.1%	6.4%
ELECTRICITY, GAS AND WATER	8.9%	6.4%	9.0%	11.0%	11.5%	12.0%	12.0%	11.0%	9.0%	8.1%
CONSTRUCTION OF PUBLIC INFRASTRUCTURE	4.0%	7.1%	5.5%	6.0%	6.0%	5.5%	7.0%	7.0%	6.5%	6.0%
COMMERCIAL	7.0%	5.4%	4.5%	5.0%	5.5%	5.5%	7.0%	7.0%	6.5%	6.0%
TRANSPORT, STORAGE AND COMMUNICATIONS	4.1%	5.6%	7.0%	7.5%	8.2%	9.0%	12.0%	9.0%	8.0%	7.0%
FINANCES	6.4%	12.3%	9.5%	8.0%	7.0%	6.5%	8.8%	9.0%	7.0%	6.5%
PUBLIC ADMINISTRATION	2.4%	2.7%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
OTHER SERVICES	1.1%	4.0%	4.0%	3.0%	4.0%	4.0%	4.5%	6.5%	6.5%	6.5%
INDIRECT TAXES	*5.0%*	*4.0%*	*4.7%*	*3.0%*	*4.5%*	*4.2%*	*5.0%*	*5.6%*	*5.2%*	*4.8%*
GDP	**5.6%**	**4.1%**	**4.7%**	**5.2%**	**5.8%**	**6.4%**	**7.0%**	**7.0%**	**6.5%**	**6.0%**

In the designed scenarios, two fundamental indicators were considered as influences on the future behavior of energy sector demand: rates of GDP growth by sector (Chart 5.1.) and rates of population growth determined by the National Statistics Institute until 2050 (INE), that forecast 6.42 million inhabitants in 1990 and 14 million inhabitants approximately in 2030. This fact would imply a population growth rate of 2.408% in the period 1990 - 1995 and a progressive decrease of 1.282% in the period 2025–2030.

Through the use of these rates and tendencies the number of homes for 1990 was calculated as 1.48 millions. From this total, 807,740 homes would belong to the urban area and 671,367 to the countryside. In 2030 the number of homes would reach 3.15 millions (2,393,507 homes would belong to the urban area and 756,839 to the countryside).

The designed scenarios were also based on the energy structure of demand developed for the mitigation analysis considering the existing statistical information and the coefficients of energy intensities for each sector. The autonomous technological events that could allow improvements in energy efficiency in different uses and the energy intensity in different sectors (residential, commercial, industrial, rural, transport and agricultural), were also considered in order to carry out a "bottom–up" analysis of the whole energy sector in the country.

The design of the energy transformation structure has considered eight modules that mediate all the processes of energy supply to the sectors of demand (beginning from the initial requirement of natural resources): production of unrefined petroleum, production of natural gas, treatment of natural gas, refinement of petroleum, lubricant production, electric power generation, production and transport of vegetal carbon, transmission and distribution of energy. This structure has been based on the flow diagram of the National Energy System and includes the contractual volumes of natural gas exports to Brazil, the volumes of natural gas that would be required for thermoelectric generation projects in Brazil and the probable export quantities of electric energy to the Brazilian market.

ANALYSIS OF DEMAND AND ENERGY TRANSFORMATION

The energy demand in 1990 was basically concentrated on three sectors: residential, transport and industry (94.61%). These sectors define the energy structure demand in the country and, as we can see in the chart 5.2, this demand is mainly covered by firewood, gasoline, natural gas, diesel oil and LPG. Sources like electricity, waste and animal manure should also be considered but in a secondary way.

The first three mentioned energy sources comprise 73.61% of the total energy demand. if we also consider the three other sources mentioned later on, this percentage totals 91.33%, a quantity that shows that energy demand in the country is highly concentrated in traditional sources (biomass or petroleum derivatives).

Chart 5.2. Energy demand by sectors – Base Scenario.
Barrels of Equivalent Oil (BEO), 1990.

Source of energy / Sector	RESIDENTIAL	COMMERCIAL / INDUSTRIAL RURAL	INDUSTRIAL	TRANSPORT	AGRICULT. – LIVESTOCK	Total
ELECTRICITY	448,413	195,539	450,410	0	0	1,094,362
NATURAL GAS	25	0	2,500,215	0	0	2,500,240
GASOLINE	20,389	5,210	138,961	2,921,428	5,130	3,091,119
AVIATION GASOLINE	0	0	0	48,430	0	48,430
JET FUEL	0	0	0	649,377	0	649,377
DIESEL/GAS OIL	36,210	0	353,931	1,824,618	55,721	2,270,479
FUELOIL/RESIDUAL	0	0	173,879	537	0	174,416
LGP	1,450,563	42	43,243	94	4,076	1,498,018
OTHER PRODUCTS FROM PETROLEUM	0	0	819	0	0	819
UNREFINED PETROLEUM	0	0	21,497	0	0	21,497
BITUMINOUS CARBON	0	0	126	0	0	126
ANTHRACITE COAL	0	0	54	0	0	54
LIGNITE	0	0	3	0	0	3
TURBA	0	0	0	0	0	0
F.WOOD	2,962,026	440,263	0	0	0	3,402,289
VEGETAL CARBON	15,154	0	61,052	0	0	76,207
ETHANOL	659	0	0	0	0	659
ANIMAL MANURE	668,582	228,043	0	0	0	896,625
VEGETAL RESIDUES	90,547	0	0	0	0	90,547
BAGASSE	0	0	1,081,741	0	0	1,081,741
SOLAR ENERGY	39,061	0	0	0	0	39,061
HYDROELECTRIC ENERGY	338	0	0	0	0	338
BITUMEN	0	0	23,045	0	0	23,045
PETROLEUM COKE	0	0	0	0	0	0
LIGNITO COKE	0	0	413	0	0	413
PARAFFIN	24,783	0	0	0	0	24,783
ASPHALT	0	0	527	0	0	527
GREASE	0	0	4,574	0	0	4,574
KEROSENE	177,946	0	62,509	249	573	241,276
OILS	0	0	91,148	0	0	91,148
BATTERIES	16,517	0	0	0	0	16,517
Total	5,951,216	869,097	5,008,147	5,444,732	65,500	17,338,691

Source: PNCC based on results of the LEAP system.

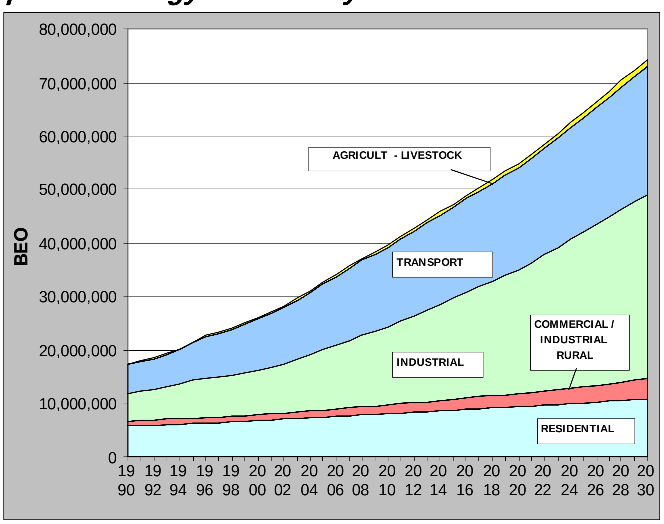
According to this analysis, the energy demand projected for the period 1990 - 2030 would have a global annual growth of 3.7% in the modest scenario and of 4.5% in the extreme (high) scenario. The modest scenario also suggests that, among the sectors of energy demand, the agricultural sector would have an average annual growth of 7.41%, followed by the industrial sector (4.93%), transport (3.78%), commercial (3.70%) and the residential sector with 1.53%. On the other hand, the extreme (high) scenario suggests that the agricultural sector would reach an average annual growth of 7.85%, followed by the industrial sector (6.03%), the commercial area (4.73%), transport (4.45%) and the residential sector with 1.53%. In conclusion, the total energy demand for the year 2030 in absolute terms would be approximately 4.28 times more than the total energy demand of 1990, in the modest scenario, and 5.82 times more than 1990 in the extreme (high) scenario.

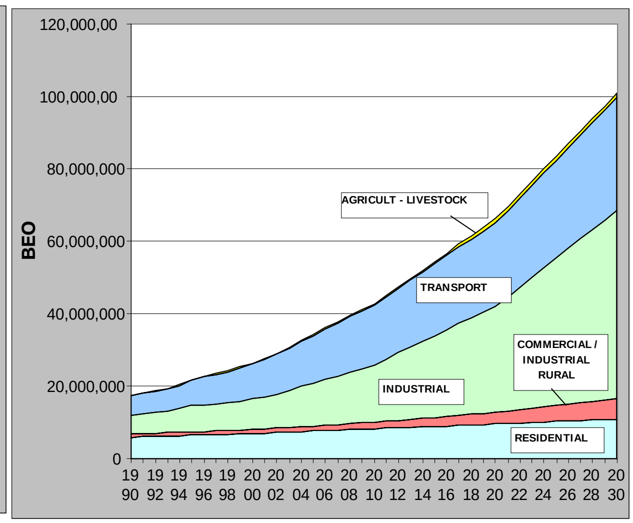
Chart 5.3. Demand of Energy by Sectors. Base Scenario (BEO) 1990 - 2030.

SECTOR / YEAR	1990	1995	2000		2010		2020		2030	
SCENARIO	REAL	REAL	MODEST	EXTR.	MODEST	EXTR.	MODEST	EXTR.	MODEST	EXTR.
RESIDENTIAL	**5,951,214**	**6,350,090**	**6,954,760**	**6,954,760**	**8,194,715**	**8,194,715**	**9,532,846**	**9,532,846**	**10,934,947**	**10,934,947**
URBAN > 10000 h	1,678,044	2,174,429	2,855,071	2,855,071	4,191,332	4,191,332	5,535,117	5,535,117	6,780,249	6,780,249
URBAN < 10000 h	395,505	457,614	526,384	526,384	660,020	660,020	784,939	784,939	880,725	880,725
RURAL < 2000 h	3,877,665	3,718,047	3,573,305	3,573,305	3,343,363	3,343,363	3,212,790	3,212,790	3,273,973	3,273,973
COMMERCIAL / INDUSTRIAL RURAL										
COMMERCIAL - GENERAL	**869,097**	**910,117**	**1,072,970**	**1,083,025**	**1,641,563**	**1,829,053**	**2,465,861**	**3,167,000**	**3,722,879**	**5,513,205**
INDUSTRIAL	**5,008,147**	**7,164,871**	**8,339,679**	**8,440,778**	**14,553,833**	**15,744,642**	**22,901,253**	**29,314,343**	**34,356,098**	**52,125,871**
MINNING - METALURGY	445,014	365,172	449,795	449,795	896,077	896,077	1,459,375	1,459,375	2,160,072	2,266,195
GENERAL INDUSTRIES	2,664,626	4,577,736	5,697,993	5,769,757	10,563,530	11,596,920	17,376,250	23,026,400	26,982,940	42,823,460
ROADS AND HIGHWAYS	64,551	180,714	236,409	238,664	435,421	462,670	709,039	868,587	1,049,746	1,555,639
CONSTRUCTION	122,937	324,564	426,186	430,251	784,954	834,077	1,278,218	1,565,843	1,892,427	2,804,424
ELECTRICITY	1,021	2,562	3,817	3,921	10,836	11,336	25,652	26,838	53,364	58,481
PETROLEUM INDUSTRY	1,504,028	1,345,456	1,110,132	1,133,043	1,355,886	1,436,433	1,423,627	1,738,209	1,425,821	1,825,944
OTHERS	205,971	368,668	415,347	415,347	507,129	507,129	629,092	629,092	791,729	791,729
TRANSPORT	**5,444,732**	**6,942,479**	**9,399,101**	**9,541,511**	**14,774,167**	**16,379,239**	**19,041,826**	**23,091,321**	**24,043,213**	**31,028,742**
TERRESTRIAL	4,484,969	5,868,673	8,002,961	8,124,217	12,817,340	14,209,820	16,471,300	19,974,140	20,735,070	26,759,450
BY AIR	703,081	843,186	1,116,010	1,132,920	1,563,847	1,733,745	2,053,959	2,490,760	2,643,023	3,410,927
BY TRAIN	151,948	124,589	157,741	160,131	221,287	245,328	290,879	352,738	374,529	483,345
PLUVIAL - LACUSTRINE	104,735	106,031	122,389	124,243	171,693	190,346	225,688	273,684	290,591	375,020
AGRICULT. LIVESTOCK										
USE OF ENERGY	**65,500**	**243,140**	**303,405**	**308,565**	**496,387**	**531,991**	**770,638**	**866,613**	**1,140,865**	**1,345,715**
TOTAL	**17,338,690**	**21,610,697**	**26,069,914**	**26,328,639**	**39,660,665**	**42,679,639**	**54,712,423**	**65,972,124**	**74,198,002**	**100,948,480**

Source: PNCC based on results of the LEAP system.

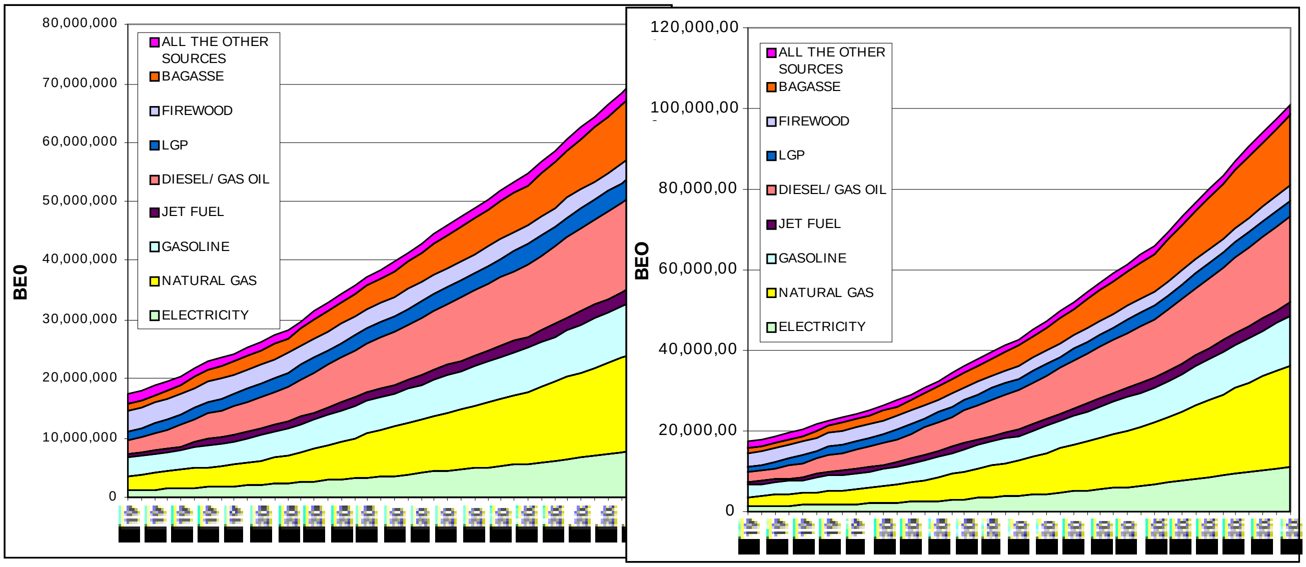
Graph 5.1. Energy Demand by sector. Base Scenario: Modest - Extreme (BEO) 1990–2030.





Source: PNCC based on results of the LEAP system.

Graph 5.2. Energy demand by source. Base scenario: Modest - Extreme (BEO), 1990–2030.



Source: PNCC based on results of the LEAP system

The analysis of the base scenarios (modest and extreme) forecasts that, in the long term, the most important energy sources used in the country will be reduced to eight. The modest scenario proposes that during the period 1990–2030 the electricity would have an annual average growth rate of 5.18% followed by diesel oil (5.04%), natural gas (4.99%), jet fuel (3.5%), gasoline (2.81%), LPG (2.33%), bagasse (5.99%) and firewood (-0.12%).

Chart 5.4 Energy demand by sources. Base Scenario (BEO) 1990 - 2030.

SOURCE OF ENERGY / YEAR	1990	1995	2000		2010		2020		2030	
SCENARIO	REAL	REAL	MODEST	EXTREME	MODEST	EXTREME	MODEST	EXTREME	MODEST	EXTREME
ELECTRICITY	1,094,362	1,591,580	2,070,697	2,081,595	3,614,278	3,808,537	5,641,014	6,611,438	8,243,432	11,073,720
NATURAL GAS	2,500,240	3,225,328	4,044,405	4,103,311	8,256,226	8,961,966	12,179,040	15,313,640	17,523,890	25,304,880
GASOLINE	3,091,119	3,530,087	4,254,417	4,314,446	5,554,920	6,109,632	7,277,765	8,734,329	9,363,074	12,010,060
JET FUEL	649,377	812,605	1,083,627	1,100,046	1,520,169	1,685,321	1,998,240	2,423,192	2,572,891	3,320,420
DIESEL/GAS OIL	2,270,479	3,973,479	5,338,893	5,413,494	8,859,061	9,718,280	12,157,110	14,725,050	16,212,930	21,611,180
LGP	1,498,018	1,843,193	2,226,667	2,227,178	2,681,804	2,688,391	3,268,568	3,303,802	3,762,866	3,861,277
FIREWOOD	3,402,289	3,345,608	3,312,161	3,316,612	3,270,731	3,337,477	3,233,693	3,423,228	3,240,478	3,589,113
BAGASSE	1,081,741	1,884,083	2,340,432	2,369,909	4,338,937	4,763,399	7,137,238	9,458,019	11,083,150	17,589,590
OTHER SOURCES	1,751,067	1,404,734	1,398,614	1,402,048	1,564,548	1,606,644	1,819,763	1,979,423	2,195,293	2,588,228
TOTAL	17,338,691	21,610,697	26,069,913	26,328,639	39,660,674	42,679,647	54,712,431	65,972,121	74,198,004	100,948,468

Source: PNCC based on results of the LEAP system

On the other hand, the extreme scenario forecasts that electricity and natural gas for the same period (1990–2030) would have an average annual growth rate of 5.96%, followed by diesel oil (5.79%), jet fuel (4.16%), gasoline (3.45%), LPG (2.40%), bagasse (7.22%) and firewood (0.13%).

ANALYSIS OF GREENHOUSE GAS EMISSIONS

The emissions of GHG generated by the energy sector were calculated using emission factors taken from the environmental database of the LEAP (EDB-LEAP). These emission factors were calculated in studies carried out by the SEI-B for the different sectors (residential, commercial, institutional, industrial, transport, agricultural, loss of fuels by distribution, electricity generation and production of natural gas) taking as references, the investigations carried out in Senegal (June, 1992), the Global Energy Sector (energy demand for sectors and emissions in refineries), the U.S studies based on the U.S. EPA data (energy demand for sectors and transformation), the IPCC Guides 1995 (energy demand for sectors and transformation) and the OMS study related to the production of vegetal carbon.

National theoretical emission factors have been used in three particular cases. The first of them was developed on the National Oil Company (YPFB) database and it was related to the CO2 and CH4 emission caused by the burning and flaring of natural gas in fields of exploitation. It has been reported that 1.92785 kg of CO2 for m3 (93%) correspond to the burning of natural gas and 40.803 g of CH4 for m3 (7%) to the flaring of natural gas. The second theoretical factor reports that 1.911 kg of CO2 for each kg of ethanol is consumed in residential uses (cooking and lighting). Finally, the third factor points out that 3.123 kg of CO2 kg of candle paraffin is consumed in residential lighting.

As a result of the analysis, it is possible to observe that the growth of the GHG[1] emissions in the period 1990–1997 was not constant. The non biogenic CO2 shows a growth of 52% up to 1994 (with an average annual growth rate of 11.03%). In 1995, there was a sudden decrease in these emissions as a result of important reductions in the burning of natural gas in the exploitation fields. Later on, this rate increased again, reaching an average annual growth rate of 5.53% for the period 1990 - 1997. On the other hand, the biogenic CO2 shows an average annual growth rate of 1.97% for the mentioned period.

The behavior observed for the non biogenic CO2 was also observed for the CH4 emissions. The CH4 average annual growth rate totaled 2.96% for the mentioned period and presented an average annual growth rate of 25.89% during the period 1990–1994. Finally, the N2O had an average annual growth rate of 11.17% in the period 1990 – 1997. These rates were 1.14% for CO, 8.23% for NOX and 3.47% for COVNM. In the case of SO2, an increase is observed in the national emissions during the analyzed period with an average annual growth rate of 0.41%.

Chart 5.5. ***Greenhouse gas emissions (Gg), 1990 - 1997.***

EMISSION / YEAR	1990	1991	1992	1993	1994	1995	1996	1997
NON BIOGENIC CARBON DIOXIDE	5,135.68	5,312.68	5,844.78	6,933.90	7,804.51	6,757.73	7,237.60	7,487.62
BIOGENIC CARBON DIOXIDE	3,355.99	3,532.68	3,538.51	3,595.26	3,667.71	3,759.11	3,801.00	3,848.29
METHANE	23.77	28.53	33.44	49.16	59.71	29.47	29.07	29.16
NITROUS OXIDE	0.0131	0.0158	0.0156	0.0172	0.0195	0.0224	0.0250	0.0275
CARBON MONOXIDE	396.83	397.51	399.70	399.19	396.61	408.83	422.87	429.61
NITROGEN OXIDES	21.00	23.82	25.65	26.46	28.62	31.57	34.71	36.54
VOLATILE HYDROCARBONS	2.41	2.13	2.17	2.39	2.66	2.95	3.00	3.06
SULPHUR DIOXIDE	0.5042	0.5024	0.5005	0.4984	0.4964	0.4942	0.4921	0.4899

The different activities related to the demand and transformation of energy during 1990 have determined that the Residential sector was the main producer of CO2 (biogenic and non biogenic) emissions with 2,827.15 Gg (33.29% of the total), followed by sectors like

[1] The estimations of Green House Gas Emissions do not discount the contributions made by the international bunkers as recommended in the IPCC Guide (1996) for the elaboration of National Inventories of GHG emissions.

transport with 1,888.35 Gg (22.24%), industrial with 1,709.10 Gg (20.13%), natural gas production with 813.06 Gg (9.57%), electric generation with 665.88 Gg (7.84%), commercial with 480.60 Gg (5.66%), petroleum refinement with 71.95 Gg (0.85%), agricultural with 24.94 Gg (0.29%) and production of lubricants and other Products with 10.63 Gg (0.13%).

In the CH4 emissions, the most important contributor was the production of natural gas with 72.32%. The main N2O emissions contributor was the industrial sector with 99.24%, while the CO was mainly emitted by sectors like transport (55.96%) and residential (39.96%). The NOX emissions were basically produced by the transport sector with 67.52% and the COVNM emissions were mainly related to the production of vegetal carbon (almost the 100%). Finally, the residential sector was the main SO2 producer with practically the 100% of the total.

As we mentioned before, 1994 is a very particular year and the previously described structure basically remains unalterable in the long term except in the industrial and transport sectors that take a significant importance due to the volumes of natural gas burning in new discovered fields. During this year the residential sector stills being the main contributor of CO2 emissions (biogenic and non biogenic) but just with the 24.97% of the total. The production of natural gas contributes with the 21.28%, the industry with the 19.95%, the transport with the 19.59% and the electric generation with the 8.69%. With respect to the CH4 emissions, the sector that mainly contributes to the emission of these gases is the production of natural gas that reaches the 86.43% while the structure in the other gases emissions practically does not change.

Chart 5.6. Greenhouse gas emissions by Sector (Gg), 1990 and 1994.

EMISSION/SECTOR	RESIDENTIAL	COMMERCIAL INDUSTRIAL RURAL	INDUSTRIAL	TRANSPORT	AGRICULTURE	TRANSMITION DISTRIBUTION	/CARBON PRODUCTION	ELECTRIC GENERATION	LUBRICATOR PRODUCTION	OIL REFINE	NATURAL GAS PROCESING	NATURAL GAS PRODUCT.	CONDENSED OIL PRODUCTION	TOTAL
	DEMAND					TRANSFORMATION								
NON BIOGENIC CARBON DIOXIDE	594.99	1.30	1,106.34	1,888.35	24.94	0.00	0.00	624.12	10.63	71.95	0.00	813.06	0.00	5,135.68
BIOGENIC CARBON DIOXIDE	2,232.16	479.30	602.76	0.00	0.00	0.00	0.00	41.76	0.00	0.00	0.00	0.00	0.00	3,355.98
METHANE	0.01	0.07	0.01	0.50	0.00	2.77	0.00	0.00	0.01	0.04	0.00	17.19	3.17	23.77
NITROUS OXIDE	0.0001	0.00	0.0130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0131
CARBON MONOXIDE	158.57	9.99	2.95	222.05	0.56	0.00	2.64	0.06	0.01	0.00	0.00	0.00	0.00	396.83
NITROGEN OXIDES	1.36	1.04	3.84	14.18	0.33	0.00	0.18	0.03	0.04	0.00	0.00	0.00	0.00	21.00
VOLATILE HYDROCARBONS	0.00	0.00	0.00	0.00	0.00	0.00	2.41	0.00	0.00	0.00	0.00	0.00	0.00	2.41
SULPHUR DIOXIDE	0.5042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.5042

EMISSION/SECTOR	RESIDENTIAL	COMMERCIAL INDUSTRIAL RURAL	INDUSTRIAL	TRANSPORT	AGRICULTURE	TRANSMITION DISTRIBUTION	/CARBON PRODUCTION	ELECTRIC GENERATION	LUBRICATOR PRODUCTION	OIL REFINE	NATURAL GAS PROCESING	NATURAL GAS PRODUCT.	CONDENSED OIL PRODUCTION	TOTAL
	DEMAND					TRANSFORMATION								
NON BIOGENIC CARBON DIOXIDE	675.76	4.04	1,381.97	2,246.88	88.93	0.00	0.00	875.83	6.70	83.51	0.00	2,440.89	0.00	7,804.51
BIOGENIC CARBON DIOXIDE	2,188.57	450.91	907.11	0.00	0.00	0.00	0.00	121.12	0.00	0.00	0.00	0.00	0.00	3,667.71
METHANE	0.01	0.07	0.01	0.54	0.00	2.95	0.00	0.00	0.00	0.04	0.00	51.60	4.48	59.70
NITROUS OXIDE	0.0001	0.00	0.0189	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0195
CARBON MONOXIDE	156.22	9.79	3.81	222.60	1.10	0.00	2.92	0.16	0.01	0.00	0.00	0.00	0.00	396.61
NITROGEN OXIDES	1.41	0.99	6.50	18.14	1.26	0.00	0.20	0.09	0.03	0.00	0.00	0.00	0.00	28.62
VOLATILE HYDROCARBONS	0.00	0.00	0.00	0.00	0.00	0.00	2.66	0.00	0.00	0.00	0.00	0.00	0.00	2.66
SULPHUR DIOXIDE	0.4964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.4964

Source: PNCC based on results of the LEAP system

The result of the base scenarios analysis forecasts that the biogenic and non biogenic carbon dioxide (CO2) would be the most important GHG during 1990–2030, reaching in 2030 an emission of 29,355.56 Gg in the modest scenario and 39,403.65 Gg in the extreme scenario (see Chart 5.7).

The average annual rates of growth in non biogenic CO2 emissions for this period reaches 3.51% in the modest scenario and 4.19% in the extreme scenario. The rates related to biogenic CO2 emissions reaches 2.48% (modest) and the 3.42% (extreme)

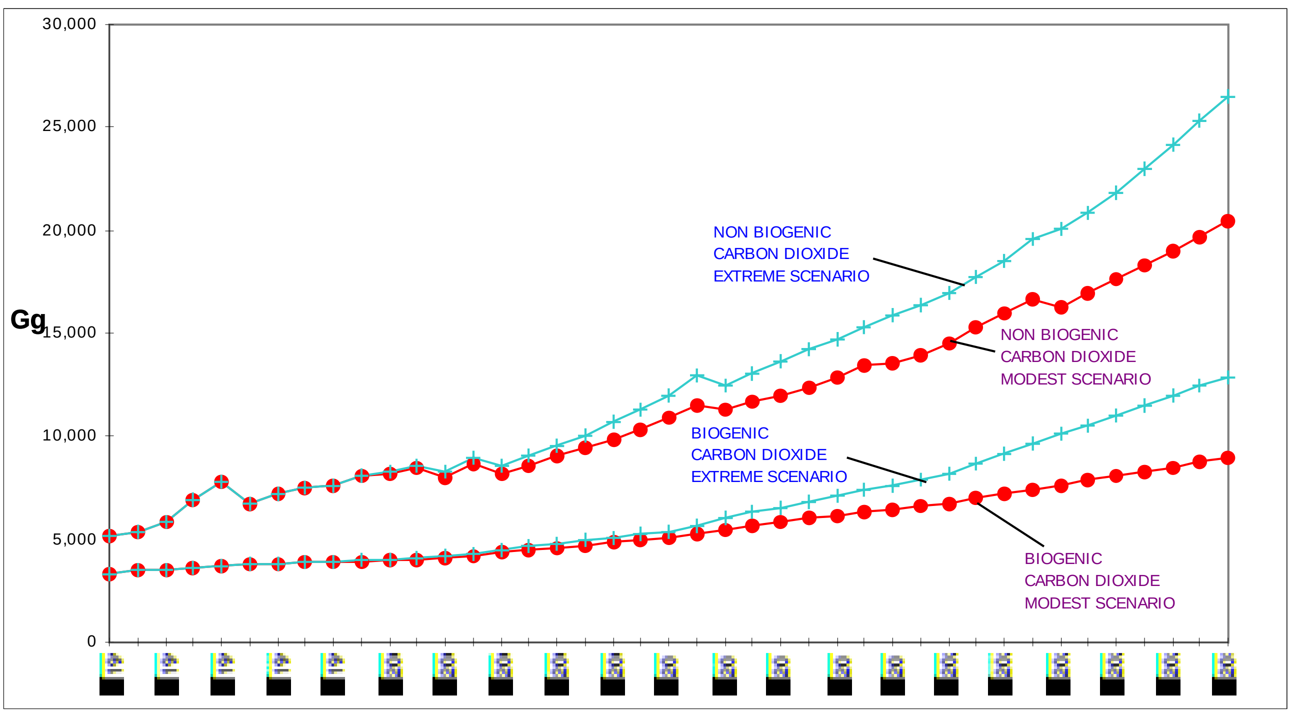
During the same period (1990 – 2030), methane (CH4) would reach an average annual growth rate of 0.71% and 1.20% respectively, nitrous oxide (N2O) emissions would reach 6.8% and 7.87%, carbon monoxide (CO) 1.66% and 2.21%, nitrogen oxides (NOX) 4.61% and 5.42%, volatile hydrocarbons (COVNM) 4.49% and 4.61% and sulphur dioxide (SO2)–0.41% in both scenarios.

Chart 5.7. Greenhouse gas emissions. Base scenario (Gg), 1990–2030.

EMISSION / YEAR	1990	1995	2000		2010		2020		2030	
SCENARIO	REAL	REAL	MODEST	EXTREME	MODESTO	EXTREME	MODESTO	EXTREME	MODESTO	EXTREME
NON BIOGENIC CARBON DIOXIDE	5,135.68	6,757.73	8,226.68	8,317.22	10,885.07	11,989.52	14,539.57	16,926.45	20,412.67	26,526.37
BIOGENIC CARBON DIOXIDE	3,355.99	3,759.11	3,984.76	4,005.29	5,061.95	5,359.16	6,748.56	8,183.93	8,942.89	12,877.28
METHANE	23.77	29.47	25.02	25.09	20.75	21.62	24.99	27.76	31.53	38.29
NITROUS OXIDE	0.0131	0.0224	0.0362	0.0366	0.0846	0.0932	0.1261	0.1615	0.1822	0.2713
CARBON MONOXIDE	396.83	408.83	451.80	456.19	520.62	560.17	629.91	732.30	765.68	950.88
NITROGEN OXIDE	21.00	31.57	41.87	42.43	67.45	74.04	93.68	114.41	127.29	173.73
VOLATILE HYDROCARBONS	2.41	2.95	3.33	3.33	6.13	6.13	9.64	9.64	13.98	14.64
SULPHUR DIOXIDE	0.5042	0.4942	0.4832	0.4832	0.4576	0.4576	0.4373	0.4373	0.4283	0.4283

Source: PNCC based on results of the LEAP system

Graph 5.3 Carbon Dioxide Emissions. Base Scenario (Gg), 1990–2030.



In order to determine the direct GHG contribution on climate change, Global Warming Potential (GWP) for each emission has been taken into account. In the Chart 5.8 the GWP has been estimated in thousands of tons of equivalent CO2 for the limit case of 100 years according to the methodology proposed by the IPCC Revised Guide 1996 for the Elaboration of GHG Inventories (biogenic CO2 is not included).

Chart 5.8. Global Warming Potential of the direct GHG - Case 100 years IPCC/1996, Base Scenarios (thousands of tons of equivalent CO2), 1990 - 2030.

EMISSION / YEAR	GWP	1990	1995	2000		2010		2020		2030	
SCENARIO	100 Years	REAL	REAL	MODEST	EXTREME	MODEST	EXTREME	MODEST	EXTREME	MODEST	EXTREME
NON BIOGENIC CARBON DIOXIDE	1.00	5,135.68	6,757.74	8,226.68	8,317.22	10,885.07	11,989.53	14,539.57	16,926.45	20,412.66	26,526.38
METHANE	21.00	499.12	618.95	525.41	526.87	435.70	454.01	524.74	582.96	662.21	804.17
NITROUS OXIDE	310.00	4.06	6.95	11.21	11.36	26.23	28.89	39.08	50.07	56.48	84.12
Total		5,638.86	7,383.64	8,763.31	8,855.45	11,347.00	12,472.42	15,103.39	17,559.49	21,131.35	27,414.67

Source: PNCC based on results of the LEAP system

In terms of GWP, CO2 has contributed to 91.08% in 1990 for the total emissions of the sector. This contribution would reach 96.6% in 2030 in a modest scenario and 96.76% in a extreme scenario. The CH4 contributions reached 8.85% in 1990 and would reach 3.13% in 2030 in a modest scenario and 2.93% in an extreme scenario. Finally, N2O contribution reached 0.07% in 1990 and should reach 0.27% in 2030 (modest scenario) and 0.31% in an extreme scenario.

Chart 5.9. ***Greenhouse gas emissions by Sector. Base Scenario (Gg), 2030.***

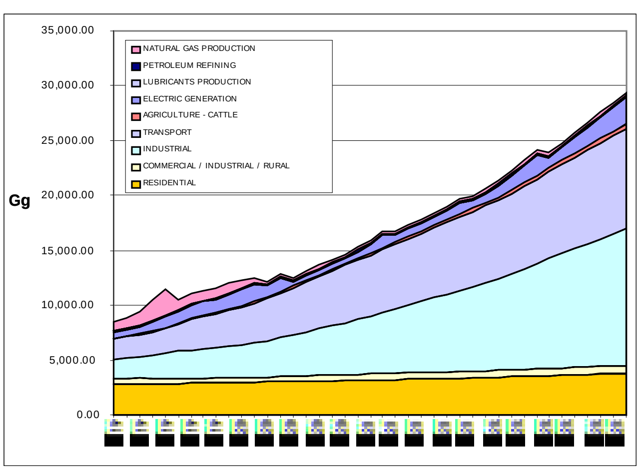
MODEST SCENARIO EMISSION / SECTOR	RESIDENTIAL	COMMERCIAL / INDUSTRIAL RURAL	INDUSTRIAL	TRANSPORT	AGRICULTURE	TRANSMITION / DISTRIBUTION	CARBON PRODUCTION	ELECTRIC GENERATION	LUBRICANTS PRODUCTION	PETROLEUM REFINING	NATURAL GAS PROCESING	NATURAL GAS PRODUCTION	CONDENSED PETROLEUM PRODUCTION	TOTAL
	DEMAND					TRANSFORMATION								
NON BIOGENIC CARBON DIOXIDE	1,966.46	59.90	6,309.39	9,057.01	444.28	0.00	0.00	2,167.79	7.21	152.58	0.00	248.04	0.00	20,412.66
BIOGENIC CARBON DIOXIDE	1,837.29	642.35	6,175.71	0.00	0.00	0.00	0.00	287.53	0.00	0.00	0.00	0.00	0.00	8,942.88
METHANE	0.03	0.10	0.11	4.93	0.00	11.38	0.00	0.96	0.00	0.08	0.00	5.24	8.70	31.53
NITROUS OXIDE	0.0002	0.00	0.1277	0.0543	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1822
CARBON MONOXIDE	140.00	23.04	25.37	555.03	5.52	0.00	15.32	1.39	0.01	0.00	0.00	0.00	0.00	765.68
NITROGEN OXIDE	1.88	1.66	43.88	71.11	6.30	0.00	1.07	1.35	0.03	0.00	0.00	0.00	0.00	127.28
VOLATILE HYDROCARBONS	0.00	0.00	0.00	0.00	0.00	0.00	13.98	0.00	0.00	0.00	0.00	0.00	0.00	13.98
SULPHUR DIOXIDE	0.4283	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.4283

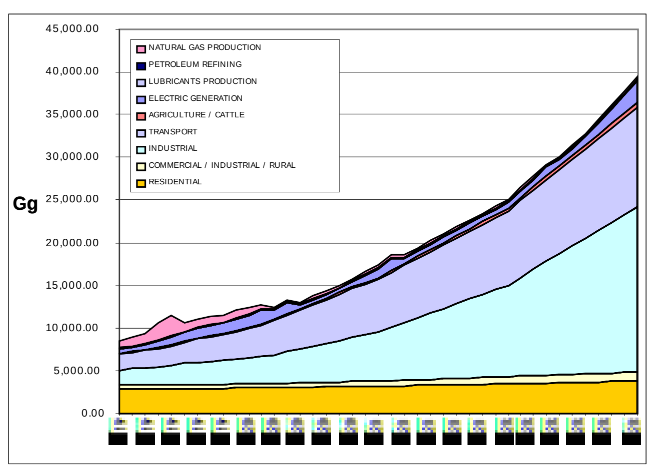
EXTREME SCENARIO EMISSION / SECTOR	RESIDENTIAL	COMMERCIAL / INDUSTRIAL RURAL	INDUSTRIAL	TRANSPORT	AGRICULTURE	TRANSMITION / DISTRIBUTION	CARBON PRODUCTION	ELECTRIC GENERATION	LUBRICANTS DE PRODUCTION	PETROLEUM REFINING	NATURAL GAS PROCESING	NATURAL GAS PRODUCTION	CONDENSED PETROLEUM PRODUCTION	TOTAL
	DEMAND					TRANSFORMACION								
NON BIOGENIC CARBON DIOXIDE	1,966.46	88.71	9,493.26	11,688.45	524.05	0.00	0.00	2,330.27	7.31	179.82	0.00	248.04	0.00	26,526.37
BIOGENIC CARBON DIOXIDE	1,837.29	951.26	9,801.21	0.00	0.00	0.00	0.00	287.53	0.00	0.00	0.00	0.00	0.00	12,877.29
METHANE	0.03	0.14	0.16	6.36	0.00	16.40	0.00	1.15	0.00	0.10	0.00	5.24	8.70	38.28
NITROUS OXIDE	0.0002	0.00	0.2011	0.0701	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2714
CARBON MONOXIDE	140.00	34.12	36.35	716.29	6.51	0.00	16.04	1.57	0.01	0.00	0.00	0.00	0.00	950.89
NITROGEN OXIDE	1.88	2.46	67.50	91.77	7.44	0.00	1.12	1.54	0.03	0.00	0.00	0.00	0.00	173.74
VOLATILE HYDROCARBONS	0.00	0.00	0.00	0.00	0.00	0.00	14.64	0.00	0.00	0.00	0.00	0.00	0.00	14.64
SULPHUR DIOXIDE	0.4283	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.4283

Source: PNCC based on results of the LEAP system.

According to the modest scenario, during 2030, the industrial sector will be the main CO2 (non biogenic and biogenic) contributor with 12,485.1 Gg (42.53% of the total) in the emissions generated by demand and energy transformation. These contributions will be followed by transport with 9,057.01 Gg (30.85%), residential with 3,803.75 Gg (12.96%), electric generation with 2455.32 Gg (8.36%), commercial / industrial / rural with 702.25 Gg (2.39%), agricultural with 444.28 Gg (1.51%), production of natural gas with 248.04 Gg (0.85%), refinement of petroleum with 152.58 Gg (0.52%) and production of lubricants and other products with 7.21 Gg (0.02%).

Graph 5.3 Carbon Dioxide Emissions by sector . Base scenario (Modest and Extreme) (Gg), 1990 - 2030.





In the case of CH_4 emissions, the sectors related to the transmission, transport and distribution of fuels would be the major contributors with 36.09% followed by the production of condensed petroleum with 27.59%. The N_2O emissions would be basically produced by the industrial sector (70.09%); the CO by transport (72.49%) and the residential sector (18.28%), the NOX by transport (55.87%) and the industrial sector (34.47%); the COVNM by the production of vegetal carbon with practically 100% of the emissions and the SO_2 by the residential sector with almost 100% of the total.

According to an extreme scenario, the industrial sector will be the biggest contributor in CO_2 (non biogenic and biogenic) emission in 2030 with 19,294.47 (48.97% of the total), followed by sectors like transport with 11,688.45 Gg (29.66%), residential with 3,803.75 Gg (9.65%), electric generation with 2617.8 Gg (6.64%), commercial / industrial / rural with 1,039.97 Gg (2.64%), agricultural with 524.05 Gg (1.33%), production of natural gas with 248.04 Gg (0.63%), petroleum refinement with 179.82 Gg (0.46%) and production of lubricant and other products with 7.31 Gg (0.02%).

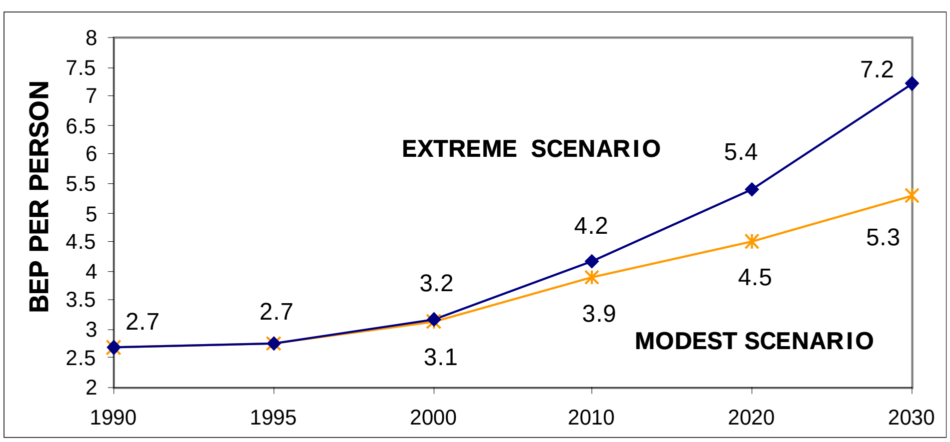
In the case of CH_4 emissions, the sector related to the transmission, transport and distribution of fuels would be the major contributor with 42.84% followed by the production of condensed petroleum with 22.73%. N_2O emissions would basically be produced by the industrial sector (74.10%); CO by transport (75.33%) and the residential sector (14.72%), NOX by transport (52.82%) and the industrial sector (38.85%); COVNM by the production of vegetal carbon with practically 100% of the emissions and SO_2 by the residential sector with almost 100% of the total.

Analysis of Indicators

Through the knowledge of energy demand and emission scenarios, some sustainability aspects relating to the national energy system were calculated. The first considered factor was associated to per capita energy consumption.

The modest scenario forecasts that per capita consumption will increase from 2.7 Barrels of Equivalent Oil (BEO) per person in 1990 to 5.3 BEO / person in 2030 and the high scenario forecasts that this increase would go from 2.7 BEO / person in 1990 to 7.2 BEO in the 2030.

Graph 5.4. Evolution of the Per Capita Energy Consumption. Base scenario (BEO/inhabitant), 1990 - 2030.



Source: PNCC based on results of the LEAP system.

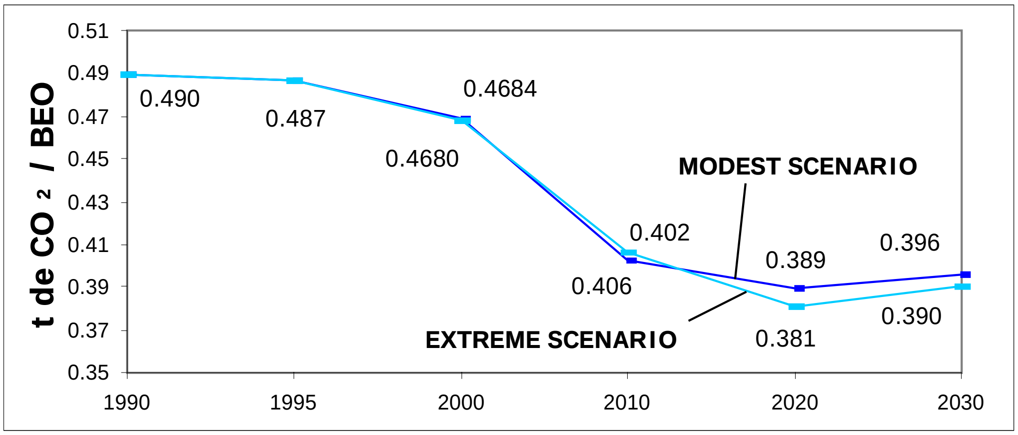
The per capita consumption in the modest scenario will grow to an average annual rate of 1.7% in the period of analysis, while in the extreme scenario this rate will reach 2.48%.

The global CO2 (biogenic and non biogenic) emissions related to the final BEO consumption would diminish for the year 2030 in respect of their current level (Graph 5.5). In the modest scenario it would go from 0.49 t of CO2 / BEO in 1990 to 0.396 t of CO2 / BEO in the year 2030, while in the high scenario it would go from 0.490 t of CO2 / BEO in 1990 to 0.390 t of CO2 / BEO in the year 2030. The behavior of this factor is similar in both scenarios.

In this sense, the CO2 emissions related to the BEO of final consumption will diminish (modest scenario) to an average annual rate of 0.54% in the analyzed period. In a high scenario this rate would reach 0.57%. This reduction is due to several factors but fundamentally to the growth of natural gas consumption in the residential and transport sectors, to the decrease of biomass consumption in the rural areas and to the incorporation of hydroelectric plants in the International Interconnected System (SIN) and certain renewable energy (with generation capacity) in the rural areas.

Finally, it is possible to estimate the CO2 (biogenic and non biogenic) emissions in the energy sector by person, which constitute a very important indicator from the point of view of the climatic change and the sustainability of the sector.

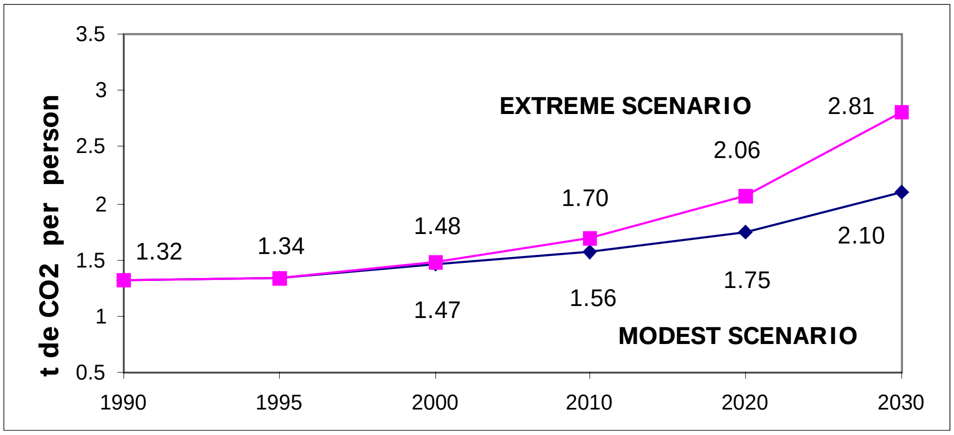
Graph 5.5. Evolution of Carbon Dioxide Emissions by BEO of Consumption.
Base scenario (tons of CO2/BEO), 1990 - 2030.



Source: PNCC based on results of the LEAP system.

In this case, the investigation forecasts that the CO2 emissions will not register a quick and permanent growth. The modest scenario forecasts that this increase would go from 1.32 t / person in 1990 to 2.10 t / person in 2030 and the extreme scenario forecast that this increase would go from 1.32 t / person in 1990 to 2.81 t / person in the year 2030 with average annual rates of growth of 1.17% and 1.91% respectively.

Graph 5.6. Evolution of the Carbon Dioxide Emissions Per Capita, Base Scenario (t of CO_2/habitante), 1990 - 2030.



Source: PNCC based on results of the LEAP system.

MITIGATION SCENARIOS FOR THE ENERGY SECTOR

After analyzing the results of the scenarios based on long term projections, it is possible to observe clearly that, between the demand sources, the industrial sector is the main contributor of GHG emissions (CO_2 especially), followed by transport, residential and commercial sectors. In the processes of energy transformation the most important contributor of GHG emissions is electric generation and in a smaller quantity, the production of natural gas.

The evaluation of the GHG mitigation potential has been developed (because of the mentioned percentages) in the energy sector, estimating different reduction options, as much from the point of view of the demand sources as for the transformation processes. The mitigation measures have been mainly focused on the efficient use and conservation of different energy sources, the reduction in the use and intensity of several fuels (fossils and biomass), the substitution of liquid fuels by gassy fuels (natural gas), the increment of renewable energy in residential use and the use of renewable energy for electricity generation, especially in the rural areas. In the process of selection of mitigation measures, the realization of a qualitative analysis with a matrix of sources has been fundamental in order to assess different uses for each of the sectors of energy demand. This has allowed a greater accuracy in the analysis field.

Chart 5.10. Qualitative matrix of Sources and Uses for the Mitigation Analysis in the Rural and Residential Sub-sector.

USES \ SOURCE	USUAL													ALTERNAT	
	ELC	LGP	KER	GLN	DIE	ALC	F.W	CBV	RSV	EST	BAT	PIL	VEL	SOL	otras
1. Lighting	X ↓	X ↓↓	X ↓↓		X ↓↓							X ↓↓	X ↓↓	↑	
2. Cooking	X	X ↓	X ↓↓			X ↓↓	X ↓↓	X ↓↓	X ↓↓	X ↓↓					
3. Water heating	X ↓↓↓	X ↓↓↓	X ↓↓↓				X ↓↓↓	X ↓↓↓	X ↓↓↓	X ↓↓↓				↑↑↑	
4. Heating	X ↓↓↓	X ↓↓					X ↓	X ↓	X ↓	X ↓				↑↑↑	
5. House conditioning	X ↓↓↓														
6. Food refrigeration	X ↓↓	X ↓↓	X ↓↓↓												
7. Audio-Vision	X										X ↓↓↓	X ↓↓↓			
8. Domestic supplies	X ↓														
9. Water distrib.	X ↓			X ↓	X ↓									↑↑	
10. Battery recharging	X ↓													↑↑↑	
11. Electricity generation				X ↓	X ↓									↑↑↑	

X Usual employment of sources in the different base scenarios.

↓ ↓↓ ↓↓↓ Reduction in consumption of the specific sources (three levels).

↑ ↑↑ ↑↑↑ Increase in the use of alternative and substitutive sources (three levels).

USES \ SOURCE	USUAL													ALTERNAT	
	ELC	LGP	KER	GLN	DIE	ALC	FWO	CBV	RSV	EST	BAT	PIL	VEL	SOL	otras
1. Lighting	1,2,31,6 62	2,33,5	2,33		2,33							5	2,31,33 5	31	
2. Cooking		5	4			4	1,2,4,64	1,2,4,64	1,2,4,64	1,2,4,64					
3. Water heating	2,32	2,32	4				2,32,4,64	2,32,4,64	2,32,4,64	2,32,4,64				32	
4. Heating	11,31,32	11,31,32					11,31,32	11,31,32	11,31,32	11,31,32				32	
5. House conditioning	11														
6. Food refrigeration	1,61,62	5,61,62	5,61,62												
7. Audio-Vision											33,5	33,5			
8. Domestic supplies	61,62,63														
9. Water distribution	33			33,5	33,5									33	
10. Batteries recharging														33	
11. Electricity generation				33,5	33,5									33	

Mitigation Measures:

Source: Andrés Trepp del Carpio

1 Improvements in energy conversion of electric supplies
  11 Energy conservation through the use of thermal isolators.
2 Substitution of technologies and supplies.
3 Use of renewable sources
  31 Solar energy: Extension in the uses of natural lighting.
  32 Solar - thermal energy.
  33 Photovoltaic conversion
4 Expansion of LGP provisions.
5 Expansion of the electricity network
6 Projects related to mitigation.
  61 Demand Side Management, Sucre.
  62 Demand Side Management, La Paz y Santa Cruz.
  63 ESMAP 2
  64 National Biomass Program.

The selection of mitigation measures was mainly based on the guidelines of the General Plan of Economic and Social Development (Bolivia 1997 – 2002) as a possibility to include these options in the politics, plans and programs derived from this national strategy of development. The selection of these measures also considered some fundamental approaches that arose from the analysis of the demand and transformation base scenarios: the importance of each sector (not only in the demand of energy but in their contribution to GHG emissions), the importance of each energy source, the global demand and contribution of these sources to GHG emissions, the use of energy by sector, etc.

Naturally, these approaches are intimately associated to the theme of climate change and that is why the selected options are related to the economic, political, social and environmental context in Bolivia.

MITIGATION MEASURES

The evaluations carried out have allowed the establishing of different mitigation measures in the energy sector, that could help in reducing the levels of GHG emissions and that could be applied in Bolivia through technical and economic support internationally.

- *To achieve efficiency in the lighting of the residential sector*
- *To achieve efficiency in biomass cookers*
- *To achieve efficiency in refrigeration (residential sector)*
- *To increase the residential use of natural gas*
- *To increase the use of solar energy in the heating of water*
- *To provide electricity with renewable energy to rural areas*
- *To achieve efficiency in the commercial sector*
- *To achieve efficiency of the commercial use of biomass*
- *To improve the use of electrical energy in commercial use*
- *To save energy in the industry sector*
- *To increase the use of natural gas in the transport sector*
- *To reduce the burning of natural gas in fields of exploitation*
- *To redistribute expansion options in the electrical generation sector*

Through the comparison of the base and mitigation scenarios it is possible to forecast a reduction in global demand for energy in the whole energy sector. In the modest scenario the reduction would reach 0.36 million BEO for the year 2005 (1.1% reduction), 1.33 million BEO for the year 2010 (3.35 %), 2.87 million BEO for the year 2020 (5.25 %) and 5.14 million BEO for the year 2030 (6.93 %). In the high scenario the reduction would reach 0.44 million BEO for the year 2005 (1.28 %), 1.58 million BEO for the year 2010 (3.70 %), 3.63 million BEO for the year 2020 (5.50 %) and 7.12 million BEO for the year 2030 (7.05 %).

The emissions of non biogenic CO_2 could also be reduced. In a modest scenario this reduction would total 7.03% for the year 2005, 5.81% for 2010, 12.75% for 2020 and 15.07% for 2030. The emissions of biogenic CO_2 could be reduced to 2.3% for 2005, 4.07% for 2010, 6.14% for 2020 and 6.96% for 2030.

In a high scenario, the emissions of non biogenic CO_2 could be reduced by 7.07% for 2005, 5.87% for 2010, 15.65% for 2020 and 17.32% for 2030. Biogenic CO_2 emissions could decrease by 2.81% for 2005, 4.86% for 2010, 6.83% for 2020 and 6.66% for 2030. Similarly, all the other emissions (except the CH_4 and N_2O emanations that would register non significant increases in their emissions) would also register reductions in their emissions in both scenarios (extreme and modest).

Chart 5.11. Reduction of the GHG emissions to the atmosphere Mitigation Scenarios Vs Base Scenarios (Gg), 2005 -2030.

Reduction in a modest scenario

EMISSION / YEAR	2005	2010	2020	2030	TOTAL 2001 - 2030
NON BIOGENIC CARBON DIOXIDE	604.99	632.31	1,854.36	3,076.40	44,386.28
BIOGENIC CARBON DIOXIDE	102.93	205.86	414.22	622.59	9,625.09
METHANE	6.38	0.67	-1.05	-2.76	35.43
NITROUS OXIDE	-0.02	-0.03	-0.06	-0.08	-1.34
CARBON MONOXIDE	30.39	60.77	154.35	247.94	3,514.85
NITROGEN OXIDES	28.95	57.90	661.92	23.34	12,918.19
VOLATILE HYDROCARBONS	0.01	0.03	0.07	0.12	1.69
SULPHUR DIOXIDE	0.02	0.03	0.07	0.11	1.61

Reduction in an extreme scenario

EMISSION / YEAR	2005	2010	2020	2030	TOTAL 2001 - 2030
NON BIOGENIC CARBON DIOXIDE	640.75	703.84	2,649.50	4,595.15	61,406.12
BIOGENIC CARBON DIOXIDE	130.10	260.20	559.17	858.15	12,913.62
METHANE	6.05	0.01	-2.22	-4.44	7.98
NITROUS OXIDE	-0.02	-0.04	-0.07	-0.11	-1.74
CARBON MONOXIDE	39.18	78.35	204.66	330.97	4,650.46
NITROGEN OXIDES	29.71	59.41	666.76	32.45	13,027.48
VOLATILE HYDROCARBONS	0.02	0.04	0.08	0.13	1.91
SULPHUR DIOXIDE	0.02	0.04	0.08	0.12	1.83

Source: PNCC based on results of the LEAP system

The results of the Cost - Benefit Analysis, (which is based on a global and integrated social Cost - Benefit analysis in the energy and environmental system of the country) was carried out with the pattern of Energy Planning (LEAP) and with the methodology developed by the National Program of Climate Change to calculate the annual costs of energy saving.

This social Cost - Benefit analysis is centered on the denominated “opportunity costs” which is basically referred to a group of actions in the energy system and not to the energy consumer. The inflation rate considered for the analysis is 5.56% for the whole period of and a rate of real discount of 12.07% (a social rate of discount adopted in December 1998 by the National Government).

Chart 5.12. Results of the Cost's Reduction Analysis for the CO2 emissions Modest and Extreme Scenarios.

MODEST SCENARIO

MITIGATION MEASURES	Balanced Cost of Energy Saving $US / GJ	Total Cost million $US (1990)	Benefit Million $US (1990)	Current Net Value to 2030 millions of $US	Relation Cost / Benefit	Balanced Cost of Reduction $US (1990) / t CO2	Annual balanced Cost $US / Year	Average Emissions Reduction 2001 - 2030 Gg CO2 / Year
Efficiency in lighting of the residential sector	14.101	2.90	1.45	1.45	0.5003	5.09	157,540	42.27
Efficiency in The use of biomass cookers	0.197	0.45	9.02	-8.57	19.9790	-5.52*	-931,520	230.43*
Efficiency in the refrigeration uses Residential Sector	62.267	51.45	4.81	46.64	0.0935	150.00	5,070,160	44.76
Increase of gas in the residential sector	---	9.00	2.74	6.26	0.3042	20.00	680,600	46.89
Increase in the use of solar energy in order to heat water	---	12.06	1.86	10.20	0.1542	70.00 190.00*	1,108,870	22.33 8.18*
Use of renewable energy for rural electricity	---	14.96	6.93	8.03	0.4632	100.00	873,130	12.24
Efficiency in the lighting of the Commercial Sector	1.39	0.29	1.35	-1.06	4.6619	-1.00	-115,160	52.01
Efficiency in the use of biomass	0.259 firewood 0.389 est.	0.22	3.03	-2.80	13.6199	-6.48*	-304,840	64.315*
Conservation of electric energy for Commercial uses	13.238	14.06	6.37	7.69	0.4531	5.17	836,700	220.98
Conservation of Energy in the Industry	4.420 p.e. 0.518 p.t.	2.80	4.69	-1.89	1.6750	-1.90 -3.18*	-205,420	147.65 87.74*
Increments in the Use of Natural Gas for Transport	---	59.28	119.06	-59.78	2.0084	-70.00	-6,480,000	120.34
Reduction in the gas burning in the exploitation fields	---	0.00	18.34	-18.34	---	-9.48	-1,990,000	286.88
Redistribution of options related to the expansion and generation of electric energy	---	19.42	68.38	-48.96	3.5211	-10.00 110.00*	-5,320,000	550.60 -67.99*

* BIOGENIC CO2
est. : manure
p.e. : electric processes
p.t. : thermal processes

EXTREME SCENARIO

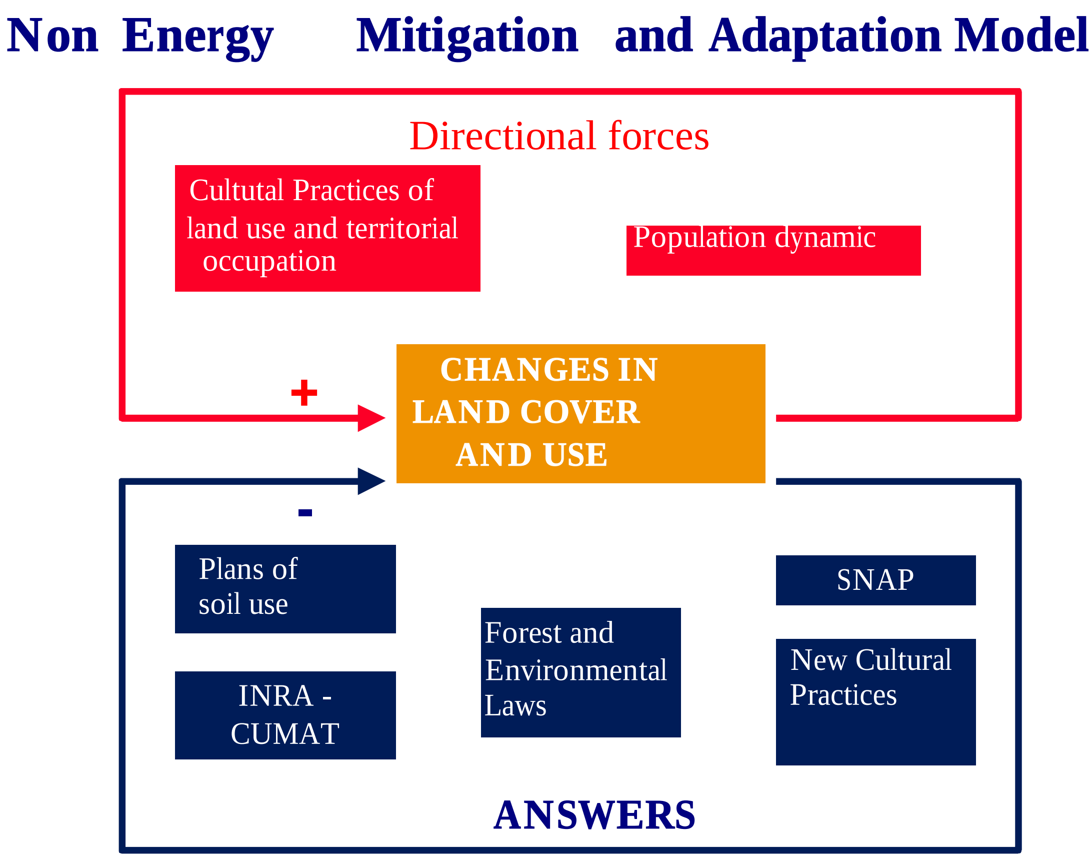
MITIGATION MEASURES	Balanced cost of Energy saving $US / GJ	Total Cost million $US (1990)	Benefits million $US (1990)	Current net value to 2030 Million $US	Relation Cost / Benefit	Balanced Reduction costs $US (1990) / t CO2	Balanced Annualized Cost $US / Year	Average Emissions reductions 2001 - 2030 Gg CO2 / Year
Efficiency in the lighting of the Residential Sector	14.101	3.84	1.32	2.52	0.3445	7.37	273,730	50.76
Efficiency in The use of Biomass cookers	0.197	0.58	11.48	-10.90	19.7931	-6.21*	-1,180,000	260.80*
Efficiency in the Refrigeration - Residential Sector	62.267	56.55	4.06	52.49	0.0718	160.00	5,706,230	48.68
Increment in the use of residential Gas	---	11.80	3.33	8.47	0.2822	30.00	920,240	43.71
Increment in the Use of Solar Energy in the heating of water	---	15.29	2.12	13.17	0.1387	80.00 200.00*	1,431,440	25.64 9.94*
Rural Electrification Based on Renewable Energies	---	18.95	8.76	10.19	0.4623	100.00	1,107,880	14.56
Efficiency in The Illumination o Commercial Sector	1.39	0.38	1.29	-0.91	3.3952	-1.78	-98,870	75.10
Efficiency in the use Of Commercial Biomass	0.259 firewood 0.389 est.	0.29	3.93	-3.65	13.7049	-5.89*	-396,580	91.95*
Conservation of Electric Energy in the Commercials Uses	13.238	19.17	6.62	12.55	0.3453	5.74	1,364,290	324.86
Conservation of Energy in the Industries	4.420 p.e. 0.518 p.t.	3.65	5.37	-1.72	1.4712	-1.19 -1.85*	-187,010	215.32 138.09*
Increment in the use of Natural Gas for Transport	---	75.37	149.75	-74.38	1.9869	-70.00	-8,090,000	156.32
Reduction in the gas burned in the exploitation field	---	0.00	18.34	-18.34	---	-9.48	-1,990,000	286.88
Redistribution of expansion options In order to generate electric Energy	---	25.02	79.60	-54.58	3.1815	-10.00 120.00*	-5,930,000	872.44 -67.99*

* BIOGENIC CO2
est. : manure
p.e. : electric processes
p.t. : thermal processes

AGRICULTURE, CATTLE RAISING AND FORESTRY SECTORS

In order to confront the environmental deterioration processes in the non-energy sector (increase of the agricultural frontier and consequent deforestation), the mitigation measures are delineated in the context of environmental legislation and use of land.

In this sense, it is expected that the Mechanism of Clean Development (MCD), with the supplementary principle of effective agricultural and forest activity, could directly support the technological change sustaining the adaptation of agricultural practices. This is necessary for maintaining long periods of productivity and diminishing incidences of agricultural practices in forests.



Other mitigation measures are basically related to the necessity for protecting forest biodiversity through the strengthening of protection and surveillance mechanisms, (especially in protected areas) and through a change in practices associated to a sustainable forest management.

A third group of mitigation measures draw attention to the increase in forested areas (forests induced by man), in order to develop forests with energy functions or extensive and intensive cultivation of timber species.

In the agricultural and cattle raising sectors, the mitigation measures point to the improvement of soil and water resource use, the implementation of agro-forestry systems, the natural regeneration of pastures and the improvement in animal breeding techniques in order to lessen methane emissions.

The selected measures maintain a close relationship with the strategic guidelines determined by the General Plan of Economic and Social Development of Bolivia (1997 – 2002) in order to integrate the program specified by the National Development Strategy.

The implementation of the selected measures will require technical and economic support from the international community. In this respect, Article 4, paragraph 3, of the United Nations Framework Convention on Climate Change states that "The developed countries and the other members of Annex II will provide new and additional financial resources to cover the entirety of the usual expenses made by the developing countries in order to complete their commitments."

In a similar way, Article 12, paragraph 6, of the Kyoto Protocol points out that one of the functions of the Mechanism of Clean Development is "to help, as necessary, the financing of projects with certified activities."

All the mitigation measures related to the GHG emissions in agriculture, cattle raising and forest sectors, have been discussed and have found a consensus based on consultations between all the interested sectors.

These measures use as evaluation approaches for project priority: their consistency with national politics, programs and development plans; the opportunity of reaching the proposed objectives, the mitigation potential of emissions; the existence of barriers for their implementation and the benefits (cost and effectiveness) of the mentioned measures.

BASE SCENARIO EMISSIONS (1990)

The activities related to land use change and the burning of forestry biomass are the main sources of carbon dioxide emissions in Bolivia. According to the National Inventory of Emissions (1990 and 1994) based on the IPCC Guide lines (1995 - 1996), the quantity of GHG emitted by agriculture, cattle raising and forest sectors was even superior to the emissions generated by the energy sector.

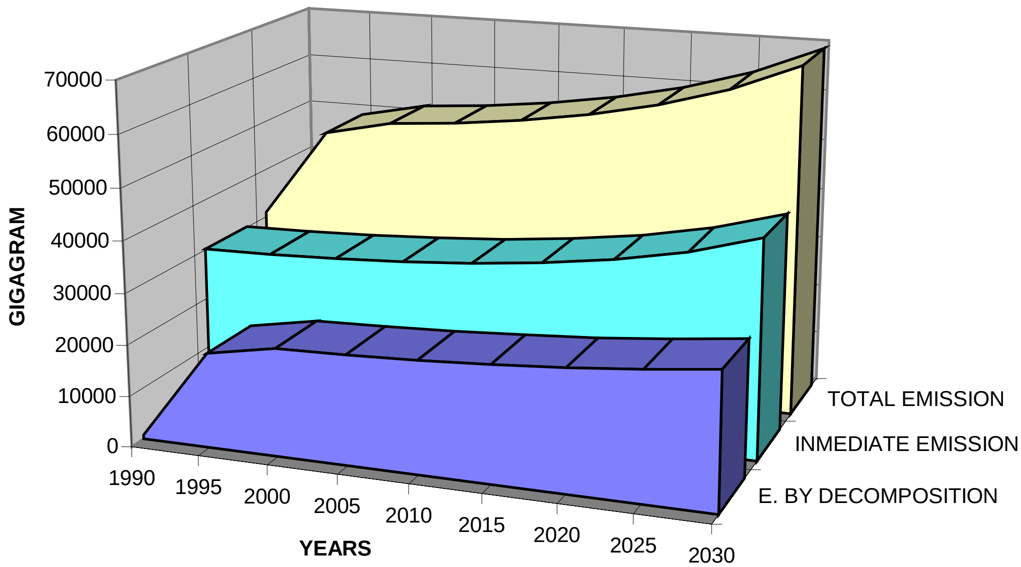
CO2 emissions related to land use change and forestry reached 38,617.11 Gg in 1994 and with increases to (according to COPATH) 51,772.46 Gg in 2000; 54,476.00 Gg in 2010; 59,600 Gg in 2020 and 69,161.00 Gg in 2030 (Graph 5.7)

The deforestation rate and the percentage of the deforested area dedicated to agriculture, pastures, timber extraction, fire and other land use were also calculated for each type of forest. The estimates were carried out using the rate of deforestation of 100,000.00 ha/year for the whole national territory (CUMAT, 1992 and Plan of National Forest Action, MACA/FAO, 1993).

The main sources of methane emission (CH4) are the livestock's enteric fermentation and manure management. Methane emissions totaled 744.63 Gg during 1994 with increases to 568.26 Gg all through 2000; 748.03 Gg during 2010; 839.47 Gg in 2020 and 870.02 in 2030 (Graphic No.5.8). These projections were obtained in relation to the increase of cattle population.

The steps followed to select the mitigation measures for carbon dioxide emissions are shown in the diagram. N 1. The approaches for the selection of these measures were based on their priority, consistency with the national development programs, opportunity, mitigation potential and barriers to their implementation.

Graphic 5.7. Base Scenario of future carbon dioxide emissions that derive from the forestall sector - Bolivia



Graphic No.5.8. Base scenario of future methane emissions that derive from the cattle raising sector - Bolivia.

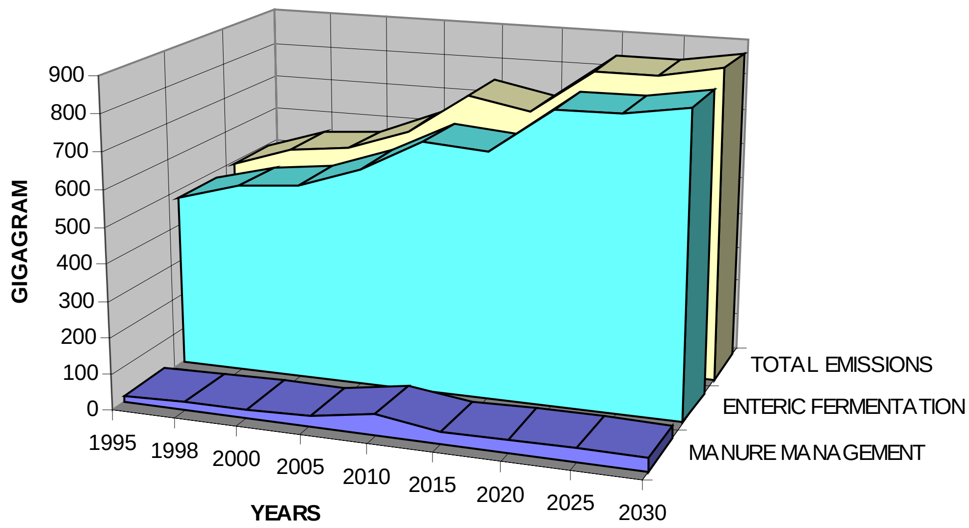
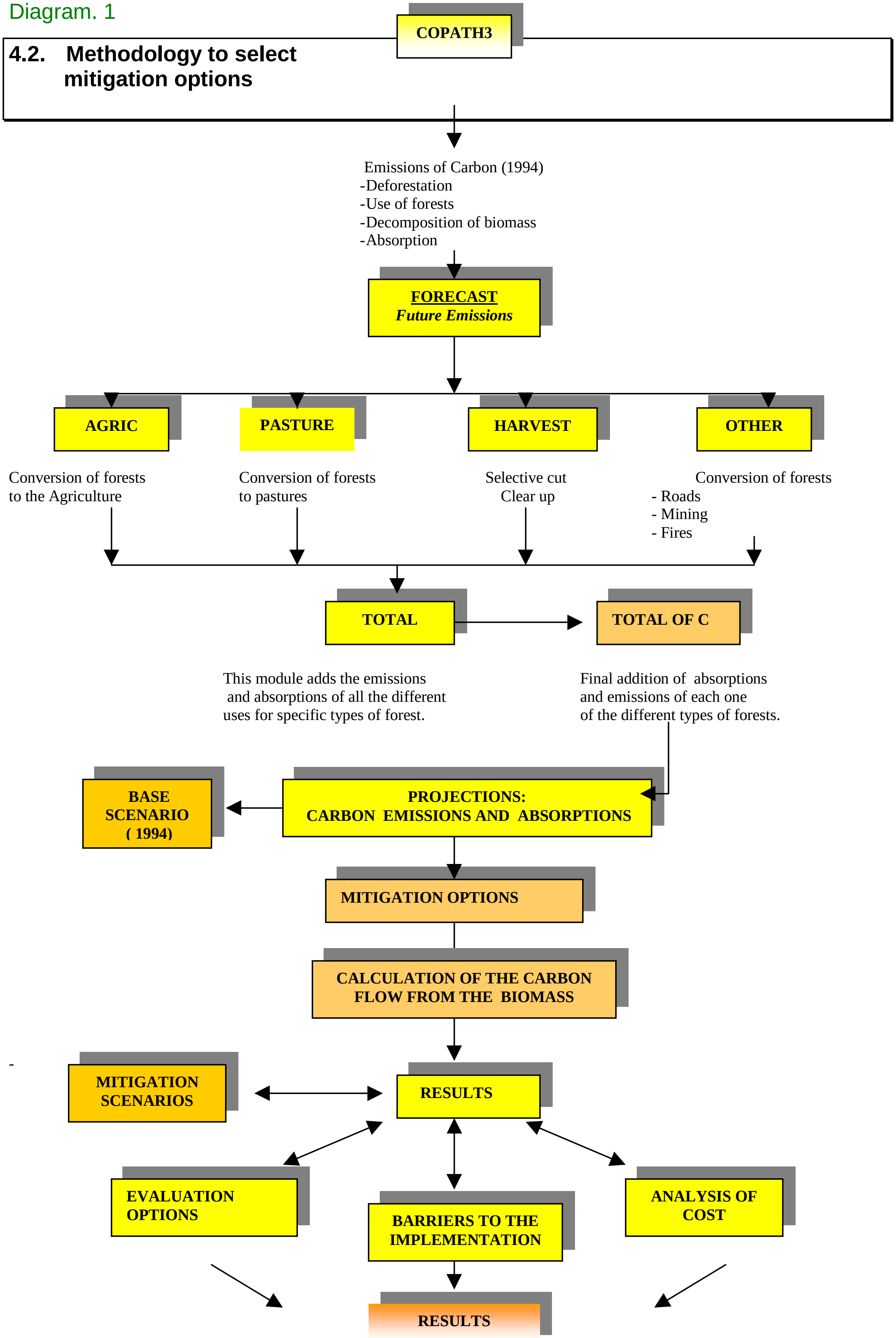


Diagram. 1

4.2. Methodology to select mitigation options



Measures to mitigate GHG Emissions

It is difficult to choose the most appropriate mitigation measures for the forestry sector since this issue is closely related to other economic, social and cultural problems in the country: land tenancy, expansion of the agricultural frontier, traditional cultivation methods, extensive cattle raising, traditional breeding of animals and the selective and industrial exploitation of tropical forests. We should also add the big discrepancies regarding the size of existing forest cover and the current deforestation indexes in the country.

The mitigation measures in the forestry sector are mainly related to the changes in the land use which normally vary with the environmental and ecological conditions of each region. The major part of the proposed mitigation measures are directed at the Amazon basin of the country where the highest rates of deforestation are registered. The mitigation measures are conceived to promote the sustainable use of renewable resources and to encourage the appropriate use of these resources.

Framed inside the politics of Sustainable Development promoted by the Government (New Forestry Law No. 1700 and the Law INRA No. 1715), the mitigation measures outlined for the forestry and agricultural sector plan to reduce the carbon emissions in two ways:

- Increasing the storage of carbon.
- Avoiding carbon emissions and encouraging forest conservation controlling the deforestation process.

The selected mitigation measures, taking into account previous approaches, are the following:

- **Formation of tree growing areas**; that could increase the drains of carbon dioxide. These plantations (native and exotic species), could also benefit the regions with a high desertification process (high plains, inter-Andean valleys and the Chaco plains).

- **Natural regeneration of forests** through the implementation of projects that promote the natural regeneration of native arboreal species in deforested areas which were once covered by primary forests. This measure is also contemplated in the New Forest Law (Art. 69).

- **Proposition of new alternatives to the traditional agriculture** which is based in the burning of fields and in the felling of trees. These alternatives will be directed to the reduction of greenhouse gas emissions (CO_2, CO, NOx, N_2O, and CH_4) and to the encouragement of sustainable land use in order to diminish impacts on the environment.

- **Implementation of the New Forestry Law** in order to establish mechanisms to fulfill the reduction of greenhouse gas emissions. The application of this law should be presided by an information campaign in order to generate a growing social support.

- **Invigoration of the planning, protection and surveillance capacities in the protected areas** promoting the sustainable use of resources and the conservation of biological diversity.

In the agricultural and cattle raising sectors, the mitigation measures, beyond the reduction of greenhouse gas emissions, are mainly directed to the improvement of cultivation productivity and to the breeding of animals. Some of the proposed measures are as follows:

- **Control of land at risk from degradation**: in order to increase the drains of carbon dioxide, and with the intention of giving a solution to the problems derived from the degradation of all areas suffering from desertification. Through this measure, the implementation of agro-forestry systems and the regeneration of natural grasslands should be implemented.

- **Improvement of animal breeding techniques** in order to reduce the methane emissions generated by the enteric fermentation, related to the breeding of bovine and ovine livestock in Bolivia. New handling systems of breeding should be developed.

EVALUATION AND PROJECTION OF THE MITIGATION MEASURES

Numerous analysis of mitigation have been carried out in forestry and agricultural sectors in order to establish the potential of the different measures for reducing carbon dioxide. Until now, there are no standard procedures to estimate the economic implications of this reduction and there are not even procedures to estimate the exact quantity of retained carbon by sector and by mitigation measure (EPA, 1995). During the elaboration of the current document, once the different mitigation measures were selected, the mentioned parameters limited the estimation of carbon reduction for future scenarios:

- The potential quantity of retained carbon through the formation of new tree growing areas in the temperate area of Bolivia reaches 2.39 tons C/ha annually. In 40 years time, this quantity would be considered as optimistic since the forest repopulation is normally made in marginal lands, with a shortage of nutrition.

- Through the natural regeneration of tropical forests in Bolivia it is possible to retain 5.62 tn C/ha per year for a 30 year period, considering an annual vegetable growth rate of 12.50 tn ms/ ha per year for these type of forests.

- The application of alternative agricultural systems to the traditional practices based on felling and burning, means 1.35 tons C/ha of carbon would be retained annually for a 40 year period. This quantity was estimated by Dixon et all (1993) and Krankina & Dixon (1994) in studies carried out for humid tropical regions of South America where the values vary between 0.78 and 2.04 tons C/ha/year.

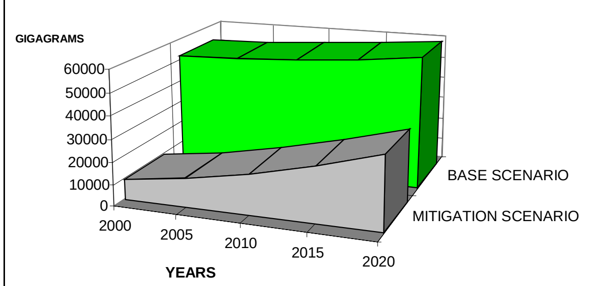
- Carbon emissions retained through the implementation of the New Forest Law, plus the invigoration of the planning and protection capacities in protected areas totals 119.21 tons C/ha in humid tropical forests. Considering that the average biomass of these forests are 238.42 tons/ha, the retained carbon could total 300 tons ms/ha in the primary forests of the Amazon area of Bolivia.

- The control of land at risk from degradation could allow the retention of 1.35 tons C/ha/ year for a 40 year period with the application of agricultural systems. The retained carbon could total 1.12 tons C/ha/ year, for a 25 year period through the natural regeneration of grasslands.

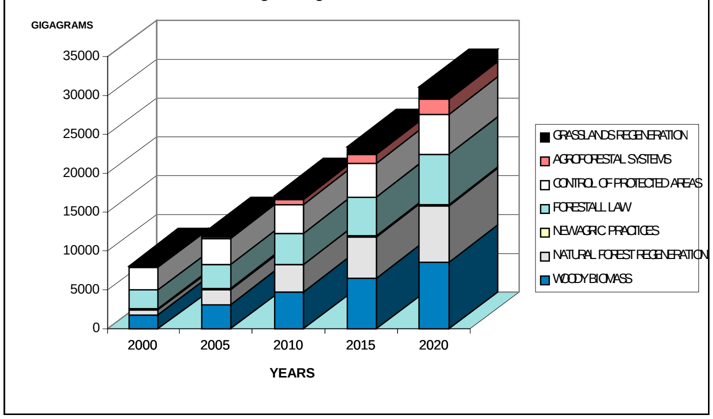
Regarding the reduction of methane emissions, the application of mitigation measures, referring to the improvement of techniques for animal breeding, would increase the productivity indexes of the bovine and ovine livestock by 10%. This represents a reduction of 3.8% annually in methane, generated by enteric fermentation assuming the measure is applied to 5% of bovine and ovine livestock existing in the country.

The total reduction of greenhouse gas emissions, resulting from the mitigation measures described previously, are shown in the Chart. 5.13. According to this chart a considerable reduction would be accomplished if the Bolivian government executes at least seven of the measures. In this case, CO2 emissions would be reduced by 15.63% for the year 2000, 23.01% for 2005 and 31.63% for 2010 (Graph 5.9).

Graphic.5.9. Carbon Dioxide Emissions in the base and mitigation scenarios for the agricultural, cattle raising and forestall sectors of Bolivia



It can also be noticed that the mitigation measures that contribute better in reducing carbon dioxide, are those referring to the formation of new tree growing areas, the regeneration of natural forests, the implementation of the New Forest Law and the protection and surveillance of the protected areas. (Graph 5.10).



Graphic.5.10. Reduction of carbon dioxide emissions through mitigation measures

CHART Not 5.13. Total reduction of greenhouse gas emissions (carbon dioxide and methane) in the mitigation and base scenarios.

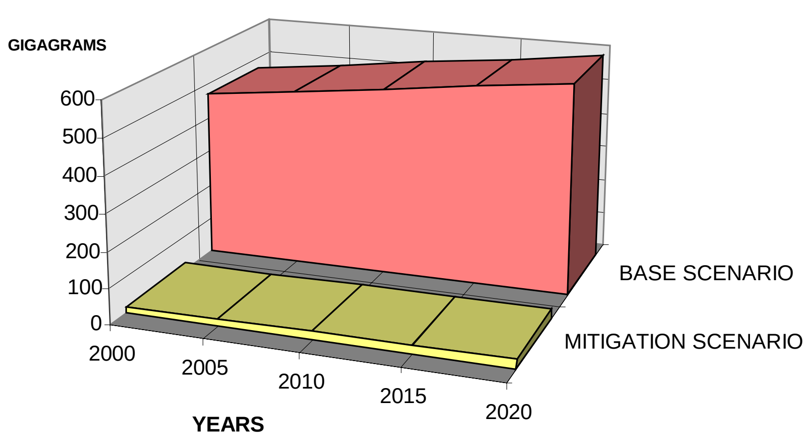
MITIGATION MEASURES FOR THE FORESTAL, AGRICULTURAL AND CATTLE RAISING SECTORS	YEAR				
	2000	2005	2010	2015	2020
CARBON DIOXIDE (CO2)					
FORESTAL SECTOR:					
- Generation of tree growing areas. (forestation and reforestation)	1.930.42	3,215.03	4,754.10	6,547.64	8,595.65
- Natural regeneration of forests.	649.69	1,938.75	3,485.63	5,290.31	7,352.81
- Alternatives to the traditional agricultural practices (burn of fields and felling of trees)	86.58	98.95	111.33	123.70	136.08
- Implementation of the New Forest Law	2,409.51	3,075.22	3,924.84	5,009.21	6,393.16
- Invigoration of the planning, protection and surveillance capacities in the protected areas.	2,862.03	3,317.88	3,846.33	4,458.95	5,165.14
AGRICULTURAL SECTOR:					
Prevention and control of land degradation:					
- Implementation of agro-forestry systems .	81.92	283.03	603.93	1,128.58	1,968.69
- Natural grassland regeneration	73.39	239.99	509.91	944.61	1,644.70
TOTAL (GG) SCENARIO "A" USING MITIGATION MEASURES.	8,093.54	12,168.85	17,236.07	23,503.00	31,260.23
TOTAL (GG) SCENARIO "B" WITHOUT MITIGATION MEASURES	51,772.47	52,882.51	54,476.54	56,658.30	59,600.05
PERCENTAGE OF **METHANE (CH4)** REDUCTION	15.63%	23.01%	31.63%	41.48%	52.45%

CATTLE RAISING SECTOR:					
To improve animal breeding techniques.	17.83	19.02	20.21	21.41	22.60
TOTAL (GG) SCENARIO "A" USING MITIGATION MEASURES.	17.83	19.02	20.21	21.41	22.60
TOTAL (GG) SCENARIO "B" WITHOUT MITIGATION MEASURES	467.74	498.13	528.52	558.91	589.30
REDUCTION PERCENTAGE	3.81%	3.81%	3.82%	3.83%	3.83%

The quantity of carbon dioxide retained through measures used as an alternative to traditional practices is insignificant in relation to other mitigation measures. However, each hectare converted to the sustainable handling of land (agro-forestry systems) represents between 1 and 3 hectares of humid tropical forest protected from the burning of fields and felling of trees.

As a result, significant levels of potential carbon dioxide would be retained in the considered ecosystems. For the period 1998 – 2030, CO2 reduction would vary from 14% to 21% for each hectare of protected forest, 29% to 41% for two protected hectares and 43% to 62% for three hectares of protected forest. In consequence, this mitigation measure can be considered one of the best alternatives for reducing carbon dioxide emissions in Bolivia. On the other hand, the application of measures for improving animal breeding allows a reduction in methane emissions (CH4) by 3.81% for the year 2000, 3.81% for 2005 and 3.82% for 2010 (Graph Not. 5.11).

Graphic No. 5.11 Methane emissions (CH4) in the base and mitigation scenarios – Cattle raising sector of Bolivia.



ANALYSIS OF COSTS

The budget required to implement the appropriate mitigation measures in reducing carbon dioxide and methane emissions in the forestry, agricultural and cattle raising sectors for the year 2000, is US $48.66 million. The highest costs are related to the improvement of animal breeding techniques and to the application of alternatives to traditional agricultural practices (Chart No.5.14).

The highest unitary cost (US$/Gg of reduced CO2), also refers to the application of alternatives to traditional agricultural practices (burning of fields and felling of trees) basically, because the total quantity of mitigated carbon does not include the potential emissions retained per hectare of forest protected from deforestation. The unitary cost per ton of mitigated carbon dioxide varies between 1 and 79 dollars.

CHART NO.5.14. Total and unitary cost of mitigation measures outlined to reduce greenhouse gas emissions (carbon dioxide and methane) in Bolivia.

MITIGATION MEASURES FOR THE FORESTAL, AGRICULTURAL AND CATTLE RAISING SECTORS	YEAR 2000		YEAR 2010		YEAR 2020	
	TOTAL COST 103 US $	UNITARY COST US$/Gg	TOTAL COST 103 US $	UNITARY COST US$/Gg	TOTAL COST 103 US $	UNITARY COST US$/Gg
FORESTAL SECTOR:						
- Generation of tree growing areas. (forestation and reforestation) .	3,044.00	1,576.80	4,204.00	884.20	5,364.00	624.00
- Natural regeneration of forests.	4,400.00	6,772.49	6,400.00	1,836.11	8,400.00	1,142.42
- Alternatives to the traditional agricultural practices (burn of fields and felling of trees)	6,848,57	79,105.18	8,806.42	79,105.18	10,764.27	79,105.18
- Implementation of the New Forest Law	3,307.50	1,372.68	5,387.56	1,372.68	8,775.78	1,372.68
- Invigoration of planning, protection and surveillance capacities in the protected areas.	3,492.58	1,220.32	4,693.74	1,220.32	6,308.00	1,220.32
AGRICULTURAL SECTOR: Prevention and control of land degradation:						
- Implementation of agro-forestry systems .	2,420.00	29,540.11	6,276.85	10,341.86	16,280.54	8,269.74
- Natural grassland regeneration	1,210.00	16,714.15	3,138.42	6,154.92	8,140.27	4,949.40
CATTLE RAISING SECTOR:						
To improve animal breeding techniques	16,945.00	950.39	19,287.00	954.02	21,629.00	956.89
ANNUAL BUDGET (US $)	41,667.65		58,193.99		85,661.86	

s/d: Non determined, because it doesn't end up completing the unit of the used measure (Gigagram).

Similarly, the increase of tree growing areas in order to mitigate carbon dioxide emissions, have a high cost and they would vary from US $500.00 to 750 by hectare.

For the next ten years, the budget required to implement new mitigation measures will be increased, especially if bigger reductions of carbon dioxide and methane emissions are planned. The budget would rise to US $58.19 millions for the year 2010 and to US $85.66 millions for the following decade.

The sustained international cooperation from the countries of Annex I, supported by government national politics, is the only way to fulfill the implementation of mitigation measures in the forest and agricultural sectors of Bolivia.

CHAPTER V

SYSTEMATIC OBSERVATION, EDUCATION, AND PUBLIC AWARENESS

OBSERVATION

Global systems of observation for land with regional and international investigation initiatives

The international scientific community is carrying out efforts to define groups of work in the area of “global change." Four aspects of environmental change in global scales are recognized (I) changes in land cover and usage, (II) a decrease in biodiversity in a global scale, (III) changes in the atmospheric composition, especially the increase of CO2 concentration, and (IV) climate change taken as a central topic in the investigation of global changes.

The investigations related to global changes highlight the relationship between changes in land cover and usage and changes in atmospheric composition, especially the increase in CO2 concentration.

In this sense, there are different initiatives at global level: the IGBP (International Geosphere Biosphere Program) dedicated to the investigation of the environmental changes of global character and the IHDP (International Human Dimensions Program) orientated to investigating the human dimension for global environmental changes. These programs, jointly with ICSU, SCOPE (Scientific Committee on the Problems of the Environment) and IPCC (Intergovernmental Panel on Climate Change) constitute the scientific reference for the investigation of global change, in cooperation with the United Nations programs.

There are also, inside the United Nations Programs, initiatives of global observation like the G3OS, composed of three systems for earth observation: the GCOS (Global System of Climate Observation), the GOOS (Global System of Oceanic Observation) and the GTOS (Global System of Terrestrial Observation). These observation systems should find similar systems on a national stage.

In this side of the world, the IAI (Inter-American Institute for Global Change Research) is constituted as the regional organization that assumes the investigation of global change in Latin America. Bolivia will soon be a member of this organization.

Data Exchange and accessibility

Bolivia is working right now to have access to mechanisms of information exchange, which is one of the reasons for promoting a closer cooperation with the different participants of the investigation process. We need cooperation networks that will allow the exchange of data and results through varying publications.

The Government is trying to promote the access to public data, integrating its institutions with the cooperation networks and facilitating a process of information exchange. The implementation of an informative bulletin and/or a scientific magazine could support this process.

Bolivia is a highly vulnerable country because of climate change that affects agricultural production, forests and water resources and human health. However, it does not have a hydro-meteorological network that might cover the whole territory.

In order to adapt the different productive sectors to the needs of climatic change and to increase the levels of human security, Bolivia has the important task to improve its observation capacities and monitor climate change. Part of its priorities are to increase the levels of knowledge regarding the directional forces that produce a deterioration in the productive bases of society (natural and human resources), to control the increase of GHG emissions and to promote strategic alliances of work between the scientific community and the political and social participants.

At present, this network is being managed by the National Service of Meteorology and Hydrology (SENAMHI), an entity that belongs to the Ministry of Sustainable Development and Planning, which participates as a member of the World Meteorological Organization.

The SENAMHI has the following objectives: to centralize the meteorological information, to operate and to maintain the national network of stations, to study the climate and to provide information about weather and water resources, and to provide the necessary information for institutions that work with the use of non renewable natural resources. However, limitations of infrastructure are a constant obstacle for making a scientific study of the existing climate variations and changes.

In spite of these limitations, Bolivia participates in the meetings of the Intergovernmental Panel of Climatic Change (IPCC), in the meetings of the UNFCCC and in the different Programs promoted by the United Nations related to biodiversity, desertification and natural resources.

Resulting from this, the Vice-ministry of Environment, Natural Resources and Forest Development has created the National Program of Climatic Changes (PNCC) with the objective of facing the commitments contracted in the United Nations Framework Convention on Climate Change and in the Kyoto Protocol.

Similarly, the creation of the Inter-institutional Climatic Change Council (CICC) responds to the necessity for coordinating environmental actions between the government and private and scientific institutions, with the purpose of suggesting political actions relating to climate change and its implications. The CICC is composed of the following institutions:

- Ministry of Sustainable Development and Planning
- Vice-ministry of Environment, Natural Resources and Forest Development
- Vice-ministry of Foreign Policy

- Vice-ministry of Energy
- Vice-ministry of Agriculture and Cattle Raising
- Vice-ministry of Public Investment and External Financing
- National academy of Sciences
- Confederation of Private Investors
- Non - governmental organizations

In recent years, different institutes and universities have joined in their efforts to investigate green house gas emissions and analyze vulnerability and mitigation measures.

EDUCATION

The increase in scientific capacities related to climate change constitutes a transcendental element in accomplishing the following strategic objectives:

- To improve the method of acquiring data and information;
- To increase the understanding of global change and its repercussions for society;

In the way this process is carried out nationally, regionally and internationally, both objectives crisscross, which is why better methods of observation and measuring are basic conditions for improving understanding.

Improvement in infrastructure can not be seen as a purely institutional development. The main goal should be to find strengths in the existing infrastructure nationally, and its diversity.

In this sense, it is important to define the high-priority topics in the field of climate change, to generate groups of work and cooperation networks that could have access to eventual beneficial projects.

These networks will be composed according to the high priorities of the society and in agreement with the global tendencies, to facilitate international cooperation.

Meteorology and environmental quality

The meteorological capacities of the country must be improved in order to have a greater understanding of climate variability. Increases in agricultural productivity depend strongly on the availability of reliable climatic and meteorological data. In this sense, the expansion of the meteorological network of measurements is a significant requirement.

The SENAHMI must be strengthened in its capacities of information treatment. The possibility of working together with the municipalities must be evaluated, with the intention of fulfilling the acquisition of municipal meteorological data, and the enlargement of the measurement network to a bigger number of stations.

The SENAHMI should also be integrated in regional initiatives for the monitoring of “El Niño” and other initiatives for measuring GHG emissions.

The meteorological investigation must reach levels of systematic work predicting risks like droughts and floods and becoming one of the constituent elements of the civil defense system. The construction of general circulation models of regional scale is indispensable and international support for the construction of these models is highly required.

The laboratories of environmental quality must support the monitoring of GHG emissions, putting a special emphasis on the monitoring of environmental quality in urban centers

Ecosystem Vulnerability

Climate change will produce modifications in the patterns of habitability for different flora and fauna species. There are medium levels of certainty that different productive ecosystems (savannas and forests) would be affected by changes in the supply of water and increases in temperature. In addition, there are high levels of certainty that the water deficit of some ecosystems will become worse, increasing erosion and desertification levels in a country that is already vulnerable from the point of view of its ecosystem.

The theme of climatic change must be divulged in ecological investigation centers in the whole country, in order to initiate further investigations related to this issue.

On the other hand, the international community should increase the communication levels among the different investigation centers, through the organization of national meetings and symposiums orientated to the training of specialists in ecosystem vulnerability.

diseases and illnesses

The monitoring of diseases and illnesses that could be exacerbated by climate change is of extreme importance. There are medium levels of certainty that this can occur. Levels of illness incidence transmitted by vectors not only expand or change the habitat of some vectors, but also generates new species of vectors that could increase illnesses related to air and water quality or to the availability of food.

The Bolivian government, with international cooperation, must strengthen the investigation centers that work on tropical diseases supporting, at the same time, the decentralization process of the system of basic health care and prevention.

There is a high certainty that illnesses and diseases which affect crops could change their patterns of incidence. A permanent observation in this field is highly recommended.

Special emphasis must be put on the development of technologies dedicated to the biological control of diseases and vectors.

Changes in the land use and cover

The use of technologies such as GIS and Tele-detection since the 70´s, have enabled the big gap in information to be overcome in areas related to the elaboration of maps and processing of territorial classifications.

The plans regarding land use, elaborated by the ZONISIG and PLUS (Santa Cruz) contemplate an environmental and socioeconomic profile that allow reliable bases to be established, for further development of colonization (points of development and infrastructure). The territorial classification will also assure the fulfillment of plans linked with the sustainable handling of forests and biodiversity protection.

Clean Development

The paradigm of clean development must be studied under the conditions and priorities of the country: industrial development, generation and use of energy, forest management, consolidation of small and medium companies, investigation of clean technologies, incentives, credits, etc.

Human vulnerability, alimentary security, handling of water resources and "environmental refugees"

Indicators for monitoring human development must be carried out in the country. The Social Index of Vulnerability, the Index of Human Development and the Index of Human Poverty could be effective parameters, but they must be revised continually in an isolated way and in their relationship with climate change.

In the scientific discussion on vulnerability and human adaptation it is possible to establish a clear incidence of poverty in vulnerability levels. Poor people are most vulnerable to climate change.

Topics like alimentary security, access to water resources and the problem of the denominated "environmental refugees" (people that has to leave their homes because of climate changes) are important publicly. From the view of climate change, these topics are highly relevant.

Finally, the government of Bolivia will make efforts to increase communication levels between different individuals, investigation centers, programs and institutions, through workshops and national symposiums in order to contribute to the training of human resources in human vulnerability.

➢ FORMAL AND NON FORMAL EDUCATION

Education must support the strategic lines of productive transformation and human security. The international community is elaborating curriculums on formal education regarding global environmental change. These curriculums could be nationally reapplied in different spheres.

On the other hand, cultural changes emerging from this adaptation process, will be introduced by parallel processes of non formal education in all spheres of society.

The characteristics of the education curriculum in climate change will be analyzed and discussed in the context of sustainable development and educational reforms.

Non-formal education will be carried out to support already existing programs related to environmental education, in order to strengthen adaptation measures. The priorities are:

- Education for technology introduction
- Education for cultural changes in production
- Education for health

The implementation of adaptation measures in the country will be realizable if it is strongly supported by an educational component. The communities, municipalities and regions will implement the adaptation measures if they are aware of the benefits of this change. Education processes must be applied together with other training processes in order to reach regional development.

Rejection to change is basically explained by a lack of awareness on repercussions that these changes can have on their way of life, individually and collectively.

In this sense, education is a tool that could help in diminishing uncertainty and assure participation of communities, municipalities and regions in projects of mitigation and adaptation regarding the impact of climate change.

CHAPTER VI
COMPLEMENTARY INFORMATION

Bolivia has begun an aggressive approach in order to cooperate in conjunction with the countries of Annex I in the reduction of GHG emissions according to the specifications of the UNFCCC and the Kyoto Protocol. Government politics now involve climate change as an important element of sustainable development.

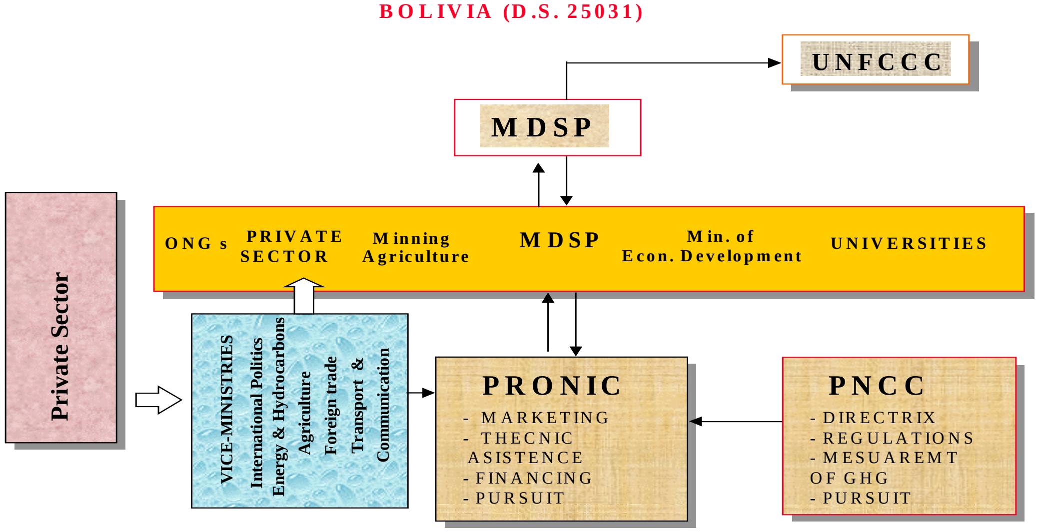
The creation of the Ministry of Sustainable Development and Planning and the development of mitigation scenarios of GHG in the energy and forest sectors (implemented through different projects), are a sample of the political will that the government wants to show to the international community.

Based on discussions of the different sectors, the government has developed a National Plan of Action on Climate Change, establishing actions and priorities that can be carried out with international support in order to reduce greenhouse gas emissions.

The combined implementation allowed to several projects to be developed with the cooperation of the countries that make up Annex I of the UNFCCC. These projects will be used as an accumulation of experience, procedures, and systems of control. Certification and systems of distribution regarding emission reduction will be implanted in future actions in projects framed by the Mechanism of Clean Development (Kyoto Protocol).

Bolivia has also constructed the National Program of Combined Implementation (PRONIC), which will take charge of managing all future projects of the Ministry of Sustainable Development. In order to accomplish this commitment, there is just one organization that approves the projects through an inter-institutional directory as is shown in the following graphic.

PROGRAM OF COMBINED IMPLEMENTATION
BOLIVIA (D.S. 25031)



UNFCC = United Nations Framework Convention on Climate Change

The actions jointly implemented in the country include the following projects:

- Project of Climatic Action Noel Kempff Mercado.
- Project of rural electrification with solar energy (Pilot stage). Departments of Chuquisaca and Oruro.
- Project of rural electrification in the counties of Ñuflo of Chavez and Guarayos.
- Formulation of projects of combined implementation.

The first two projects would count on the support of the United States Initiative Joint Implementation Office , and the two remaining have the assistance of the Netherlands Joint Implementation Office.

The international community has a historical roll which is to support the efforts of the highly vulnerable countries such as Bolivia, and to assist them in the improvement of their infrastructure for climate observation, acquisition of equipment that allow the measurement of climate change, support for the investigation of GHG emissions and the assistance in the construction of national capacities (institutional and human) in order to prop up projects of adaptation in the different sectors.

NATIONAL STRATEGY

The Government of Bolivia has developed a National Strategy in order to guarantee the implementation of the United Nations Framework Convention on Climate Change. This strategy seeks to establish a shared vision among the different actors in its implementation. The strategy also establishes the institutional mission of the organizations in charge of this implementation.

Bolivia's strategy on climate change is centered on four pillars which also respond to its lines of action in the field of economic and social development:

- To promote clean development through the inclusion of technological changes in agricultural, forest and industrial practices, to reduce emissions and to make a positive impact on the country's development.
- To cooperate on the reduction of carbon in forests, tropical areas and other natural ecosystems.
- To increase the effectiveness of infrastructure and energy use, to diminish risks of contingencies and to mitigate the effects of GHG emissions.
- To increase the observation and the investigation of climate and environmental changes in order to develop effective answers.

The implementation of this strategy also responds to the following objectives:

- To promote adaptation politics to climate change in order to obtain technological transformation in the different productive sectors, introducing clean technology that could similarly help the development of this sector.
- To increase levels of human security considering issues like contingency and human vulnerability.
- To integrate the theme of climate change into society through different educational processes.
- To generate strategic alliances in order to achieve the implementation of the National Strategy.

The strategic lines to follow are :

- To fortify and transform the productive sector;
- To increase human security;
- To use education and communication in order to achieve adaptation to climate change; and
- To make strategic alliances in order to achieve the implementation of the National Strategy.

Similarly, Bolivia has begun, with the support of the Switzerland Cooperation and the World Bank, the study of the participation strategy in the mechanism of Clean Development proposed by the Kyoto Protocol, as an immediate action to the ratification of this protocol carried out in November 1999.

REQUIREMENTS

Financial and technological support to tackle the causes and implications of climate change is urgently needed not only in Bolivia but in the whole region.

The considerable climate variations in Latin America and, particularly in Bolivia make it necessary for different resources to improve the construction of climate scenarios and to reduce levels of uncertainty.

Similar support is also needed to combat GHG emissions provoked by changes in land use, forestry and some energy sectors.

The mechanism of Clean Development represents a very important challenge for the developing countries, however, the inequalities between the national capacities lead to inequalities in the access of projects and economical support. It becomes indispensable, in this sense, to demand a fair treatment from the UNFCCC in this matter through a decisive support that could benefit the training of human resources and the consolidation of institutions working on climate change.

Finally, the decisive support of the UNFCCC to the National Program of Climate Change in Bolivia is indispensable in order to guarantee and consolidate the process of implementation of the UNFCCC.

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