National Communication

Republic of Ecuador

UNITED NATIONS FRAMEWORK CONVENTION

Climate Change

Elaboration, coordination, and editing: Luis Cáceres-Silva. Support: Roberto Carrillo (ECOENERGY)

Editing: Alejandro Bermeo and Patrick Saari

Jacket design: María Isabel Castro

Layout: Claudia Luján

Press: Gráficas Iberia
Bogotá 4-53 y América
Teléfono: 521-529

Printed in Ecuador

November 2000

National Climate Committee
Ministry of the Environment
Climate Change Project ECU/99/G31
Ave. Amazonas & Eloy Alfaro, MAG Bldg., 7th floor, office 709
Phone: (593-2) 508 510
Fax: (593-2) 508 510
E-mail: cclimat@ambiente.gov.ec
Quito, Ecuador

ministerio del ambiente
República del Ecuador

Quito, November 9, 2000
Letter MA-PCC-0849

Mr. **MICHAEL ZAMMIT CUTAJAR**
Executive Secretary
United Nations Framework Convention on Climate Change
Germany

Dear Mr. Executive Secretary:

Climate change is already a reality that is affecting all of our countries with unusual frequency and intensity. Phenomena like El Niño, which recently led to huge losses in our country, are rendering the poverty of our population even more severe, and tackling this phenomenon has become a priority for Ecuador.

The above, along with the risk of a severe deterioration of ecosystems and highly vulnerable zones, makes us fully share the provisions set forth in Articles 4.8 and 4.9 of the UNFCCC and Article 3.14 of the Kyoto Protocol.

On the basis of the principle of assuming "common but differentiated responsibilities", Ecuador signed and ratified the Convention on Climate Change and the Kyoto Protocol and has made major efforts, with the support of international cooperation, to carry out studies and evaluations on climate change and related topics.

As Minister of the Environment and President of the National Climate Committee, I am pleased to submit to you and, by your good offices, to the Conference of the Parties, the First National Communication of Ecuador as a token of our interest in collaborating to resolve this global problem.

Finally, along with my thanks for the support from the Secretariat, friendly countries, and international organizations, I would like to underscore our wish that the National Communication will help to consolidate increasingly intense and effective international cooperation that will contribute to building the road to sustainable development for our countries.

RODOLFO RENDÓN B.
Environment Minister
Republic of Ecuador

TABLE OF CONTENTS

LIST OF TABLES

LIST OF CHARTS

LIST OF MAPS

Baseline studies and assessments for the National Communication

VULNERABILITY AND ADAPTATION:

- Evidence of Climate Change. National Meteorology and Hydrology Institute (INAMHI).
- Climate Change Scenarios in Ecuador. INAMHI
- National Assessment. CC:TRAIN - Ecuador
- Evaluation of the Vulnerability of Forest Ecosystems to Climate Change. Center for the Integrated Survey of Natural Resources by Remote Sensing (CLIRSEN).
- Vulnerability of Agriculture to Climate Change. Ministry of Agriculture and Livestock (MAG).
- Study on Climate Change in Ecuador. General Summary. Ecuador Climate Change Country Study Project.
- Evaluation of the Vulnerability of Water Resources to Climate Change in Ecuador. INAMHI
- Evaluation of the Vulnerability of the Coastal Zone of the Gulf of Guayaquil. National Fishing Institute (INP), Oceanographic Institute of the Navy (INOCAR), INAMHI, University of Guayaquil, private consultants.
- Strategy of Adaptation to Climate change in the Lower Guayas River Basin. Ministry of the Environment, INP, INOCAR, INAMHI, MAG.
- Environmental, Economic, and Social Impact Assessment of the Implementation of Adaptation Measures in the Agricultural Sector. MAG.
- Environmental, Economic, and Social Impact Assessment of the Implementation of Adaptation Measures in the Forestry Sector. Ministry of the Environment - CLIRSEN.

MITIGATION:

- National Greenhouse Gas Emission Inventory. Ministry of Energy and Mines.
- Evaluatoin of Forestry Mitigation Options. CLIRSEN
- Mitigation Evaluation. Land Use – Agricultural and Livestock Sector. Ministry of Agriculture and Livestock.
- Greenhouse Gas Mitigation, Energy Sector. Ministry of Energy and Mines.

- Environmental, Economic, and Social Impact Assessment of the Implementation of Adaptation Measures in the Energy. Ministry of Energy and Mines.
- Environmental, Economic, and Social Impact Assessment of the Implementation of Adaptation Measures in the Agricultural Sector. Ministry of Agriculture and Livestock.
- Environmental, Economic, and Social Impact Assessment of the Implementation of Adaptation Measures in the Forestry Sector. Ministry of the Environment - CLIRSEN.
- Strategies for the Implementation of Climate Change Mitigation and Adaptation Measures in Ecuador. Ministry of the Environment - ECOENERGY.

Introduction

The rise of global greenhouse gas (GHG) emissions is generating a global warming that has no borders and is exerting direct and indirect impacts on mankind.

The international response is embodied essentially in the 1992 adoption of the United Nations Framework Convention on Climate Change, which is now in force, and the 1997 Kyoto Protocol, which is in the process of being ratified.

Nationally, the country adopted and ratified the two international legal instruments and, as part of this plan, the so-called Climate Change Process in Ecuador (PCCE) started in 1993, with four long-term objectives:

- Implement basic institutional capacity to tackle climate change problems.
- Analyze climate change and its possible impacts on the country's strategic areas.
- Define alternative responses to climate change for decision making.
- Fulfill international commitments.

The progress in meeting the objectives that were set forth has relied on international assistance, which has made it possible to carry out various projects that coordinated the studies and evaluations conducted by the institutions in charge of national policy on these topics, such as the Ministry of the Environment, the Ministry of Agriculture and Livestock, the Ministry of Energy and Mines, the Integrated Remote Sensing Natural Resources Survey Center, the National Institute of Meteorology and Hydrology, the Oceanographic Institute of the Armed Forces, the National Fishing Institute, the Coastline Resource Management Program, and the University of Guayaquil. Moreover, targeted support in specific aspects was provided by private companies and consultants.

The establishment of the National Climate Committee (CNC), by executive decree in June 1999, was a clear signal of the importance of climate change for the country.

The elaboration of the First National Communication of Ecuador, under the responsibility of the GEF-UNDP ECU/99/G31 Climate Change Project and with the supervision and support of the Ministry of the Environment, on behalf of the CNC, has been a major challenge and a fine opportunity to integrate and bring together, in one single document, the results of studies and evaluations made in the country over the last few years.

The process of elaborating the National Communication was developed on the basis of three phases with different key players: the integration of the studies and elaboration of the preliminary versions; consultancy and discussion; and finally approval by the National Climate Committee.

A first draft was submitted to the consideration of a wide range of public and private institutions, including those who conducted the studies and members of the CNC, who provided their comments. On the basis of this review, a second version was generated, and it was analyzed and discussed at workshops and working meetings by those who implemented the studies and related guests. Finally, a text that was agreed upon was submitted to the National Climate Committee, which approved it at the start of November 2000.

Summary

INTRODUCTION

The rise of global greenhouse gas (GHG) emissions is generating a global warming that has no borders and is exerting direct and indirect impacts on mankind. The international response is embodied essentially in the 1992 adoption of the United Nations Framework Convention on Climate Change, which is now in force, and the 1997 Kyoto Protocol, which is in the process of being ratified.

Ecuador has adopted and ratified the two international legal instruments and, as part of this plan, the so-called Climate Change Process in Ecuador (PCCE) started in 1993.

The elaboration of the First National Communication of Ecuador has been a major challenge and a fine opportunity to integrate and bring together, in one single document, the results of the studies and evaluations conducted in the country over the last few years.

The First National Communication is basically a result of the GEF-UNDP ECU/99/G31 Project on Climate Change, which like other similar projects has involved the participation of various national organizations and the support and direction of the Ministry of the Environment, on behalf of the National Climate Committee.

NATIONAL CIRCUMSTANCES

▶ GENERAL CHARACTERISTICS OF ECUADOR

Ecuador is located in the northwestern part of South America and has a territory of 256,370 km2. The country's physical, ecological, climate, etc. characteristics are determined by its special location on the planet, with the equatorial line running through it latitudinally and the cordillera of the Andes crossing it longitudinally, with transversal mountain systems crisscrossing the Andes from east to west, giving rise to inter-Andean valleys. The country's lowlands and flatlands are located to the west along the Pacific Ocean and to the east in the Amazon River basin.

Climate conditions are influenced by various factors that explain the sharp variations in time and

space throughout the country and its different regions. In contrast to countries in the world's high latitudes, Ecuador

has two highly differentiated seasons in terms of rainfall, a rainy season and a dry one, except for the Amazon region, where rainfall is high throughout the year.

The negative influence of events such the El Niño-Southern Oscillation (ENSO) can be appreciated when examining variations in gross domestic product (GDP): between 1982 and 1983, for example, the annual GDP rate declined from 3.9% in 1981 to 1.2% in 1982 and to –2.8% in 1983.

Ecuador's population in the year 2000 amounts to about 12 million inhabitants. The migration to the country's large cities has changed the country's demographic composition: urban inhabitants, who in 1960 were on the order of 29%, accounted for 55% of total population in 1990.

▶ DEVELOPMENT PRIORITIES

According to the Government's Plan to Overcome the Crisis: 2000–2003, the country's current critical situation is apparent in various indicators, but there is no doubt that the national problem with the highest priority is the sharp rise in poverty.

Various structural and current factors have led to a sharp economic downturn and a rise in the inequity of income distribution, which in turn has led to the current critical situation.

The above-mentioned Government Plan sets forth a set of immediate objectives, aimed at tackling the impacts stemming from the crisis, as well another set of objectives of a structural nature, laying the groundwork for reducing poverty over the medium and long term. Government efforts will focus on reversing the trend of growing poverty in Ecuador, promoting the steady growth of GDP and reducing the inequitable distribution of income.

▶ COUNTRY'S SPECIFIC CONCERNS

The physical, geographical, and socioeconomic conditions of Ecuador have converted it into a country characterized by high vulnerability, intensified by the direct and indirect impacts of climate change; it therefore fully shares the concerns laid out in Article 4, sections 8 and 9 of the UNFCCC and in Article 3, section 14 of the Kyoto Protocol.

Among the specific concerns, the following are noteworthy:

- Fragile ecosystems, including mountain ecosystems
- Droughts and desertification
- Erosion

- Natural disasters
- Forest cover and its deterioration
- The country's socioeconomic and environmental dependence on fossil fuels

According to the Ecuadorian Environmental Plan and the Environmental Strategy for Sustainable Development the fragile ecosystems that are being threatened include the moorlands of the high sierra, the Amazon region, the Galápagos islands, the agricultural and livestock areas of the sierra, the lake systems, the mangroves and the wetlands.

GREENHOUSE GAS (GHG) INVENTORY

The Greenhouse Gas Inventory in Ecuador conducted in 1990 included six gases (carbon dioxide, methane, nitrous oxide, nitrogen oxide, carbon monoxide, and nonmetallic volatile organic compounds) and five sectors (energy, industrial processes, agriculture, land use change and forestry, and waste management).

In 1990, GHG emissions were mainly generated by the energy sector and land use changes and forestry and, to a lesser extent, the agricultural, industrial, and waste management sectors.

The country's different activities are also reflected in the type and magnitude of the emissions, with emphasis on carbon dioxide, which accounts for more than 90% of all emissions, followed by carbon monoxide and methane.

Carbon dioxide (65.571 Gag) comes mainly from the energy sector (28.8 %) and land use change and forestry (69.5 %), which together account for almost 97% of the total.

Like CO_2, CO is emitted principally by the energy sector (50.90%) and land use change and forestry (43.88%), which together account for 94.78 % of the nation's total.

Methane emissions come mostly from agricultural activities (about 70%) with land use change and forestry accounting for 10.94%, waste management for 11.54% and the energy sector for 7.36%.

In the agricultural sector, almost 97% of methane emissions come from enteric fermentation (69.9%) and rice crops.

GENERAL DESCRIPTION OF MEASURES

Ecuador, a developing country that has experienced a severe socioeconomic crisis over the last decade, made major efforts to take

actions directly aimed at addressing the climate change process and other related processes. Obviously, the results that were obtained would not have been possible without the cooperation of friendly countries and organizations.

▶ DIRECT NATIONAL EFFORT

In the year 1993, the so-called Climate Change Process started in Ecuador with four long-term concrete objectives, which have been reached as a result of international assistance that was made available:

- Institutional capacity building to tackle climate change problems.
- Analyze climate change in Ecuador and its possible impacts on strategic areas.
- Define alternative responses to climate change for decision making.
- Fulfill international commitments.

The efforts to implement the process led to international support for the implementation of the following projects: Ecuador Climate Change Country Study, Netherlands Climate Change Studies Assistance Program, CC:TRAIN-ECUADOR, Limiting Greenhouse Gas Emissions, and the ECU/99/G31 Project on Climate Changes. In addition, the Andean Glacier Monitoring Program: A Tool for Analyzing Global Climate Change in South America is being implemented.

As for the political sphere, the creation of the National Committee on Climate (CNC), by means of an executive decree in 1999, is a sure sign of the topic's importance for the country. The CNC is a policymaking, coordinating entity in charge of implementing processes focusing on climate change in the country.

In the year 2000, the Ministry of the Environment, as President of the CNC, created the Climate Change Unit, which is being supported directly by the ECU/99/G31 Project on Climate Change and is responsible for preparing the First National Communication. Likewise, regarding the institutionalization of the Ecuadorian Committee for the Defense of Nature (CEDENMA), which brings together all the environmental nongovernmental organizations, it created the Working Group on Climate Change.

Ecuador is very interested in participating in the challenges and opportunities arising from the carbon market, and because of this it is now developing actions to meet two major objectives:

1. Definition and implementation of the Clean Development (CDM) Project Validation Process at the national level.
2. Promotion and implementation of national capacity (public and private) to prepare CDM projects and to generate significant Certified Emission Reduction Units (CERUs).

▶ RELATED NATIONAL EFFORT

The last two decades have been characterized by increasing awareness of environmental problems by society, as well as the growing willingness of players committed to the country's development to coordinate actions on these aspects.

The environmental conditions that prevailed in Ecuador's territory during the eighties and at the start of the nineties have been described in major official reports. Since 1994, environmental issues have been dealt with in greater depth and at a higher political level. The establishment of the Environmental Advisory Commission of the Office of the President of the Republic in 1993 and the creation of the Ministry of the Environment in 1996 are highly noteworthy institutional and political events.

In December 1993, Ecuador adopted the Basic Principles for Environmental Management, as well as the Basic General Environmental Policies in June 1994, which led to the elaboration of the Ecuadorian Environmental Plan in 1995.

The Environmental Strategy for Sustainable Development, prepared by the Ministry of the Environment in 1999, is the result of the entire process that the country has experienced over the last two decades. The objective is to promote development based on conservation and the sustainable use of the country's biodiversity and natural resources, using an environmental management approach.

In order to have scientific knowledge about weather and climate conditions, the Climate Observations System of Ecuador was designed and started up in 1961. The National Meteorology and Hydrology Institute (INAMHI) is in charge of this System, which now has a network of 260 meteorological stations.

▶ CLIMATE CHANGE DETECTION IN ECUADOR

National research has basically focused on climate and tropical glaciers.

Regarding climate, research has been based on meteorological information about average, minimum, and maximum temperature and rainfall from 14 stations located in the different geographical regions of the country and has confirmed the existence of a trend of rising temperatures. Rainfall trends over time have been highly uneven, with a greater inclination toward decline, especially on the coast.

The measurements made in the alpha 15 glacier on the snow-capped summit of Mount Antisana indicate that there has been a gradual diminishment of the length of glacier from 1956 to 1998. At over 4,555 meters above sea level (masl), the cover over the glaciers has declined from 70% to 54% during the period from 1956 to 1998.

▶ VULNERABILITY AND ADAPTATION (V/A)

In the context of the V/A and mitigation analysis, a methodological process has been implemented over various time phases and in the framework of different projects, with different sponsors and characteristics. Specifically in the area of V/A, the process has included the formulation of Climate Change Scenarios, the V/A evaluation, the viability analysis, and environmental, economic and social impact assessment of the application of the measures, the definition of strategies to overcome the barriers, and the preparation of project profiles.

The V/A studies were based essentially on four climate change scenarios (CCS) stemming from research on General Circulation Models, the region's experience, and knowledge about the country's climate: CCS1 (temperature: +1.0° C, rainfall: -15%); CCS2 (temperature: +1.0° C, rainfall: +20%); CCS3 (temperature: +2.0° C, rainfall: -15%); CCS4 (temperature: +2.0° C, rainfall: +20%).

AGRICULTURAL SECTOR

Ecuador has traditionally been an agricultural country. Growth of national farm and livestock production has generally relied on the expansion of the country's agricultural frontier rather than on any improvement in productivity of its production systems. The country's staple diet includes principally rice, potatoes, and tender corn, and a vulnerability assessment was conducted for these foods.

The assessment was carried out in the framework of food security in the years 2010 and 2030, under normal climate conditions and using two climate change scenarios.

Under CCS2, the supply of rice, hard corn, soybean, and potato would surpass, at different levels each, the population's needs in the year 2010. If CCS2 were assumed, however, the supply of rice and potatoes would be higher than demand, but the opposite would occur with soybean and hard corn.

For the year 2030 and under scenarios CCS2 and CCS3, demand would be higher, albeit at different levels, than the supply of rice and soybean, whereas for potatoes and hard corn, the situation would be just the opposite.

The measures of adaptation that have proven to be highly viable in terms of implementation are: agro-ecological zoning and appropriate seasons for sowing and harvesting, introduction of higher-yield varieties, the installation of irrigation systems, the appropriate use of fertilizers, and the implementation of a system for controlling pests and disease.

FORESTRY SECTOR

The assessment conducted on the basis of the Holdridge methodology, according to the climate change scenarios used, showed

considerable increases in dry areas compared to the current situation, except for CCS4, especially in the CCS3 scenario, which would be the critical scenario because it shows a clear trend toward desertification. On the basis of the results, the study defined three impact zones where the most severe impacts in terms of living zones would be exerted.

In this sector, the measures that are highly viable in terms of application are: buffer forest plantations, sustainable management of production plantations, integral rural development in watersheds, agro-forestry and woodland/grazing land systems, forest protection against pests and disease, forest protection against fires, sustainable management of native parks, sustainable management of fragile ecosystems, and a comprehensive anti-desertification program.

SEACOAST SECTOR

The assessment of the vulnerability was conducted in the lower Guayas river basin, comprising an area of 14,878 km^2. Its importance for the country's socioeconomic well-being is truly considerable, because it is one of the principal areas for agriculture, industry, and trade.

The principal impacts of the climate change scenarios that were defined would basically involve rising water levels, higher frequency of excedence, and salinity, whereas the most sensitive impacts would be the area lost to fast-rising sea levels and the impacts of floods and overflowing rivers. The increase in the average sea level would produce floods virtually along the entire coastline.

The priority adaptation measures would be as follows: establishment of a climate change biophysical and surveillance program, the adjustment of sewage and clean water systems for the city of Guayaquil, mangrove preservation and reforestation, reorganization of shrimp-farming activities, establishment of withdrawal lines, buffer zones, and urban protection borders, the adjustment of the road drainage system, and hydraulic fill of densely populated urban zones.

WATER RESOURCE SECTOR

The quantitative and qualitative analysis of the data obtained highlights the vulnerability of Ecuador's water resources to the hypotheses that have been set forth regarding climate change.

The vulnerability to which the water resources of Ecuador are exposed in the year 2010 was assessed using the climate change scenarios in the 10 hydrographic basis of various rivers, covering an area of 50,791 km^2.

Among the results of the comparison between supply and demand of water resources, the following are noteworthy:

CCS1: Increasing shortages and more severe runoff periods, which are more critical in the basins of the Esmeraldas, Pastaza (Agoyán project), and Napo (Papallacta project) rivers.

CCS2: The conditions in this scenario are of less concern than the previous ones in terms of possibility of lower supply compared to demand, in view of lesser low-water periods.

CCS3: This scenario is the most critical; the values for the shortages are the highest in the river basins mentioned in CCS1.

CCS4: The possibility of increasing rainfall generates a rise in supply, with shortages compared to demand declining over time and in amounts.

Assuming scenarios CCS1 and CCS2, which involve a drop in rainfall, the Agoyán Hydropower project would be affected by a 23% decline in water flow volumes, basically during the low-water period, and the Paute Project would meet only between 43% and 45% of average power capacity, which would mean a deficit of about 27% in energy production under normal conditions.

▶ MITIGATION

ENERGY SECTOR

Energy supply from secondary sources involves a high proportion of oil products (90.6%). Demand comes basically from the transportation (38.3%), residential (26.4%) and industrial (20.5%) sectors.

The inclusion of mitigation measures would induce the average growth rate of demand to decline from 2.8% to 2.2% until the year 2005. With the mitigation measures, the electric power generation rate would drop from an annual average rate of 4.1% to 2.6%. These measures would permit reducing CO_2 emissions by 18.5% on the demand side and by 47.1% on the supply side by the year 2025.

In the supply subsector, measures were considered in the electric power sector (energy generation using small hydropower stations, reduction of power losses) and oil and gas sector (tapping the natural gas associated to the oil fields in the northeastern area of Ecuador).

In the demand subsector, measures were proposed for the following areas: residential (substitution of luminaires, water heating, photovoltaic solar energy, improved stoves), commercial and services (substitution of luminaires), industrial (optimization of boiler combustion to generate steam), transportation (conversion of motor vehicles to compressed natural gas), and farming (biogas).

AGRICULTURAL SECTOR

To mitigate methane emissions, which essentially come from rice farming and enteric fermentation, the following measures were given priority: improvement of the diet of cattle by managing grazing land, manure management using biodigesters for the elimination of methane, and rice crop waste or residue use and management using compost heaps and recycling processes.

FORESTRY SECTOR

The baseline scenario indicates that, under conditions without mitigation, the forest's surface area will have declined by 18.6% in the year 2010 and by 37.1% in the year 2030; whereas protected natural areas will have declined by 10.4% in the year 2010 and by 20.7% in the year 2030.

The forest scenario with mitigation assumes an annual reforestation rate of 30,000 hectares per year and no intervention in the natural protected areas. On the basis of this scenario and compared to 1990, there would be a 29% increase in the forest surface by the year 2010 and a 76% increase by the year 2030, with conservation of protected natural areas of 11.7% and 26.2% in the years 2010 and 2030, respectively.

The measures that have been given priority in the forestry sector are: sustainable forestry management of native woods, productive and protective forest plantations, green belts, consolidation of the national system for protected areas and sustainable management of fragile ecosystems, management of protective forests for watersheds, development of agroforestry and woodland/grazing land systems.

ADAPTATION AND MITIGATION PROJECT PROFILES

Ecuador is proposing 38 project profiles to the international community aimed at facilitating the application of adaptation and mitigation measures that were evaluated and prioritized in the framework of the entire process that was developed.

The country is hoping that, in the context of international cooperation and in compliance with the commitments made by the countries under the UNFCCC, it can secure resources over the short term to design and implement projects, enforce the Convention, and support the country's sustainable development.

▶ ADAPTATION PROJECT PROFILES

FORESTRY SECTOR

- Community production activities to obtain nontimber products in the remaining dry forests of the canton of El Carmen.
- Sustainable management of forest plantations in the provinces of Cotopaxi y Tungurahua.
- Integral rural development in micro watersheds in the province of Loja.
- Sustainable management of the sierra moorlands of El Cajas.
- Protection plantations in the province of El Oro.
- Establishment of community agroforestry systems in the province of Tungurahua.
- Establishment of woodland/grazing land systems in the rural cattle areas of the province of Manabí.
- Forest fire protection in the green belts of the metropolitan area of the city of Quito.
- Comprehensive anti-desertification programs in areas that are vulnerable to climate change.

AGRICULTURAL SECTOR

- Agro-ecological zoning and appropriate sowing and harvesting seasons.
- Introduction of higher-yield varieties.
- Installation of irrigation systems.
- Adequate use of fertilizers.
- Implementation of a system for controlling pests and disease.

▶ MITIGATION PROJECT PROFILES

ENERGY SECTOR

- Tapping solar energy for water heating in the residential sector.
- Substitution of luminaires for other more efficient street lighting.
- Substitution of luminaires in the country's commercial and services sector.
- Biogas program for the country's agricultural and livestock sector.
- Optimization of combustion in boilers for steam generation in the industrial sector.
- Promotion and dissemination of improved stoves and firewood-saving practices.

- Rural electrification with photovoltaic solar systems.
- Electric power saving in the residential sector by substituting luminaires.
- Energy generation by means of small hydropower stations.
- Reducing electric power sector losses.
- Recovery of liquefied petroleum gas (LPG) from associated natural gas.
- Generation of electricity using residual natural gas.
- Use of compressed natural gas in motor vehicles.

FORESTRY SECTOR

- Sustainable forest management of the native forest of the Chachis on the Cayapas River.
- Building up the capacity of the National System for Protected Areas of Ecuador.
- Management of protective forests of the watersheds of the canton of Puyango.
- Establishment of agroforestry systems in the canton of El Carmen.
- Establishment of woodland/grazing land systems in the canton of Guamote.
- Productive forest plantations in the canton of Balzar.
- Protective forest plantations in the canton of Bolívar.
- Green belt around the city of Guayaquil.

AGRICULTURAL SECTOR

- Improvement of the diet of cattle, using grazing land management programs.
- Manure management through biodigesters.
- Use and management of rice crop residues using compost heaps and recycling processes.

NATIONAL REQUIREMENTS

The results obtained and the lessons learned from the implementation of the Climate Change Process in Ecuador has facilitated a systematization of the principal requirements for promoting capacity, evaluating vulnerability and adopting adaptation measures, evaluating the impacts of response measures in the country, conducting GHG inventories, setting up a climate change measurement and data-gathering system, continuously elaborating national communications, and raising the awareness of the public.

Chapter 1

Ecuador: national circumstances

COUNTRY'S GENERAL CHARACTERISTICS

▶ GEOGRAPHICAL LOCATION

Ecuador is located in the northwestern part of South America (Map 1), extends over a surface territory of 256,370 km^2, and includes the Galápagos Islands, World Natural Heritage, located at 1,000 kilometers to the west of the mainland and with a surface area of 8,010 km^2.

The country's physical, ecological, climate, etc. characteristics are determined by its special location on the planet, with the equatorial line running across it horizontally and the cordillera of the Andes extending lengthwise from north to south, which in turn is crossed by transversal mountain systems from east to west that give rise to inter-Andean valleys. The lowlands and flatlands are located to the west along the Pacific Ocean and to the east in the Amazon River basin.

MAP 1: ECUADOR IN SOUTH AMERICA

Owing to the above-mentioned conditions, Ecuador has four fully identifiable natural regions distributed territorially as follows: the coast, the inter-Andean valleys, the Amazon region and the island territory (the Galápagos archipelago).

CLIMATE IN ECUADOR

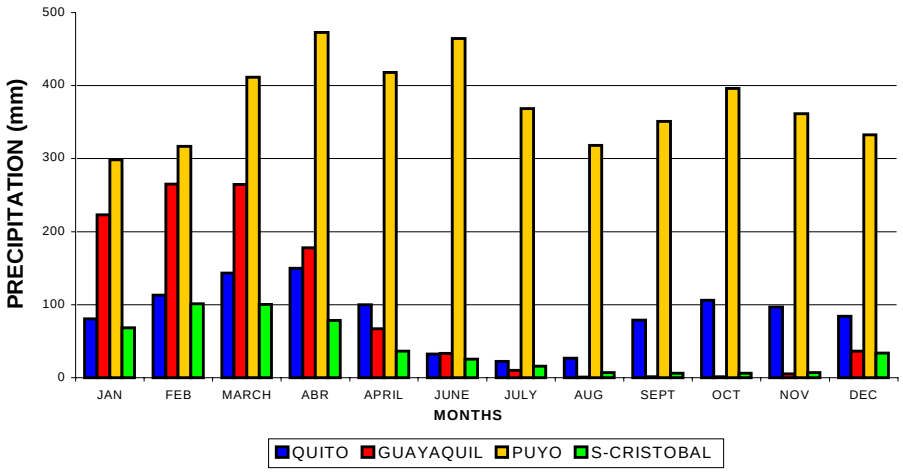
In Ecuador, during the year two seasons can be differentiated as a result of rainfall distribution over time: a rainy season and a dry season.

Ecuador's climate is affected by various factors, such as its location in the equatorial zone, the presence of the cordillera of the Andes, the Amazon river basin, and the Pacific Ocean, giving rise to marked variations in terms of space and seasons in the country's different natural regions.

In contrast to countries located in higher latitudes, Ecuador has two major seasons during the year, differentiated by the distribution of the rainfall: one is the rainy season and the other is the dry season.

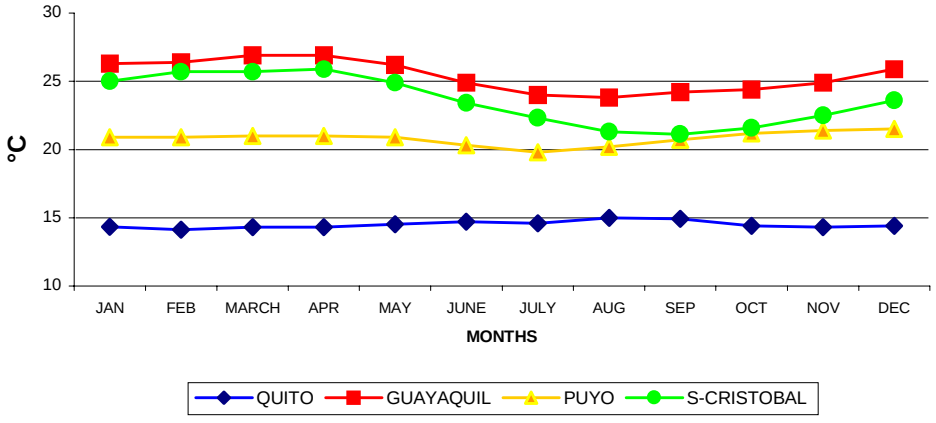
The seaboard region or coast has a very rainy season that extends from the end of December to May, with the highest rainfall in February and March, and a dry season from June to the end of December (Chart 1, Guayaquil). The highest amount of rainfall occurs in the northern part of the region, with annual amounts of up to 4,000 mm, whereas the opposite occurs in the area of the Santa Elena peninsula, with rainfall below 250 mm per year (Map 2).

Chart 1: Seasonal distribution of rainfall



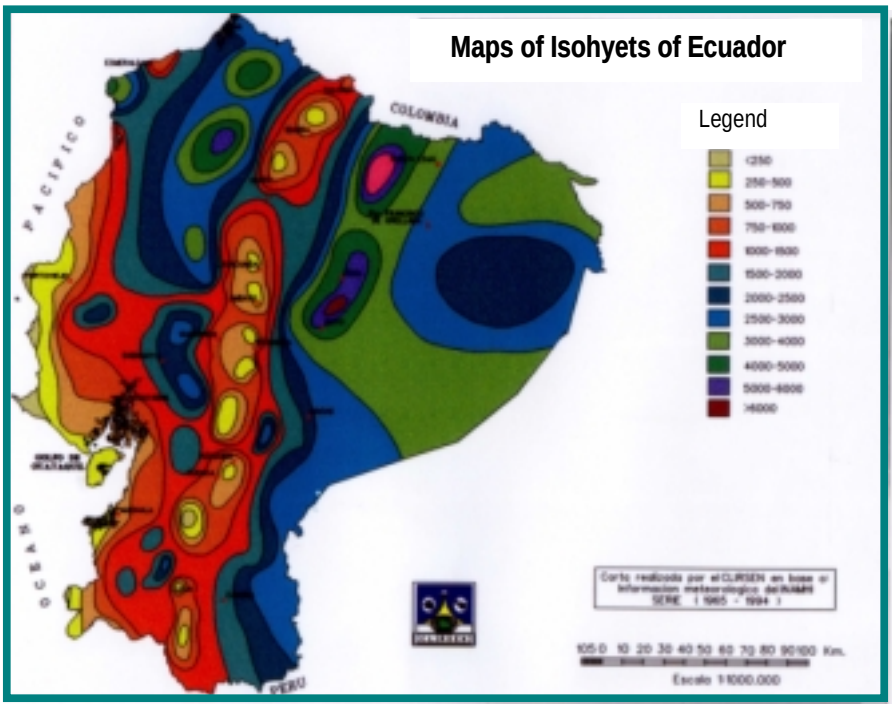
The thermal regime is characterized by a 2 to 3° C variation between the hottest and coldest months (Chart 2, Guayaquil).

Chart 2: Distribution of average temperature



The inter-Andean region or sierra has a rainy season between October and May and a dry season from June to September. Rainfall reaches two peaks during the year, one in October, the other in April (Chart 1, Quito). The highest amount of rainfall takes place in the foothills of the Occidental and Oriental cordilleras, with values of between 1,500 and 2,000 mm, which progressively decline until they amount to 500 mm per year in some inner valleys of the region (Map 2).

MAP 2: ISOHYETS OF ECUADOR



Monthly average temperature amounts to about 14.5° C in the rainy season and 15° C in the dry season (Chart 2, Quito). The altitude is very important, since temperatures decrease as altitude increases, down to 8.5° C at 3,500 meters above sea level (masl).

The Amazon region or eastern region has permanent rainfall throughout the year (Chart 1, Puyo), with levels over 6,000 mm in the north (El Reventador), and because of that it is the country's rainiest region.

Average temperature is around 21° C during most months of the year (Chart 2, Puyo).

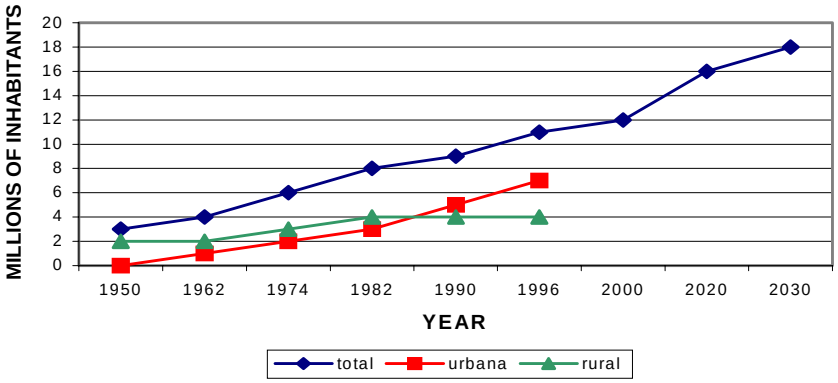
The island region has characteristics similar to those of the coastal region (Chart 1, San Cristóbal). Annual total rainfall stands at about 500 mm, but levels are far higher during the years affected by the warm phase of the El Niño Southern Oscillation (ENSO).

Average temperature during the rainy season (December to May) fluctuates between 25 and 26° C, and declines considerably to 21 or 22° C during the dry season (June to November), mainly owing to the influence of the cold Humboldt current (Chart 2, San Cristóbal).

▶ DEMOGRAPHIC PROFILE

According to the Geographic Institute of the Armed Forces (IGM) and CEPAR, the population of Ecuador in the year 2000 amounts to 11,912,879 inhabitants. A World Bank forecast for the year 2030 appears in Chart 3 below.

Chart 3: Population of Ecuador



Migration to the country's large cities has changed the country's demographic dynamics. In 1960, urban inhabitants accounted for 29% of the population, whereas by the year 1990 they accounted for 55% and by 1999 for 62% of the entire population, according to data from 1999 *Population Report.*

According to the National Statistics and Census Institute (INEC), there are three important reasons for increasingly high migration flows: economic (34.8%), family (48.2%), studies and others (17%).

The annual birth rate has dropped significantly from 45 per thousand in 1950 to 38 per thousand in 1970 and 24.7 per thousand in 1994. According to INEC forecasts, it is estimated that, for the period 2010-2015, this rate will be falling to 19.3 per thousand.

The gross mortality rate, which amounted to 19.35 per thousand in 1950, declined to 4.4 per thousand by 1995; furthermore, the life expectancy of the Ecuadorian population is 69.9 years, with a higher expectancy for women (72.5) than for men (67.3).

DEVELOPMENT PRIORITIES. THE GOVERNMENT'S PLAN TO TACKLE THE CRISIS: 2000-2003

There is no doubt that the national problem that has the highest priority is the growing severity of poverty.

The severe crisis currently being experienced by the country manifests itself in different ways; nevertheless, there is no doubt that the *national problem that has the highest priority is the growing severity of poverty.* Over the last few years, especially during the two-year period 1998-1999, the population's socioeconomic reality recorded severe setbacks in terms of human development indicators, which reached

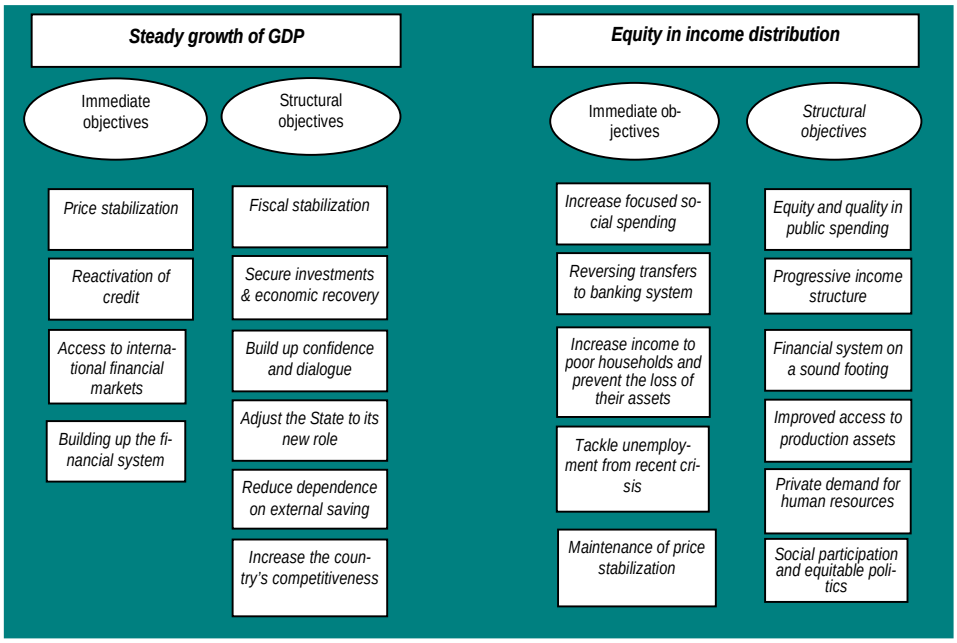
unprecedented levels, since it is now estimated that almost three fourths of the country's population are living below the line of poverty.

Various structural factors and specific situations have led to a *sharp contraction of the economy and a rise in the inequity of income distribution*, which in turn has triggered the current critical situation of the country.

The Government Plan for 2000-2003 has provided a set of immediate objectives (Chart 4), aimed at addressing the impacts stemming from the crisis of 1998-2000, as well another set of objectives of a structural nature. It should be emphasized that government efforts will focus on reversing Ecuador's poverty growth trend by promoting the steady growth of its gross domestic product (GDP) and reducing the inequity in income distribution.

It also provides specific policy guidelines, as well as multi- and inter-disciplinary actions to be implemented by the many players of the central government, the State, and civil society.

Chart 4: Current government's priority objectives



Although actions go beyond the Plan's timeframe, its objective is to lay the groundwork for these efforts to continue and be consolidated over time, with citizenship participation.

COUNTRY'S SPECIFIC CONCERNS

The physical, geographical, and socioeconomic characteristics of Ecuador have transformed it into a country characterized by high vulnerability, intensified by the direct and indirect impacts of climate change.

It fully shares the concerns specified in Article 4, paragraphs 8 and 9 of the United Nations Framework Convention on Climate Change (UNFCCC) and in Article 14 of the Kyoto Protocol.

It therefore fully shares the concerns specified in Article 4, paragraphs 8[1] and 9[2] of the United Nations Framework Convention on Climate Change (UNFCCC) and in Article 3, paragraph 14[3] of the Kyoto Protocol.

In the framework of efforts to deal with environmental issues that began in the nineties, the National Government, by means of Executive Decree No. 1802 of June 1, 1994, approved Ecuador's Basic Environmental Policies, which along with the Basic Principles for Environmental Management ratified that same year laid the groundwork for the Ecuadorian Environmental Plan.

Among the policies defined by the Ecuadorian Government, there are those aimed at giving priority to dealing with and resolving the following aspects that have been recognized as environmental problems in the country and that, in general, coincide with the issues specified in the articles set forth in the Convention, namely:

- poverty;
- erosion and disorderly land use;
- deforestation;
- loss of biodiversity and genetic resources;
- disorderly and irrational exploitation of natural resources in general;
- growing air, water, and land pollution;
- generation and deficient management of waste, including hazardous toxic matter;
- stagnation and deterioration of urban environmental conditions;
- major national health problems due to pollution and malnutrition;
- desertification and growing severity of droughts; and
- natural and environmental risks, disasters, and emergencies.

On the basis of the country's reality, as described in official documents, the concerns coinciding with those of the Convention are briefly described below.

▶ FRAGILE ECOSYSTEMS INCLUDING MOUNTAIN ECOSYSTEMS

Since small exogenous interventions can trigger major alterations and occasionally lead to the deterioration of ecosystems, the Government through its Ecuadorian Environmental Plan has identified five ecosystems that are considered to be fragile: the moorlands of the sierra, the Amazon river basin, the Galápagos islands, mountain farm zones, and lake systems.

[1] It refers to the fact that the Parties will be studying in depth the measures that might be necessary to take in order to comply with the Convention, including measures involving financing, insurance, and transfer of technology, so as to address the specific needs and concerns of the developing country Parties regarding climate change or the impact from applying response measures, especially for the more vulnerable countries.

[2] "The Parties will fully take into account the specific needs and the special situations of the less developed countries when adopting measures regarding financing and the transfer of technology."

[3] "Each Party included in Annex I will make efforts to meet the commitments indicated in paragraph 1 supra so as to reduce to a minimum adverse social, environmental, and economic repercussions for the developing country Parties, especially those mentioned in paragraphs 8 and 9 of Article 4 of the Convention. In keeping with the relevant decisions of the Conference of the Parties on the application of these paragraphs, the Conference of the Parties as a meeting of the Parties in the present Protocol shall study, in its first period of sessions, the measures that might be necessary to take in order to reduce to a minimum the adverse effects of climate change and/or the impact of the application of response measures for the Parties mentioned in these paragraphs. Among others, questions such as financing, insurance, and transfer of technology shall be studied."

As for the Environmental Strategy for Sustainable Development (1999), it has included among the ecosystems considered fragile and endangered, but liable to conservation and recovery, the mangroves, the wetlands, and arid and dry areas.

MOORLANDS OF THE SIERRA

The moorlands are located between 3,500 and 4,400 meters above sea level and have an ecosystem that was born from the association of a special climate, vegetation, and soil, but they are now being tampered with inappropriately, and this is adversely affecting the ecosystem itself and the plant, animal, and water resources subsisting there.

Pressure on the ecosystem is evident in land use changes, overexploitation of the soil, burning, indiscriminate hunting, extraction of volcanic rocks (pumice), and the introduction of outside species, especially plants. In addition, species alien to the ecosystem are grazing, sometimes excessively, on the moorlands, such as cattle, horses, etc., rather than the native species, which have almost disappeared completely.

AMAZON REGION

The Amazon region covers a surface area of about 131,000 km2 of lush plant life typical of tropical rain forests. Among its principal characteristics, it should be noted that only about 24% of its land is apt for farming.

Furthermore, in the Ecuador's Amazon region there is a wealth of biodiversity, considered to be one of the greatest in the world. It accounts for 1.9% of the entire Amazon river basin, ranking third in this region in terms of the number of amphibian species, fourth in terms of the number of birds and reptiles, fifth in terms of monkeys, sixth in terms of plants and flowers, and seventh in terms of mammals. Worldwide, this area ranks third in terms of the number of amphibians, fifth in terms of birds, and sixth in terms of butterflies.

Current rapid deforestation in the Amazon region has led to the loss of more than 50% of its plant cover, and 25% of this loss has taken place over the last 22 years.

Current rapid deforestation in the Amazon region has led to the loss of more than 50% of its plant cover, and half of this loss has taken place over the last 22 years. Deforestation, along with pollution, has caused the significant loss of enormous biodiversity in the zone. In addition, there is a rapidly growing process of pollution and resource deterioration.

Basic services in general, especially those ensuring basic sanitation, are deficient in the urban sector and absent in the rural sector.

All of these impacts are adversely affecting the living conditions of the indigenous communities and the immigrants (colonizers) and their descendants, preventing sustainable development from being ensured.

GALÁPAGOS ISLANDS

Declared by UNESCO to be a World Natural Heritage, the Galápagos islands are one of the most important natural sites of the planet for the variety

of their native fauna and flora. They cover an area of 8,010 km^2 and include 17 large islands and more than 100 small islands, where volcanic activity is substantial. Charles Darwin defined his theory of the evolution of species on the basis of the characteristics of the fauna of the Galápagos islands.

For two decades now, the pressure on the islands has been jeopardizing the stability of the ecological balance and the sustainability of the natural resources. The indiscriminate growth of the population owing to migration, the intensity of tourist of activities, and illegal fishing activities both inside and outside the marine resource reserve are aspects that are increasing the risk of this archipelago.

MOUNTAIN FARMING AND LIVESTOCK AREAS

The fragile areas are located essentially on the external flanks of the cordillera of the Andes, whose principal feature is their inaptness for farming and where factors such as the under-utilization of the land, inadequate farming practices, and flawed land-holding schemes are reducing the potential and productivity of farming areas and, at the same time, generating severe erosion.

These processes can be observed in steep areas, with slopes with a gradient of over 70% and shallow soil, whose fragility stems mostly from high erosion rates. In these mountainous areas, there is rapid deforestation and elimination of the plant cover, which is replaced by grazing land and other crops, as well as the loss of biodiversity and genetic funds.

Human interventions are provoking the vulnerability of land and animal species, and some of those that are rare or endemic are running the danger of becoming extinct.

LAKE SYSTEMS

The water accumulations in the moorlands and the beautiful landscapes generated by the lake systems of the Andes are being adversely affected by the pollution of their waters, the degradation of their environment, and the rapid accumulation of sediment.

Among the most important factors for this negative influence one should include the deficient management of watersheds, the lack of treatment for waste water discharged into the lakes, the absence of basic sanitation services for the rural dwellers of the basins, and the inadequate use of the lakes, especially for economic purposes.

The problems generated by the deterioration of water quality are also affecting the health of the population who have to use the water resources stored in the lake systems for domestic purposes since they have no clean water supply system.

MANGROVES

Mangroves are legally protected; nevertheless, the deforestation of extensive zones as a result of land use changes for the benefit of water farming activities and human settlements is a concern.

Between 1969 and 1995, the surface area of the mangroves along the coastline of Ecuador's mainland declined by 54,055 ha, that is, 26.5% of the total.

Between 1969 and 1995, the surface area of the mangroves along the coastline of Ecuador's mainland declined by 54,055 ha, that is, 26.5% of the total. When the problem is examined estuary by estuary, it is evident that the reduction is variable; to mention extreme cases, the estuary of the Chone River lost 90% of its mangroves, whereas the Santiago-Cayapas-Mataje estuary system lost only 7.3%.

The annual rate of mangrove loss has been growing steadily since 1969, except over the last five years, when it has showed some decline, especially in areas where there is a small remanent of mangroves or where there are very few adequate sites for building shrimp ponds.

WETLANDS

The resources generated in the wetlands, such as biodiversity, water, leisure, transportation, and protection against natural phenomena are being markedly affected by unsuitable human activities, which in addition are leading to their decline and pollution.

The State provides that the conservation of wetlands should be conducted on the basis of the socioeconomic needs and conditions of the country and communities.

▶ DROUGHTS AND DESERTIFICATION

In Ecuador, about 75,000 km^2 of the land has been affected, to a different extent, by drought, that is, about one fourth of the territory. In 1999, the Farm and Livestock Sector Project of the Ministry of Agriculture and Livestock estimated that there were about 90,000 hectares of desert in the country.

The Ecuadorian State defined the process and growing severity of droughts and desertification as priority environmental problems.

The Ecuadorian State defined the process and growing severity of droughts and desertification affecting all the provinces of the sierra and three provinces of the coast as priority environmental problems.

▶ EROSION

In 1998, the Ministry of Agriculture and Livestock conducted a study characterizing the eroded zones of Ecuador, which showed that 47.9% of the entire territory is suffering from some type of erosion. It is present in the highlands of the sierra or Andean zone and extends progressively down to the agricultural frontier, and this land is highly susceptible to "active" and severe erosion. In the coastal region, erosion problems can be detected in the western half toward the sea.

The Amazon and island regions also show problems of this nature, which are frequently triggered by the settlement of colonizers and deforestation.

NATURAL DISASTERS

The country is located in a geologically active zone that accumulates volcanic and seismic energy, which is periodically released, sometimes violently. There is sizable historical evidence on seismic and volcanic events, many of which have been extremely severe and intense. At present, in Ecuador, there are zones that have been signaled as under yellow alert, because of a probable eruption of the Guagua Pichincha and Tungurahua volcanoes.

Almost all the provinces of Ecuador are vulnerable to natural and anthropogenic disasters.

The adverse influence of natural disasters can be appreciated when analyzing the annual GDP rates from the year 1980 onwards. The earthquake that took place in 1986 in the northeastern region of Ecuador triggered a drop in GDP from 1.1% in 1986 to –6% in 1987.

In Ecuador, during the present century, El Niño-Southern Oscillation events occurred in 1925, 1934, 1941, 1953, 1957, 1958, 1965, 1972-1973, 1976-1977, 1982-1983, 1986-1987, and the most recent one in 1997-1998; the damage they have caused has been highly diverse, of varying magnitude and characteristics. As a result of the El Niño phenomenon and its resulting flooding, between 1982 and 1983, the annual GDP rate declined from 3.9% in 1981 to 1.2% in 1982 and to –2.8% in 1983. Another event in 1998 generated a decline in GDP from 3.4% to 1.7%.

A report from the Economic Commission for Latin America and the Caribbean (ECLAC) indicates that, in Ecuador, it is estimated that the amount of damage triggered by the El Niño Phenomenon in 1997-1998 amounted to US$4.87 billion in the social sectors (7%) and as a result of production losses (53%), higher service costs (29%), and emergency expenditures (12%). It should be emphasized that this natural disaster left in its wake about 90,000 victims, including the death of 330 persons.

FOREST COVER AND ITS DETERIORATION

In 1990, the forest cover in Ecuador amounted to about 11,551,000 hectares, of which hardly 78,000 involve forest plantations whereas the rest are native woods, which cover about 42% of the country's surface. Of this total, 80% is located in the Amazon region, 13% in the coastal region, and 7% in the sierra, the latter being noteworthy for having undergone the greatest alteration.

Deforestation in Ecuador is truly alarming because its rates are among the highest in Latin America.

Deforestation in Ecuador is truly alarming because its rates are among the highest in Latin America, fluctuating between 0.5% and 2.5% per year, with forest losses amounting to between 60,000 and 360,000 hectares of woods per year.

Alongside this, the forestry areas, that is, 78,000 hectares of planted forests, account for only between 3% and 4% of the losses due to deforestation; the future of forest cover in Ecuador is therefore quite bleak.

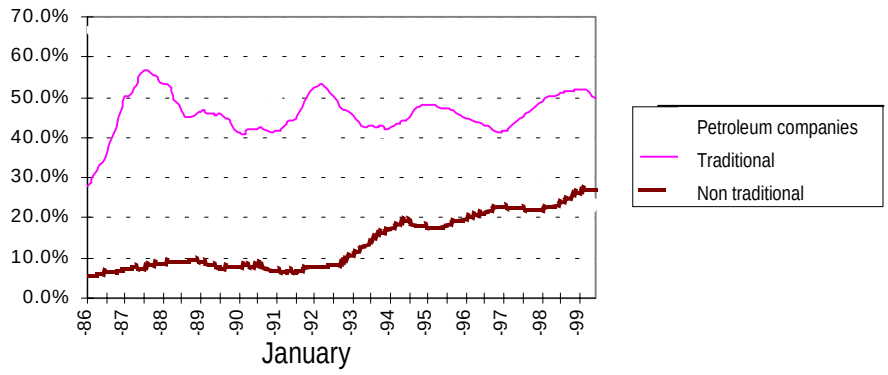
Among the principal causes of deforestation and the consequent loss of forest cover, the following are noteworthy: oil exploration and production; road building and wood exploitation; agricultural and livestock activities; shrimp, fishing, and mining industries; demographic pressure; uncontrolled settlement by colonizers; structural problems of the agricultural sector; rural underemployment and migration.

Efforts to stop the decline of the forest cover by means of reforestation and deforestation control are incipient; as a result, the prospects for the future of forest mass conservation are truly distressful.

▶ SOCIOECONOMIC DEPENDENCE ON FOSSIL FUELS

The oil sector is vital for the Ecuadorian economy, since in addition to performing the usual function of meeting national consumption demand and facilitating the majority of the country's socioeconomic activities it provides the highest amount of national revenues and the highest share of currency earnings from exports. Nevertheless, it should also be highlighted that oil-related activities have provoked and caused the severest environmental problems of local scope that has ever been borne by Ecuador.

Chart 5: Structure of national exports



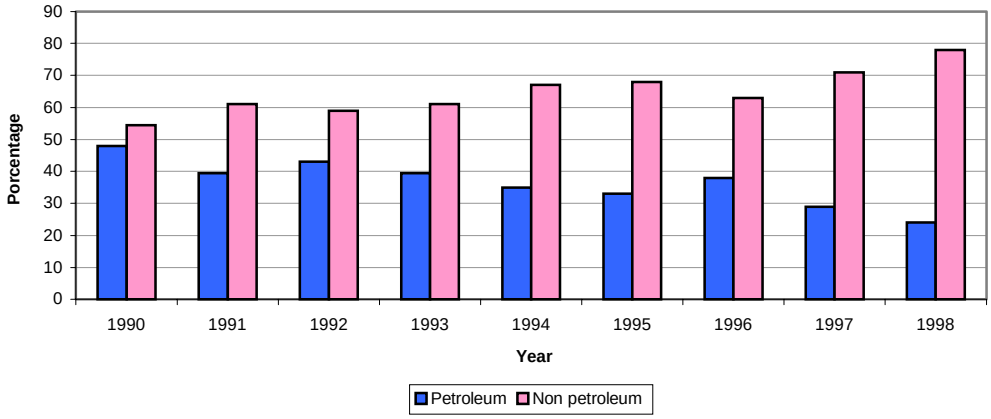
The high dependence of the Ecuadorian economy on oil is reflected in the share of added value of this sector in the country's total GDP, which has remained at about 14% throughout the nineties.

The high dependence of the Ecuadorian economy on oil is reflected in the share of added value of this sector in the country's total GDP, which has remained at about 14% throughout the nineties.

As for fiscal income, the exports of oil and other products are to a large extent financing the General Budget of the State, and therefore their contribution is considerable. Although the relative share of non-oil income has risen significantly over the last few years, it is not enough to substitute revenue from oil. The prospects for oil sector development indicate that the national economy will increase its reliance on oil exports.

For the future economic development that will continue to depend on the oil sector, it will be necessary for sector planning to be conducted in connection with an assessment of the entry into force of a world scheme for climate protection.

Chart 6: Share in the general budget



The impacts of mitigation measures on the world market, whatever their magnitude, will exert a greater relative impact on the country.

It should be considered that the impacts of mitigation measures on the world oil market, whatever their magnitude, will exert a greater relative impact on the country, owing to the marginal share of Ecuador on the international oil market (minimum absolute share, lower product quality, withdrawal from OPEC). It is urgent that national studies be conducted and that strategic guidelines regarding this be elaborated.

Chapter 2

GHG inventory

GENERAL AND METHODOLOGICAL ASPECTS

Based on the methodology of the Intergovernmental Panel on Climate Change (IPCC), Ecuador's Greenhouse Gas Inventory conducted in 1990 included six gases (carbon dioxide, methane, nitrous oxide, nitrogen oxide, carbon monoxide and nonmetallic volatile organic compounds) and five sectors (energy, industrial processes, agriculture, land use change and forestry, and waste management).

SECTOR-SPECIFIC EMISSIONS

In 1990, greenhouse gas emissions were generated principally in the energy sector and as a result of land use change and forestry. To a lesser extent, emissions came from the agricultural sector, industrial processes, and waste management. Table 1 provides a summary of GHG emissions, whereas Table 2 provides a breakdown of emissions by each subsector.

Table 1: GHG emissions (Gg). Year 1990.

Categories of GHG sources and emissions	CO_2	CH_4	N_2O	NO_X	CO	NMVOC
1. Total energy (fuel combustion + fugitive emissions)	18,877.80	41.07	0.49	85.92	615.63	132.93
a. Fuel combustion	18,877.80	20.18	0.49	85.92	615.63	132.93
b. Fugitive emissions		20.89				
2. Industrial processes	1,150.00					
3. Agriculture		398.39	0.07	2.69	62.89	
4. Land use change and forestry	45,543.14	60.67	0.42	15.08	530.89	
5. Waste management		64.02				
Total national emissions and removal	65,570.94	564.15	0.98	103.69	1,209.41	132.93

EMISSIONS BY TYPE OF GAS

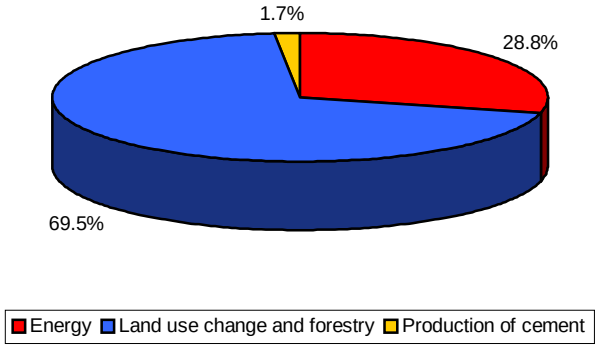
The different activities of the country are also reflected in the type and magnitude of the emissions, where carbon dioxide is noteworthy since it accounts for almost all the emissions, followed by carbon monoxide and methane.

CARBON DIOXIDE

Carbon dioxide comes principally from the energy sector (28.8%) and land use change and forestry (69.5%).

Carbon dioxide comes principally from the energy sector (28.8%) and land use change and forestry (69.5%), which together account for more than 98% of the total. The remaining percentage is generated by cement production.

Chart 7: CO_2 emissions by sector (%)



In the energy sector, transportation accounts for 47.7% of the emissions, complemented by those generated by small-scale combustion (29.48%), industry (16.50%), and energy transformation (6.36%). It should be indicated that fugitive oil and natural gas emissions and those coming from the burning of traditional biomass to obtain energy are not included.

The calculation of net CO_2 emissions owing to land use change was based on information on the tropical rain forest. The emissions come basically from the change in standing timber stock and other woody biomass (17,718.8 Gg) and from the conversion of woods and prairies (33,824.34 Gg). After a review of the inventory that was prepared and in view of the high uncertainty of the data on which the calculations were based, data on sequestration are not included.

CARBON MONOXIDE

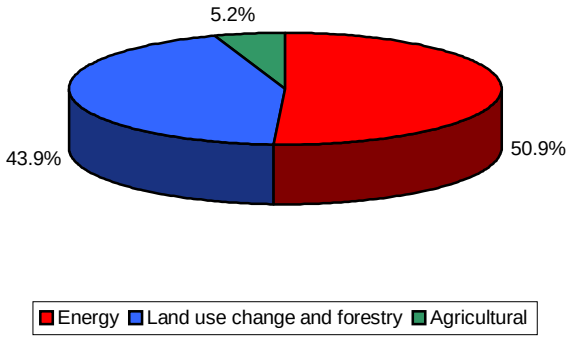
Much like CO_2, CO is emitted principally by the energy sector (50.90%) and land use change and forestry (43.88%), which together account for 94.78% of national total; the rest comes from agricultural activities.

In the energy sector, the most important sources of emissions are transportation (69%) and the burning of traditional biomass (30.7%).

CO emissions due to land use change and forestry are generated essentially by the burning of biomass on the surface of the land.

The most important sources of emission generation in the agricultural sector are the burning of rice waste (70%) and sugar cane bagasse (14%), which together account for 84% of national total.

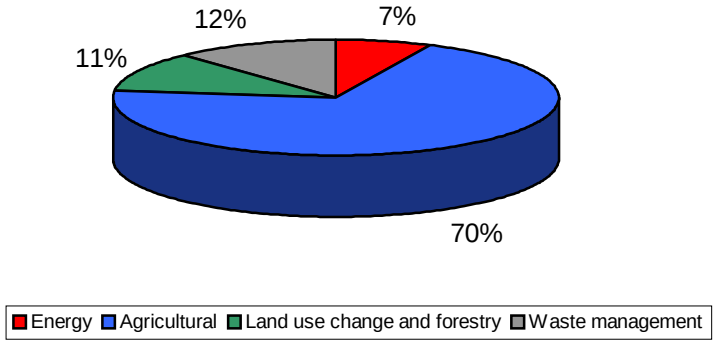
Chart 8: CO emissions by sector (%)



METHANE

About 70% of methane emissions come from agricultural activities and the rest come from land use change and forestry (10.94%), waste management (11.54%), and the energy sector (7.36%).

Chart 9: Methane emissions by sector (%)



In the agricultural sector, almost 97% of the emissions come from enteric fermentation (69.9%) and rice farming.

In the agricultural sector, almost 97% of the emissions come from enteric fermentation (69.9%) and rice farming, along with the use of manure (2.3%) and the burning of farm waste.

In the context of land use change and forestry, methane emissions come exclusively from the burning of biomass on the land's surface.

As for waste management, the emissions are generated by the elimination of solid waste on land (62.3%) and the treatment of sewage water (37.7%).

The most important source of methane emission in the energy sector is the burning of biomass to obtain energy (88.6%).

▶ NONMETHANEC VOLATILE ORGANIC COMPOUNDS (NMVOC)

Emissions of nonmethane volatile organic compounds (NMVOC) are produced in the energy sector essentially in connection with transportation activities.

▶ NITROGEN OXIDE (NOX)

Nitrogen oxide is basically generated by energy activities (83%) and, to a lesser extent, by land use change and forestry (14.6%) and agricultural activities (2.5%).

▶ NITROUS OXIDE (N_2O)

Energy sector (50%) and land use change and forestry together are responsible for emitting about 92% of N_2O emissions, whereas the rest is produced by agricultural activities.

Table 2: Detailed inventory of GHG (Gg). Year 1990.

Category of GHG sources and sinks	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1. Total energy	18,877.80	41.07	0.49	85.92	615.63	132.93
A. Fuel combustion	18,877.80	20.18	0.49	85.92	615.63	132.93
• Energy and transformation industry	1,201.00	0.01		3.17	0.24	
• Industry (ICCS)	3,116.00	0.07		6.65	0.64	
• Transportation	8,995.00	2.11	0.13	67.65	425.00	132.93
• Small-scale combustion	5,565.80	0.12	0.21	4.51	0.83	
• Traditional biomass burnt to obtain energy		17.87	0.15	3.94	188.92	
B. Fugitive emissions coming from fuels		20.89				
• Oil and natural gas		20.89				
2. Industrial processes	1,150.00					
3. Agriculture		398.39	0.07	2.69	62.89	
• Enteric fermentation		281.15				
• Use of manure		9.11				
• Rice farming		105.14				
• Farm waste burning in fields		2.99	0.07	2.69	62.89	
4. Land use change and forestry	45,543.14	60.67	0.42	15.08	530.89	
• Change in the stock of standing timber and other wood biomass	11,718.80					
• Conversion of woods and prairies 1. Onsite burning 2. Burning outside the woods 3. Released as aerial biomass	33,824.34 14,165.73 3,541.41 16,117.20					
5. Waste management		64.02				
• Elimination of solid waste on land		39.91				
• Treatment of sewage water		24.11				
National total of emissions and removal	**65,570.94**	**564.15**	**0.98**	**103.69**	**1,209.41**	**132.93**

WARMING POTENTIAL

The radioactive force produced by the different gases depends on their concentration and the length of time they stay in the atmosphere; thus it is estimated that, for a 30-year horizon, methane is 56 times more effective than CO_2 and nitrous oxide 280 times more effective, whereas for a 100-year horizon methane is 21 times more effective than CO_2 and nitrous oxide 310 times more effective.

The global warming potential (GWP) was calculated for 20 and 100 years. Over a 20-year horizon, the warming will come principally from CO_2 (67.3%) and methane (32.4%). Over a 100-year horizon, the share of the contribution of CO_2 would increase to 84.4%, whereas methane's share would decline to 15.2% (Table 3).

Table 3. GHG warming potential

Gas	20-year horizon			100-year horizon			
	Emission Gg	GWP	Relative total Gg	Relative contrib. %	GWP	Relative total Gg	Relative contrib. %
CARBON DIOXIDE CO_2	65,570.94	1	65,570.94	67.3	1	65,570.94	84.4
Energy	18,877.80		18,877.80	19.4		18,877.80	24.3
Industrial processes	1,150.00		1,150.00	1.2		1,150.00	1,5
Land use change and forestry	45,543.14		45,543.14	46.7		45,543.14	58.6
METHANE, CH_4	564.15	56	31,592.4	32.4	21	11,847.15	15.2
Energy	41.07		2,299.92	2.4		862.47	1.1
Agriculture	389.39		22,309.84	22.9		8,366.19	10.8
Land use change and forestry	60.67		3,397.52	3.5		1,274.07	1.6
Waste management	64.02		3,585.12	3.7		1,344.42	1.7
NITROUS OXIDE, N_2O	0.98	280	274.4	0.3	310	276.08	0.40
Energy	0.49		137.2	0.1		151.9	0.20
Agriculture	0.07		19.6	0.003		21.7	0.004
Land use change and forestry	0.42		117.60	0.1		130.2	0.20

Chapter 3

General description of measures

CLIMATE CHANGE PROCESS IN ECUADOR

Ecuador, a developing country that has sustained a severe socioeconomic crisis throughout the last decade, made major efforts to carry out direct actions for the climate change procss and other related actions.

Ecuador, a developing country that has sustained a severe socioeconomic crisis throughout the last decade, made major efforts to carry out direct actions for the climate change process and other related actions. Obviously, the results that were obtained would not have been possible without the cooperation of friendly countries and organizations.

The country believes that the assistance that was received was insufficient, but it has nevertheless been important to lay the groundwork for the climate change process that was developed.

After the adoption in 1992 of the United Nations Framework Convention on Climate Change, the country, through the National Meteorology and Hydrology Institute (INAMHI), started up an entire process from bottom up aimed at learning about climate change on the basis of the country's reality, scientific knowledge about the problem, the possibilities for securing international support, the need to comply with the Convention, etc.

Between 1993 and 1994, Ecuador has proposed for itself the following objectives:

- Install a basic institutional capacity to address climate change problems.
- Analyze climate change in Ecuador and its possible impacts on strategic areas.
- Define alternatives to respond to climate change in terms of decision making.
- Meet international commitments that were made.

Studies focusing on national problems helped to define the following strategic areas regarding climate change: agriculture, water resources, tropical forests, seacoast areas, lowland areas prone to flooding, and areas subject to erosion.

Initial efforts by INAMHI, along with the Ministry of Foreign Affairs and then with the leadership of the Environmental Ministry when it was established, generated major results since they managed to attract international assistance for the implementation of the following projects: Ecuador Climate Change Country Study, Netherlands Climate Change Studies Assistance Program, CC:TRAIN-ECUADOR, Economics of GHG Limitations Country Study Series, EC and UNEP-RISØ, and the ECU/99/G31 Project on Climate Change.

Furthermore, the Program for Monitoring Glaciers in the Andes: A Tool to Analyze Global Climate Change in South America, led by the French Institute for Research and Development (IRD), and national entities such as INAMHI and the National Polytechnic University, is being implemented.

PRINCIPAL PROJECTS

Ecuador Climate Change Country Study

The project, which was funded by the U.S. Environmental Protection Agency (EPA), with the technical coordination of INAMHI and the participation of various national institutions, started up, and laid the groundwork, for the Climate Change Process, because it facilitated dissemination of the topic and awareness raising, the training of staff, the generation of proposals for new projects, the elaboration of technical documentation, and the implementation of specific studies.

The person in charge of implementing the studies received training abroad at 10 workshops held in the United States and various countries of Latin America.

In terms of disseminating the results, as a whole 3,100 copies of the following studies were printed:

- Evidence of Climate Change in Ecuador – INAMHI.
- Baseline and Climate Change Scenarios – INAMHI.
- Vulnerability in the Agricultural Sector – Ministry of Agriculture and Livestock (MAG).
- Vulnerability in the Forestry Sector – CLIRSEN.
- Inventory of Greenhouse Gas Emissions – Ministry of Energy and Mines.
- Energy Mitigation – Ministry of Energy and Mines.
- Mitigation in the Agricultural Sector – Ministry of Agriculture and Livestock.
- Forest Mitigation – CLIRSEN.
- Study on Climate Change in Ecuador – Summary.

Netherlands Climate Change Studies Assistance Programa in the Coastal Area

The Project was implemented between 1997 and 1999 and was aimed at reaching the following objectives:

- Update the document “Ecuador: Profile of its Coastal Resources”.
- Assess the vulnerability of the lower Guayas River basin to rapidly rising sea levels.

For the implementation of the project, there was a Steering Committee comprised of the Ministry of the Environment, INAMHI, the Coastal Resource Management Program (PMRC), and the Directorate General of the Merchant Marine (DIGMER); implementation focused on a consulting group and the participation of various institutions in charge of sector studies such as the National Fishing Institute, the Oceanographic Institute of the Armed Forces, the Center for Integrated Surveying of Natural Resources by Remote Sensing (CLIRSEN), INAMHI, the University of Guayaquil, and private consultants.

Project CC:TRAIN-ECUADOR

This Program was established in Ecuador by UNITAR, as the overall advisory entity, the Latin American Future Foundation (FFLA) as regional partner, and the National Government represented by the National Meteorology and Hydrology Institute (INAMHI) as general project coordinator in charge of its implementation. Among its fundamental objectives, dissemination, awareness-raising, and training were the most noteworthy.

As one of the principal results, one should include the provisional establishment of the National Climate Committee in 1997. Workshops and seminars for dissemination and training have been organized in the universities of various cities of the country, and they were attended by persons working in public and private sector organizations.

Greenhouse gas emission limitation. Phase 1: Definition of a methodology for assessing climate change mitigation actions

This project was globally implemented by the UNEP Collaborating Centre for Energy and Environment (UCCEE) and the Risø National Laboratory and the Ecuadorian Foundation for Energy Studies and the Environment (FEDEMA) in the country.

ECU/99/G31 Project on Climate Change

In order to prepare the First National Communication of Ecuador to the UNFCCC, an agreement of understanding was signed with GEF-UNDP and the Ecuadorian Government, through the Ministry of Foreign Affairs and the Ministry of the Environment as the Chairman of the National Climate Committee.

The implementation includes the direct participation of various public and private organizations in charge of handling each one of the topics involving climate change nationwide, under the direction and coordination of a Basic Group.

THE NATIONAL CLIMATE COMMITTEE (CNC)

It was set up by means of Executive Decree No. 1.101, published in Official Register No. 243 of July 28, 1999, after functioning for two years as a result of its nonofficial establishment in 1997 under the project CC:TRAIN-ECUADOR.

It is comprised of the Minister of the Environment, who presides the Committee, the Minister of Foreign Affairs, the Chairman of the National Higher Education Council, two representatives of the chambers of production, one from the sierra and the other from the coast, and the Chairman of the Ecuadorian Committee for the Defense of Nature and the Environment (CEDENMA). The National Meteorology and Hydrology Institute (INAMHI) is in charge of the Permanent Technical Secretariat of the Committee.

Its organizational structure consists of essentially two entities: the policy coordination entity represented by its board of directors and the technical-scientific entity, which includes the working groups on topics directly or indirectly related to climate change.

The CNC is the political entity in charge of coordinating and implementing the climate change process in Ecuador.

The CNC is the political entity in charge of coordinating and implementing the climate change process in Ecuador.

Among the principal functions of the Committee, the following are included:

- Propose and design policies and strategies for climate aspects so as to enable the country to adopt a national stance on this subject and participate actively in international forums.
- Provide the necessary political support for the implementation of policies and strategies to address climate change processes.
- Develop a national capacity to address variability and climate change.
- Coordinate compliance with the international agreements and treaties on climate change, especially the United Nations Framework Convention on Climate Change (UNFCCC).
- Propose institutional measure for the application of the Clean Development Mechanism envisaged in the Kyoto Protocol.
- Ensure coordination of climate change actions with those involving biodiversity, desertification, and global environmental issues in general.

The functional regulations of the National Climate Committee were passed in October 2000.

CLIMATE CHANGE UNIT

The Ministry of the Environment, in order to intensify climate change actions undertaken to date and to take up new challenges and opportunities, set up in August 2000 the Climate Change Unit, which focuses essentially on three major objectives:

The Ministry of the Environment set up the Climate Change Unit in August 2000.

The Ministry of the Environment set up the Climate Change Unit in August 2000.

1. National Communication to the UNFCCC.
2. The carbon market and, specifically, the Clean Development Mechanism.
3. Coordination of the work of the National Climate Committee, the sector working groups and, in general, the development of national capacity in climate change issues.

ACTIONS REGARDING THE CLEAN DEVELOPMENT MECHANISM (CDM)

In the context of the Clean Development Mechanism envisaged in the Kyoto Protocol, Ecuador, with the leadership of the National Committee on Climate and represented by the Ministry of the Environment, has proposed two objectives that involve participating in

the challenges and opportunities stemming from the carbon market, namely:

1. Definition and implementation of the CDM Project Validation Process at the national level.
2. Promotion and implementation of national capacity (public and private) to prepare CDM projects and to generate significant Certified Emission Reduction Units (CERUs).

In the context of the objectives that were proposed, efforts are being made for the fast-track establishment of a Corporation for Promoting the Clean Development Mechanism. The goals that have been proposed require technical and economic support, for which purpose several initiatives that have not materialized are under way.

CEDENMA Working Group

The Ecuadorian Committee for the Defense of Nature and the Environment (CEDENMA) is the entity for policy coordination and representation of civil nonprofit associations aimed at preserving the environment; it encompasses more than 80 environmental, ecological, and conservationist organizations throughout the country.

In order to deal with climate change from the viewpoint of CEDENMA, a Working Group was internally established to broaden the discussion in this organization and channel the participation of its members in the activities of the National Committee on Climate.

▶ Related efforts

Relevant aspects of environmental treatment in Ecuador

The last two decades have been characterized by a gradually growing social awareness about environmental problems, as well as increasing willingness by the players committed to the country's development to coordinate actions regarding these matters.

Environmental conditions that prevailed on Ecuadorian territory during the eighties and in the early nineties are set forth in major reports such as the "Assessment of the Situation of the Environment in Ecuador" (1980-1981) and its update in 1988, as well as the documentation generated by the First Ecuadorian Congress on the Environment and the study on "Environmental Management in Ecuador" prepared by the Ministry of Foreign Affairs, as a document complementing the National Report of Ecuador to the United Nations Conference for the Environment and Development of 1992.

Since 1994, environmental subjects have been dealt with in greater depth and at a higher political level.

Since 1994, environmental subjects have been dealt with in greater depth and at a higher political level. The establishment of the Environmental Advisory Commission of the Office of the President of the Republic (CAAM) in 1993 and the creation of the Ministry of the Environment in 1996 are noteworthy in terms of institutional capacity building and politics.

The Constitution of the Republic of Ecuador, passed in 1998, in Article 86, provides that: *"The State shall protect the right of the population to live in a healthy and ecologically balanced environment that guarantees sustainable development, shall ensure that this right is not affected, and shall guarantee the preservation of nature".*

The work done by the CAAM led to Ecuador's adoption of the Basic Principles for Environmental Management in December 1993, as well as the General Basic Environmental Policies in June 1994. These two documents, which were widely disseminated, led to the elaboration of the Ecuadorian Environmental Plan in 1995, which contains specific policies and environmental strategies for the areas that require priority attention.

Among the most important legal instruments in the country's environmental context, there is the pollution prevention and control law, the water law, and the environmental management law; the elaboration and discussion of the forestry law, the biodiversity law, the new water law, and the amendments to the pollution prevention and control law are under way.

The Environmental Management Law, enacted in 1999 specifies in Article 3 that "the environmental management process will be oriented according to the universal principles of sustainable development contained in the Rio de Janeiro Declaration of 1992 on the Environment and Development."

The Environmental Management Law, enacted in 1999, in Article 3, specifies that *"the environmental management process will be oriented according to the universal principles of sustainable development contained in the Rio de Janeiro Declaration of 1992 on the Environment and Development."*

The Environmental Strategy for Sustainable Development, prepared by the Ministry of the Environment in 1999, is the result of the entire process that the country has lived over the last two decades. This strategy brings together the policies that are in force and the experiences accumulated in the country, adjusting them to new trends of thinking and knowledge and to the provisions for environmental protection that are now available.

It also has the principles, objectives, and proposals that will guide management of the Ministry of the Environment as a national environmental authority and will permit coordinating state management and the activities of social players.

The Strategy's objective is to promote, on the basis of environmental management, a development based on the sustainable conservaton and use of the country's biodiversity and natural resources.

The Strategy's objective is to promote, on the basis of environmental management, a development based on the conservation and sustainable use of the country's biodiversity and natural resources. The subject of climate change is already considered inside the strategy.

CLIMATE OBSERVATION AND MONITORING SYSTEMS

In order to obtain scientific knowledge about the weather and climate conditions, the Climate Observation System was designed and implemented in Ecuador in 1961. It is under the responsibility of the National Meteorology and Hydrology Institute (INAMH), and at present it has a network of 260 meteorological stations.

It has to be emphasized that this observation system was not designed for the purpose of detecting climate change and lacks the necessary resources to operate and update hydrometeorological instruments.

The information generated in the 40 main agrometeorological and climatological stations is transmitted via radio in real time and is processed for forecasting purposes and for a follow-up of anomalous climate events, as well as adverse events triggering flooding and droughts. The information from the rest of the stations is received in monthly installments, it is then processed by computer technology and undergoes a quality control check prior to its use and publication in the corresponding meteorological yearbooks.

EVIDENCE OF CLIMATE CHANGE IN ECUADOR

National research has basically focused on the climate and tropical glaciers.

▶ CLIMATE EVIDENCE

The research carried out in Ecuador is based on information on mean, minimum, and maximum temperature and rainfall from 14 meteorological stations located in the different geographical regions.

In the study, the concept of "change" was introduced to evaluate the trend over time of the behavior of the parameters considered; change is calculated as the difference between the final and initial values of the trend line in the different charts.

The working hypothesis that was proposed consists of the existence of growing trends in termperature, which was confirmed by the results obtained.

The working hypothesis that was proposed consists of the existence of growing trends in temperature that were statistically verified in the time series, and it was confirmed by the results obtained.

Based on analyses by station and parameter, the results were integrated by homogeneous zones, namely, the rural sea zone, the urban sea zone, the rural highland zone and the urban highland zone (Table 4).

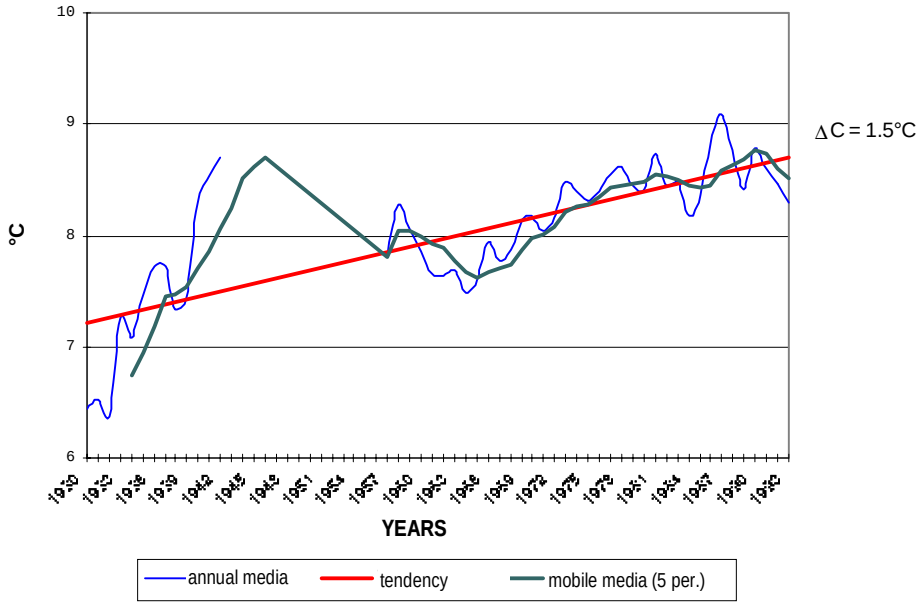
Table 4. Evidence of climate change in temperature and rainfall

Station	Value of "CHANGE"			
	Mean temperature (°C)	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall %
Quito	1.5	2.4	1.3	-1.3
Tulcan	1.6	0.9	1.9	9
Ibarra	1.6	1.2	1.1	-1.8
Cotopaxi	1.5	0.8	0	-15
Ambato	0.5	2.8	2.3	-8
Baños	1	2.3	0	18
Riobamba	1.5	1.7	1.3	25
Loja	0.7	1.3	1.3	24
Portoviejo	0.5	0.8	1	-36
Ancon	0.1			-50
Guayaquil	1	2	1.3	-37
Milagro	0.8	0.6	-0.2	-46
Babahoyo	0.6	0.2	0.2	-2
Machala	0.8			-24

The principal results of the research may be summarized as follows:

- The rural sea zone does not show any clear positive trend in terms of temperature.
- The urban sea zone shows a growing trend in terms of mean and extreme temperatures. "The change" varies between 0.5° C and 1° C in the case of the mean temperature. A decline in rainfall is also noted.
- The rural highland zone, well represented by the Cotopaxi station, has reported consistent results pointing to upward trends in terms of temperature. The value of the change in mean temperature is 1.5° C (Chart 10).

Chart 10. Mean temperature at the Cotopaxi station



- The urban highland zone has recorded upward temperature trends, with higher intensity in the coastal area. The value of change in mean temperature varies between 0.5° C and 1.6° C.

Absolute minimum and maximum temperatures tend to be increasingly higher.

- The rainfall trend over time is highly uneven, with a greater tendency toward decline, especially in the coastal region. If the ENSO effect were to be felt, the signal might become more perceptible.
- Absolute minimum and maximum temperatures tend to be increasingly higher.
- The positive trend in the values for absolute minimum temperature is more evident in the inter-Andean region than in the coastal region.
- The changes in absolute maximum temperature generally are more intense in the inter-Andean region than in the coastal region.

▶ RECEDING TROPICAL GLACIERS

The French Institute for Research and Development (IRD), along with research institutions in Bolivia, Peru, and Ecuador, are conducting an Andean Glacier Monitoring Program: A Tool to Analyze Global Climate Change in South America. In the framework of this study, on Ecuadorian territory, an evaluation of Mount Antisana was conducted.

Until the late eighties, the glaciers in South America, located principally in Patagonia and Tierra del Fuego, covered about 26 square kilometers. The glaciers of the tropical Andes from Bolivia to Venezuela account for about 10% of all Andean glaciers, but their high vulnerability to climate change makes them a fundamental tool to study variability and climate change.

Measurements of the alpha 15 glacier on the snow-capped summit of Mount Antisana indicate that there has been a gradual decline in the length of the glacier between 1956 and 1998.

Measurements of the alpha 15 glacier on the snow-capped summit of Mount Antisana indicate there has been a gradual decline in the length of the glacier between 1956 and 1998. In the year 1999, as a result of the change of phase of the El Niño phenomenon, the length of the glacier increased by 16 meters (Table 5).

Table 5. Variation in the length of Mt. Antisana's 15 alpha glacier

Year	Length (m)	Length lost/won (m)	Loss (%)
1956	2235	0	0
1965	2193	-42	2
1993	2103	-90	6
1996	2049	-54	8
1997	1989	-60	11
1998	1963	-26	12
1999	1979	+16	11

The sensitivity of the glaciers on Mount Antisana to the hot phases (El Niño) and cold phases (La Niña) of the ENSO phenomenon is highly noteworthy. The above confirms a high inverse correlation between ENSO events, characterized by a multivariable index and the balance of the mass measured on the glacier (Chart 11).

The balance of the mass tends to diminish in the face of high-intensity ENSO events, whereas during La Niña events it tends to level out, sometimes even becoming positive. The sensitivity is also notorious in the face of a change of phase; thus, after the 1997-1998 event, the glacier of the Antisana advanced by more than 20 meters.

At over 4,555 meters above sea level, the ice cover on the glaciers of Mount Antisana has diminished from 70% to 54% during the period from 1956 to 1998.

Studies conducted in other countries indicate that their glaciers are receding as part of a process that has intensified since the eighties, with deglaciation speeding up in all areas.

At over 4,555 masl, the ice cover on the glaciers of Mount Antisana has diminished from 70% to 54% during the period from 1956 to 1998 (Chart 12).

Chart 11 .Ratio between the balance of the mass in the ablation zone of Mt. Antisana's 15 alpha 15 glacier and the ENSO multivariable index

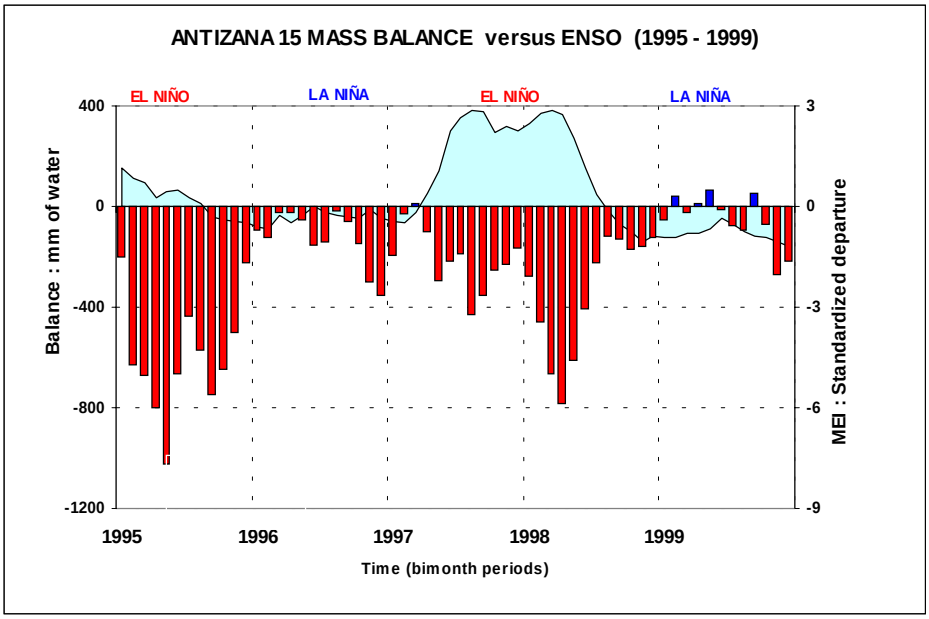
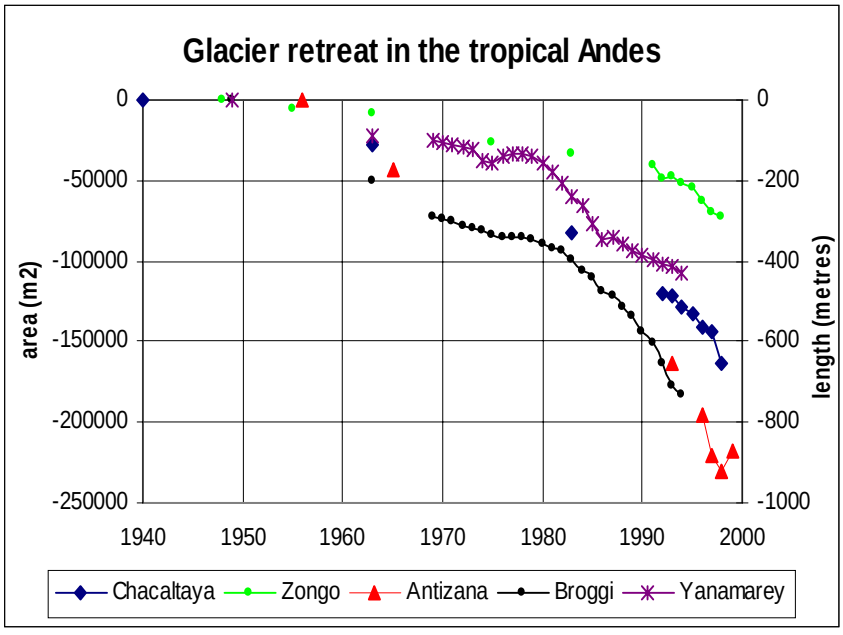


Chart 12: Evolution of the area or length of the five glaciers being monitored in Bolivia, Peru, and Ecuador



The importance of glaciers comes from their contribution to water supply for irrigation (country's central valleys), clean water supply for the city of Quito, and hydropower generation for the cities of La Paz and Lima

With respect to adaptation and mitigation, a methodological process has been implemented in various phases over time and in the framework of different projects with different sponsorship and characteristics.

Specifically, in terms of adaptation, the process has been as follows:

1. Presentation of climate change scenarios that support vulnerability and adaptation studies.
2. Evaluation of the vulnerability to climate change in the agricultural, forestry, seacoast, and water resource sectors, from which proposals for adaptation measures were generated.
3. Analysis of the variability and evaluation of the environmental, economic, and social impacts of the implementation of the adaptation measures suggested in the previous studies, on the agricultural, forestry, and seacoast sectors, using a methodology specifically developed for this purpose.
4. Definition of strategies in order to overcome obstacles that prevent the implementation of measures for the agricultural, forestry, and seacoast sectors.
5. Presentation of project profiles aimed at implementing effectively and practically the measures and to combat the adverse impacts of climate change while helping to contribute to the country's sustainable development for the forestry and agricultural sectors.

▶ CLIMATE CHANGE SCENARIOS

In order to generate climate change scenarios that support vulnerability and adaptation scenarios, research was conducted on the basis of General Circulation Models, which when run led to the conclusion that the models most apt for Ecuador are the CCCM, GISS, and GF2.

Five climate change scenarios (CSS) were defined and used in all V/A analyses.

On the basis of the results of the research that was presented, the region's experience, and the country's knowledge of climate, five climate change scenarios(CSS) were defined and used in all V/A analyses:

CCSM: General circulation model

CCS1: Temperature: + 1.0ºC
Rainfall: - 15%

CCS2: Temperature: + 1.0ºC
Rainfall: + 20%

CCS3: Temperature: + 2.0ºC
Rainfall: - 15%

CCS4: Temperature: + 2.0ºC
Rainfall: + 20%

The results of these scenarios were transformed into 12 monthly rainfall and temperature maps and one annual map for each one of the four scenario proposals, that is, a total of 52 maps.

▶ AGRICULTURAL SECTOR

General remarks

Ecuador has traditionally been an agricultural country. In 1998, according to projections by the SICA-World Bank Project, 31% of the country's territory was used for agriculture and livestock-raising purposes, such as grazing land, permanent cropland, fallow land, transitory crops, and resting land. The sector contributes about 17% of the country's GDP, and 31% of the labor force is involved in sector activities.

As a rule, national farming and livestock production growth has relied on expanding the agricultural frontier rather than on improving the productivity of production systems. Using 1990 as the baseline year, it has been estimated to date that the growth rate of land use for farm and livestock purposes is 5.7% per year in terms of used surface.

The country's staple diet includes, as a priority, rice, potatoes, and tender corn. Hard corn is important as a raw material for the elaboration of meal for feeding animals and livestock activities. Soybean is used to manufacture oil and vegetable shortening.

The above-mentioned crops are concentrated in certain regions of the country, for example rice in the provinces of Guayas and Los Ríos (94%), hard corn in the provinces of Manabí, Los Ríos, and Guayas (70%), potatoes in the central and northern provinces of the country's sierra (87%), and soybean in the province of Los Ríos (97%).

EVALUATION OF VULNERABILITY

Methodological aspects. The evaluation was conducted for the potato and tender corn crops in the Guayllabamba river basin in the inter-Andean region and for the rice, soybean, and hard corn crops in the Guayas river basin.

For the analyses and projections of the agricultural and livestock sector, version 3 of the DSSAT Program, which includes the biological requirements of crops and the physical characteristics of the soil being studied, was run.

The evaluation is part of a determination of food security under normal climate conditions and under two of the climate change scenarios developed.

The evaluation is part of a determination of food security under normal climate conditions and under two of the climate change scenarios developed: the Optimistic Scenario (1° C in temperature and 20% rise in rainfall, ECC2) and the Pessimistic Scenario (2° C rise in average temperature and 15% decline in rainfall, ECC3).

Scenarios were developed for the surface, production, and per capita consumption variables under conditions with and without climate

change. On the basis of this perspective, the demand of each one of the crops considered came from multiplying the population forecast by per capita consumption; at the same time, the demand divided by the expected yield gives the surface to be harvested, with the determination of the following factors:

Food security under climate change

Taking as a baseline the results of the agricultural scenarios, with and without climate change, the food security situation was evaluated, comparing supply with demand. Supply is given by the agricultural scenario under climate change and the demand is calculated on the basis of per capita consumption and the population that is forecast.

The percentage impact in production and surface required is calculated as the difference between supply and demand (Table 6).

Table 6. Impact on food security (%)

Product	2010						2030					
	Without climate change		Optimistic scenario		Pessimistic scenario		Without climate change		Optimistic scenario		Pessimistic scenario	
	Surface	Product.	Surface	Product.	Surface	Product.	Surface	Product.	Surface	Product.	Surface	Product.
Rice	61	107	-38	23	-38	-49	104	162	-51	-3	-51	-60
Hard corn	20	69	-17	417	-17	199	35	114	-25	309	-25	137
Soybean	41	42	-29	23	-29	20	62	80	-38	-3	-38	-5
Potato	56	56	-36	178	-36	-17	62	97	-38	120	-38	-34

Food Security - year 2010

The demand required in the year 2010 for the four crops studied to meet the needs of the projected population, in general, assumes an extension of land surface dedicated to production.

With the pessimistic scenario, there would be a 49% shortage of rice.

The situation by crop and year is different, as indicated in the analyses presented below.

Rice. Under conditions without climate change in the year 2010, 1,738,981 metric tons of rice production would be required, which would imply a 61% rise in land surface used.

If there is a climate change under the optimistic scenario, rice supply would exceed by about 23% the requirements of the population, whereas with a pessimistic scenario, there would be a 49% shortage of rice, which would have to be covered by imports and the expansion of cultivated surfaces.

Hard corn. In the year 2010, without climate, the Ecuadorian population would need a production amounting to 69% more than that for the year 1990, which would imply a 20% rise in land surface dedicated to this crop.

Under conditions of climate change, with the optimistic scenario, the production of hard corn would yield a surplus of 417% whereas with the pessimistic scenario the surplus would be on the order of 199%.

Soybean. Soybean farming would have to expand its land surface by 41%, and its production would have to increase by 42% in order to meet the needs of the population in the year 2010.

The inclusion of climate change with its optimistic option would lead to a 23% production surplus, whereas with the pessimistic option production would also record a surplus, of 20%.

Potato. As for potato requirements to feed the population in the year 2010, there will be a 56% deficit in production, and therefore it would be necessary to expand cropland by about 56%. Climate change with its optimistic generation would generate a production surplus of 178%.

The pessimistic option for climate change would trigger a deficit of 17% in potato production.

The pessimistic option for climate change would lead to a different situation and would trigger a deficit of 17% in potato production, which would have to be covered by imports and/or the expansion of cropland.

Food security - year 2030

For the year 2030, the estimated population of Ecuador would probably generate a pressure on food supply (Table 6).

Rice. To meet the needs of the population, rice production should increase by about 162% with a 140% expansion of land surface.

With the optimistic option, climate change would generate a small deficit, on the order of 3%, in rice production whereas with the pessimistic option the deficit in rice production would amount to 60%, which would have to be covered by an increase in cropland surface, the introduction of higher-yield varieties, and/or imports.

With the pessimistic option, the deficit in rice production would amount to 60%.

Hard corn. To meet the population's demand, production should increase by about 114% and cropland by 35%.

With climate change, the situation would be different, because expected production would rise by 309% under the optimistic scenario and by 137% under the pessimistic scenario.

Soybean. Production would have to increase by 80% compared to the year 1990, with a 62% expansion of surface land to meet the demand of the population.

Climate change would enable deficits to decline considerably to 3% in the optimistic scenario and to 5% in the pessimistic scenario.

With the pessimistic scenario the deficit would be on the order of 34%.

Potato. The population of about 18.5 million inhabitants in the year 2030 will be requiring a 97% increase in potato production, with an expansion of cropland on the order of 62%.

Climate change, with the optimistic option, would solve the problem, because it is estimated that there will be a surplus production of 120%, whereas with the pessimistic scenario the deficit would be on the order of 34%.

ENVIRONMENTAL, ECONOMIC AND SOCIAL INVESTMENT FOR THE IMPLEMENTATION OF ADAPTATION MEASURES

All the measures that were proposed showed a high viability for implementation and were highly compatible with international plans, program and agreements.

The assessment was conducted on a list of measures that brought together those suggested in the vulnerability studies and others related to sector studies and plans of current interest.

All the measures that were proposed showed a high viability for implementation and were highly compatible with international plans, programs, and agreements (Table 7).

Table 7. Assessment of viability and impacts

MEASURES	VIABILITY	IMPACTS	
		Environmental	Socioeconomic
Agro-ecological zoning and suitable seasons for sowing and harvesting	High	Irrelevant	Irrelevant
Introduction of higher-yield varieties	High	Irrelevant	Irrelevant
Implementation of irrigation systems	High	Irrelevant	Irrelevant
Suitable use of fertilizers	High	Moderate	Irrelevant
Implementation of pest and disease control systems	High	Irrelevant	Irrelevant

The high viability of all the measures means that they entail virtually no major barriers for their implementation.

Environmental and socioeconomic impacts are negligible in four of the five measures, in other words, they are highly sustainable in environmental and socioeconomic terms.

Regarding the results of the environmental impacts, almost all the measures show a negligible impact. The application of the measure of adequate use of fertilizers would trigger moderate environmental impacts owing to the possible adverse impact on the soil, flora, and fauna stemming from the use of agrochemical products. All the measures would generate insignificant socioeconomic impacts.

The environmental financial analysis indicates that, when including certain externalities that have been quantified, the rate of return grows considerably in all the measures, which therefore turn out to be economically profitable.

Definition of the adaptation measures

The measures that led to a positive balance in the previous assessment are mentioned below.

Agro-ecological zoning and suitable seasons for sowing and harvesting

Objective: Sustained agricultural and livestock production, keeping in mind the vulnerability of the country's various areas to the impacts of climate change, conservation of natural resources, and environmental protection.

Introduction of higher-yield varieties

Objective: Increase productivity and reduce pressure on expanding the agricultural frontier, avoiding deforestation, and making efforts to maintain carbon sequestration capacity, improving comprehensive biological control systems and promoting new land uses.

Implementation of irrigation systems

Objective: Facilitate a better use of water resources through the use of suitable irrigation systems for each crop and production zone, as well as reduce potential water deficit for agricultural and livestock activities.

Suitable use of fertilizers

Objective: Apply a methodology to regulate the adequate use of fertilizers and generate optimal fertility conditions in the land, as well as achieve maximum productivity in a smaller or equal area of cropland, ensuring crop diversification to meet national demand for food.

Implementation of a pest and disease control system

Objective: Reduce the impacts of soil and surface water pollution produced by the indiscriminate use of pesticides and herbicides, whose application may eventually lead to declining yields, making it necessary to apply increasingly higher amounts to mitigate their effects and, finally, to increase productivity.

The attack of pests and diseases would be mitigated if a technological package adapted to each zone and crop were to be applied, including crop rotation, sowing varieties whose resistance has been tested, and the application of agrochemical products at suitable seasons of the year and in adequate amounts, as well as the implementation of comprehensive biological control.

ADAPTATION STRATEGIES

Sector strategies

Institutional:

- Coordinate inter-institutional actions with those organizations involved in agricultural and livestock sector development regarding the matter in order to avoid duplication of functions.
- Integrate the sectors involved with agricultural and livestock development organizations to implement adequate zoning and integral natural resource and environmental management.

Technological:

- Promote national and international cooperation agreements with institutions that can facilitate technological packages for the benefit of small and medium farmers for the purchase of improved seeds, irrigation equipment, and fertilizers.

Training and information:

- Raise awareness and educate about the importance and benefits of improved varieties, adequate irrigation systems for each crop and region, adequate fertilization and the systematic control of pests and diseases leading to increased productivity and higher standards of living, conserving environmental conditions, and sustaining food security.

Financial:

- Seek funding among national and international organizations involved in agricultural and livestock development that would enable farmers to implement actions to increase production and obtain higher benefits.

Specific strategies

- Involve production sectors in the task of identifying, formulating, and determining the benefits of the agricultural and livestock zoning of the country to ensure support in the application of this measure.

- Production of certified seeds that guarantee production and promotion of their use among companies and producers.
- Disseminate the concept of environmental externalities as part of the management of high-altitude watersheds, preventing the destruction of the basin for the benefit of the users of the lower parts.
- Avoid the use of inadequate fertilizers, especially nitrogenates and phosphates, and give incentives to the use of compost and organic matter.
- Promote the creation of a geographical information system for controlling and monitoring the planning and implementation of the measures that are proposed in order to facilitate timely and low-cost decision making.

CONSTRAINTS

In the agricultural sector, constraints arose that directly or indirectly rendered the implementation of the studies difficult and that could become barriers for future work in this area. The following are noteworthy:

- Lack of updated and complete information regarding agricultural activities. Existing data are not always centralized and available.
- Computer equipment available is from earlier generations and therefore does not meet the needs of the studies.
- The lack of awareness, dissemination, and training on the importance of climate change in the agricultural sector is noteworthy.
- The vulnerability and adaptation studies conducted in the agricultural sector do not cover all geographical sectors of the country, nor do they focus on important staple food crops, nontraditional crops, and those used for industrial purposes.
- Existing information to determine animal load capacity does not meet the country's needs.
- The lack of resources prevented an in-depth definition of strategies and project profiles.

The vulnerability and adaptation studies conducted in the agricultural sector do not cover all geographical sectors of the country, nor do they focus on important staple food crops, nontraditional crops, and those used for industrial purposes.

▶ FORESTRY SECTOR

General remarks

Ecuador has about 11.5 million hectares of forest. Its native woods are categorized as natural protected areas (35.7%), protective forests (27.8%), and productive forests (36.5%). Its forest plantations cover an area of 78,000 hectares, 90% of which are in the inter-Andean region, 8% in the coastal region and 2% in the Amazon region.

ASSESSMENT OF VULNERABILITY

General and methodological aspects

The Holdridge model was used to classify living zones throughout the country's territory. The information on rainfall and temperature coming from a series of data corresponding to a 20-year period helped to define the current conditions scenario (CCS).

Each one of the climate change scenarios (CCS) previously defined for the vulnerability studies was applied to the model:

CCS1	Temperature:	+1ºC	Rainfall:	-15%
CCS2	Temperature:	+1ºC	Rainfall:	+20%
ECC3	Temperature:	+2ºC	Rainfall:	-15%
ECC4	Temperature:	+2ºC	Rainfall:	+20%

Principal results

Table 8 shows the area of each one of the life zones and its percentage share (%) of the country's total, under current conditions and under each one of the climate change scenarios used.

Table 8. Life zone areas (%) with and without climate change

LIFE ZONES	CCS	CCSM	CCS1	CCS2	CCS3	CCS4
14-Cold temperate steppe	0.20	0.00	0.59	0.00	0.29	0.00
15-Cold temperate humid forest	5.14	0.00	0.53	0.21	0.07	0.06
16-Cold temperate very humid forest	3.09	0.00	0.31	0.64	0.00	0.51
18- Hot temperate desert	0.00	0.24	0.00	0.00	0.00	0.00
19-Hot temperate desert	0.00	0.65	0.00	0.00	0.00	0.00
20-Hot temperate thorny steppe	0.00	0.43	1.18	0.00	1.48	0.00
21-Hot temperate dry forest	3.18	12.13	7.14	7.26	8.49	4.49
22-Hot temperate humid forest	7.41	3.89	5.5	10.31	3.85	8.46
23-Hot temperate very humid forest	2.00	0.00	0.45	0.00	0.40	2.08
26-Subtropical desert scrub	0.06	0.00	0.27	0.00	0.24	0.00
27-Subtropical thorny scrub	2.74	0.39	0.18	0.36	0.37	0.20
28-Subtropical dry forest	1.18	2.14	3.08	1.73	4.38	1.32
29-Subtropical humid forest	15.23	11.57	11.93	4.25	10.76	5.61
30-Subtropical very humid forest	29.50	24.26	30.22	32.37	23.07	19.56
31-Subtropical rain forest	1.28	0.37	0.00	0.64	0.08	3.72
33-Tropical desert scrub	0.11	0.00	0.01	0.00	0.23	0.00
34-Tropical thorny woodland	0.14	0.00	2.3	0.75	2.37	0.98
35-Tropical very dry forest	2.50	4.95	6.63	3.73	5.74	3.68
36-Tropical dry forest	14.80	16.12	19.08	25.36	20.21	13.00
37-Tropical humid forest	6.74	16.22	9.9	9.71	14.21	18.01
38-Tropical very humid forest	4.70	6.64	0.65	2.68	3.78	18.32
Total Dry Zones (%)	25	37	40	39	44	24
Total Humid Zones (%)	75	63	60	61	56	76

CCS: Current condition scenario
CCSM: Climate change scenario according to global model
CCS1: Climate change scenario 1
CCS2: Climate change scenario 2
CCS3: Climate change scenario 3
CCS4: Climate change scenario 4

According to the quantitative climate change scenarios, except for scenario CCS4, a considerable increase in dry zones can be noted compared to the current situation.

According to the quantitative climate change scenarios, except for scenario CCS4, a considerable increase in dry zones can be noted compared to the current situation, especially in scenario CCS3, which would be the critical scenario, because it assumes the highest number of variations toward drier zones, that is, presenting a clear trend toward desertification, because in general all the dry zones increase by 75%, compared to the current situation, which would mean 44% of the country's total surface.

The highest increases can be seen in the tropical thorny woodlands, the subtropical desert scrub, the subtropical dry forest, and the hot temperate dry forest.

The tropical thorny woodland is located in a strip running from north to south through the provinces of Manabí and Guayas and a coastal strip to the south of the province of El Oro.

Subtropical desert scrub covers the westernmost part of the Santa Elena peninsula.

The subtropical dry forest is located for the most part between the provinces of El Oro and Loja, appearing also in small areas to the north and south of Manabí and around the valley of El Chota between the provinces of Imbabura and Carchi.

The highest drops appear in the cold temperate humid forest (99%), the subtropical rain forest (94%), and the hot temperate very humid forest.

The hot temperate dry forest covers a large part of the inter-Andean area except for the province of Loja.

The highest drops, however, appear in the cold temperate humid forest (99%), the subtropical rain forest (94%), and the hot temperate very humid forest (80%).

Critical impact zones

On the basis of the results, impact zones where the most severe effects and the highest variations in terms of living zones would occur were defined.

Zone A. This zone is comprised of the coastal regions of the provinces of El Oro, Guayas, and Manabí.

Zone B. The most critical zones are located in the inter-Andean region, especially in the central provinces.

Zone C. The critical zones are located to the south of the country and include the entire province of Loja and part of the province of El Oro.

Environmental, economic, and social assessment of the implementation of adaptation measures

The possible impacts of climate change in Ecuador indicate the importance of having the country adopt adaptation measures for forest ecosystems in order to preserve and increase the forest surfaces on the national territory.

The adaptation measures that were selected are highly compatible with the general environmental and forest management plans of the State.

The adaptation measures that were selected (Table 9) are highly compatible with the general environmental and forest management plans of the State, with international efforts focusing on climate change, desertification, and sustainable development, and with the laws and regulations of the environmental and forestry sector and do not entail major technical and institutional barriers. All of these aspects have ensured that the viability index is high and moderate for most measures.

The analysis of the environmental and socioeconomic impact of the adaptation measures indicates that the impact is positive.

The financial environmental analysis concludes that all the measures, considering the value of externalities (environmental services, carbon sequestration), have favorable financial indices.

Table 9. Total feasibility matrix: Forestry sector

TOTAL FEASIBILITY MATRIX				
ADAPTATION MEASURES IN THE FORESTRY SECTOR				
ADAPTATION MEASURES	VIABILITY LEVEL	IMPACT LEVEL	FINANCIAL VIABILITY	FEASIBILITY LEVEL
Protective forest plantations	High	Positive	High	High
Sustainable management for plantations	High	Positive	Moderate	High
Integral rural development programs in watersheds	High	Positive	Moderate	Moderate
Woodland/grazing land systems	Moderate	Positive	High	Moderate
Agroforestry systems	Moderate	Positive	High	Moderate
Protection against pests	Moderate	Positive	Moderate	Moderate
Protection against fires	Moderate	Positive	Moderate	Moderate
Sustainable management of native forests	High	Positive	Low	Low
Management program for fragile ecosystems	High	Positive	Low	Low
Comprehensive anti-desertification programs	Moderate	Positive	Low	Low

Definition of adaptation measures

Protective forest plantations

Objective: Establish forest masses that provide environmental services such as soil protection, water regime regulation, and CO_2 sequestration and reduce the vulnerability of ecosystems to climate change.

Sustainable management of production plantations

Objective: Apply forest management techniques for plantations, using principles of sustainability, in order to obtain timber

products for industry and crafts, thus reducing the pressure on native forests.

Integral rural development in watersheds

Objective: Formulate and implement a integral rural development program, using a sustainable management approach in watersheds to preserve land, plant, and water resources and conserve environmental quality.

Agroforestry and woodland/grazing land systems

Objective: Increase the use of multi-purpose forest species in the agricultural and livestock area in order to reduce the deterioration of land resources from erosion.

Forestry protection against pests and disease

Objective: Promote prevention activities in order to reduce the risk of pests and disease on forest plantations.

Protection against forest fires

Objective: Disseminate and implement prevention and control activities in order to reduce the frequency of forest fires in a predictable climate change scenario and protect biodiversity.

Sustainable management of native forests

Objective: Apply forest management techniques for native forests, using principles of sustainability, in order to obtain timber and nontimber products, ensuring their conservation and the continuity of their biological processes and contributing to their adaptation to climate change.

Sustainable management of fragile ecosystems

Objective: Conserve fragile ecosystems that are vulnerable to climate change, such as Andean moorlands, wetlands, and mangroves by conserving genetic banks and maintaining ecosystems such as biological corridors in order to facilitate the process of adaptation to climate change.

Comprehensive anti-desertification program

Objective: Formulate and carry out a comprehensive anti-desertification program, using forest activities as a strategy to preserve land and water resources.

ADAPTATION STRATEGIES

The principal strategies being proposed are described below.

Sector strategies

- Elaborate a nationwide ordering of forest territory as an instrument to analyze and plan long-term forestry sector activities.
- Formulate and implement forestry-environmental training programs aimed at the primary and middle levels of formal education, especially in rural areas.

- Promote voluntary forest certification as a tool to offer environmentally certified forest products on the national and international market.
- Promote the establishment of a national forest fund to manage the forestry sector over the short, medium, and long term, with national and international funding of programs on climate change, sustainable development, and natural resource conservation, as well as charging duties and tolls for the use of environmental services.

Specific strategies

- Promote and monitor the application of standards in the field that would permit evaluating the results of forestry development and establishing regulations for the mitigation of social and environmental impacts generated by the development of native forests.
- Promote the payment for environmental services at the national and international level for the benefit of rural inhabitants participating in protective forest plantations.
- Promote a system of incentives for small and medium-sized timber producers in order to meet short-term subsistence needs.
- Implement a geographical information system to control and monitor forest activities nationwide in those areas classified as protective and productive forest plantations, native forests, fragile ecosystems, and watersheds, agroforestry, woodlands/grazing land, management of pests and fire prevention, anti-desertification and erosion control programs, which will be a valuable tool for implementing the ordering of forest territory and integral and sustainable rural development plans.

CONSTRAINTS

The forestry sector involved in the vulnerability and mitigation evaluations has faced the following constraints and obstacles:

- Information available in the country regarding the forestry sector is scattered and not up-to-date, and there are no national statistics that include aspects about annual plantations, rates of illegal development, etc.
- The working team focusing on the base of existing resources was set up only for the purpose of the studies, that is, it is not a permanent team.

▶ SEACOAST SECTOR

The seacoast sector is very important for the country's socioeconomic well-being, and traditionally it is the most vulnerable to climate anomalies, especially those related to the floods generated by

ENSO events. In the climate change process, the sector is considered to be one of the strategic areas.

ASSESSMENT OF VULNERABILITY

The assessment of vulnerability was conducted in the lower Guayas river basin, in an area with a perimeter of 630 km and a surface extension of 14,878 km^2, of which a third is covered by estuaries. Its importance for the country's socioeconomic activities is truly considerable because it is one of the principal areas for national agricultural, industrial, and commercial development.

The area of study includes the estuaries of the Guayas river-Jambelí Canal and the Salado Estuary-El Moro Canal, whose banks and islands are covered by salt mangroves and shrimp farms, as well as the basins of the Daule and Babahoyo rivers, which come together to form the Guayas River and which are characterized by agricultural activities.

Methodological aspects

The study was based essentially on the methodology of the Intergovernmental Panel on Climate Change (IPCC), called the seven-step methodology, with three scenarios (two climate change scenarios) and the subdivision of the area of study into ten segments.

The scenarios used are called the Basic-LANM0, the Moderate-LANM1, and the Severe-LANM2 (Table 10).

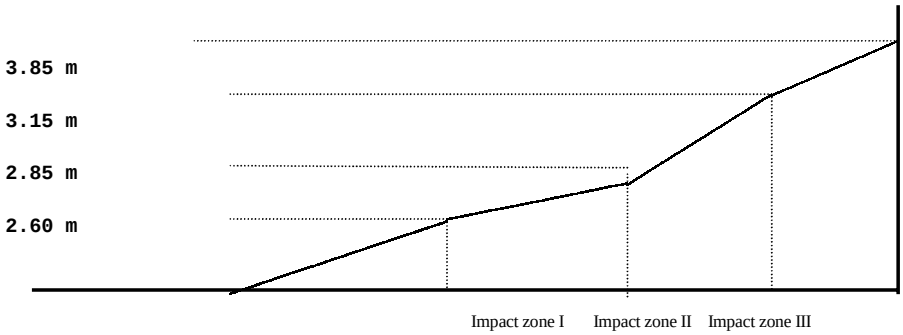
The figure of 3.85 m represents the average level of water reached in a 100-year return period acting on the LANM 2.

In addition, impact zones were defined in order to evaluate the flooding problems generated by the LANM (Chart 13). The figure of 3.85 m represents the average level of water reached in a 100-year return period acting on the LANM 2; nevertheless, the historical record indicates that there is a value of 4.33 m for Guayaquil owing to the flow of the river and the hydraulics of the estuary.

Table 10. Climate change scenarios

	LANM0	LANM1	LANM2
Sea level	0.0 m	0.3 m	1.0 m
Rainfall	Average	Moderate, 15% decline from the average	20% rise over the average
River discharge	Average	15% decline from the average	20% rise over the average
Rise in air temperature	Normal	+1° C	+2° C
Anomalies in sea temperature	Normal	<1° C	>2.5° C

Chart 13: Impact zones



Impact zone I represents the flooding area for LANM0, Impact zone II is the additional flooding area for LANM1, and Impact zone III the additional flooding area for LANM2.

Main results

The principal impacts of the climate change scenarios could occur basically in water levels, frequency of excedence, and salinity.

The main impacts of the climate change scenarios could occur basically in water levels, frequency of excedence, and salinity, whereas the most sensitive impacts, according to the study, would involve the areas lost as a result of the LANM and the impacts of rainfall and river flooding (Table 11).

Virtually all seacoast areas are subject to flooding, especially in the face of the possibility of LANM2.

Table 11. Impacts on the natural system (km²)

Lost areas	LANM0	LANM1	LANM2
Due to impacts of the LANM			
• Shrimp farms	171	231,5	355,2
• Mangroves	301,5	347,3	532,7
• Urban area		38	71,2
• Leisure areas	2,5	7,2	12,9
Due to impacts of rainfall and river flooding			
• Bananas	137,7	125	150
• Rice	200	200	200
• Sugar cane	675	675	675

In the extreme case, with a 100-year return period, the flooded area would be 75 km^2 without LANM, it increases considerably with LANM1 to 625 km^2, if it is 0.30 m, and to 971 km^2 with a 1.00-meter LANM.

Assuming the minimum case, for a return period of hardly a year, without LANM the flooded area would extend over 43 km^2 and with a LANM of 1.00 m over 539 km^2 (Table 12).

Table 12. Floodable areas (km²)

Scenario/return period	1	1/10	1/100
BASIC – LANM0	42.79	62.29	75.09
LANM1	191.89	411.49	624.09
LANM2	539.69	759.39	971.99

If the LANM2 scenario were to occur, there would be losses amounting to US$1.305 billion and an additional amount of US$1.04 billion would be endangered.

The estuary of the Guayas River would be the most affected because salt water could intrude upstream in the Daule and Babahoyo rivers and generate changes in salinity.

The economic losses could reach significant amounts; thus, on the basis of the results of the Flood Risk Model, if the LANM2 scenario were to occur, there would be losses amounting to US$1.305 billion and an additional amount of US$1.04 billion would be endangered (Table 13).

Table 13. Capital at risk

	CAPITAL AT RISK (million US$)			
	WITHOUT DEVELOPMENT		WITH DEVELOPMENT 2010	
	LOSSES	ENDANGERED	LOSSES	ENDANGERED
LANM0	136	404	193	573
LANM1	408	526	607	756
LANM2	881	716	1305	1040

If the LANM2 scenario were to occur, it could generate an evacuation of 327,000 persons and about 200,000 additional inhabitants would be in danger.

In view of the problems that were detected, the population could be in danger under all the scenarios considered in the assessment. For example, if the LANM2 scenario were to occur, it could generate an evacuation of 327,000 persons and about 200,000 additional inhabitants would be in danger (Table 14).

Table 14. Potential population at risk

	POPULATION			
	WITHOUT DEVELOPMENT		WITH DEVELOPMENT 2010	
	EVACUATED	IN DANGER	EVACUATED	IN DANGER
LANM0	17.340	75.352	28.220	77.620
LANM1	167.940	132.746	194.576	145.343
LANM2	284.325	184.669	327.005	204.787

If the LANM2 scenario were to occur, the mangroves would lose a surface area of about 532 km^2, and an area of 1,300 km^2 would be in danger.

The ecological area would sustain considerable damage if LANM2 scenario were to occur, the mangroves would lose a surface area of about 532 km^2, and an area of 1,300 km^2 would be in danger (Table 15).

Table 15. Potential impacts on mangroves (km^2)

	LANM0		LANM1		LANM2	
	Loss	In danger	Loss	In danger	Loss	In danger
MANGLAR	0	463.2	347.3	698.5	532.7	1,299.6
CHURUTE	0	20.8	25.3	27.3	38.9	46.2

Vulnerability profile assessment

When combining the climate scenarios with the socioeconomic scenarios, the following cases have emerged for examining the vulnerability profile of the Guayas river basin (Table 16).

Table 16. Scenario cases

	LANM0	LANM1	LANM2	No Develop-ment	Develop-ment
CASE 1	X			X	
CASE 2	X				X
CASE 3		X		X	
CASE 4		X			X
CASE 5			X	X	
CASE 6			X		X

CASE 1. Basic Climate Change without Development. The situation in 1998 is taken as the baseline. The amounts in terms of danger and loss are minimal due to LANM impacts on the coastline, but the impacts due to river flooding and intense rainfall associated to climate variability (ENSO) exert a significant impact on the farmland for banana, rice, and sugar crops, as well as on support infrastructure.

CASE 2. Basic Climate Scenario with Development. Due to development impacts, the amounts in terms of danger and losses increase, whereas climate conditions remain at average levels.

CASE 3. Moderate Climate Scenario without Development. The impacts are felt in the mangroves and the shrimp industry, and because of this the amounts in terms of losses and danger increase in these sectors. The opposite could occur in the infrastructure because of the decline in rainfall, although the ENSO could mark the difference.

CASE 4. Moderate Climate Scenario with Development. The development increases the values in losses and danger, in both land and water farming sectors and their respective installations.

CASE 5. Severe Climate Scenario without Development. The impacts on the mangroves and the shrimp industry reach critical levels, because the floodable areas are extensive and threaten the industry. The same can be said for the agricultural sector because of the rise in rainfall and the occurrence of ENSO.

CASE 6. Severe Climate Change with Development. This is the most critical situation of all the cases because development means that the amounts in losses and danger reach figures on the order of three times the GDP for 1998.

ENVIRONMENTAL, ECONOMIC, AND SOCIAL ASSESSMENT OF THE IMPLEMENTATION OF ADAPTATION MEASURES

In the seacoast sector, two types of measures were defined; the first were adjusted to the IPCC methodology and the second were the outcome of an update of the first study.

The first group includes options "without measures" and "total protection."

Response options

Option without measures: A rise in sea level amounting to 0.3 meter would cause extensive flooding, and many areas subject to tide impacts would be under more frequent pressure, which would endanger both the inhabitants and capital goods.

The intrusion of salt water into the Daule River would complicate clean water supply for the city of Guayaquil and adjacent towns.

The intrusion of salt water into the Daule River would complicate clean water supply for the city of Guayaquil and adjacent towns, in addition to irrigation for farming purposes. The floodable area amounts to 978.76 km^2, which corresponds to Impact Zone II.

Flooding due to LANM2 (1.00 m) would be much more extensive, covering an area of 1,204.01 km^2.

Flooding due to LANM2 (1.00 m) would be much more extensive, covering an area of 1,204.01 km^2, endangering the mangroves and shrimp farms installed in floodable sectors located in Impact Zone III.

Total protection option: It envisages the implementation of all the feasible measures to minimize losses of any coastal area and to preserve the present situation of capital goods distributed in this area.

The options are:

Coastal defense. It includes the improvement and reconfiguration of the retaining walls of the shrimp farms, the building of walls on both banks of the Daule and Babahoyo rivers, as well as the recovery of the beach of Jambelí.

Raising the terrain. It includes a hydraulic fill for the areas that could be flooded by LANM1 and LANM2, in the urban zones, especially the cities of Guayaquil and Puerto Bolívar. The option is the most

advantageous owing to the experience that the country already has from the hydraulic fills of Trinitaria Island and the city of Babahoyo.

Guayas River Basin Development Plan. It envisages a set of projects to control the inflows of the Daule, Babahoyo, Chimbo, Bulubulu, Taura, Catarama, Vinces, and Pedro Carbo rivers, which would not only prevent flooding of river banks but also provide drainage and irrigation to the farm zones during the rainy and dry seasons, respectively.

The option "without measures" does not reduce the vulnerability of the zone in the study; quite the opposite occurs when the total protection option is adopted, because capital goods that could amount to values between two and three times GDP can be protected with an investment of under US$2 billion.

On the basis of the previous study, an assessment of the list of measures prepared for this purpose was conducted. This analysis basically includes the identification of the compatibility of the measures with the country's principal sector, regional, and sectional plans and programs, international agreements, and related legal aspects, and the identification of potential technical, institutional, and social barriers that the measures would have to face for their implementation.

The most relevant incompatibilities are related to the national legal and standard-setting framework, principally due to the lack of updating. The most important barriers are those involving external institutions and the lack of governability and abuse of power. As for the international institutions, the lack of financial capacity is the most important barrier for the application of the majority of the adaptation measures proposed (Table 17).

Table 17. Result of the viability analysis of the measures

Measure	Viability
1. Adjustment and maintenance of the road drainage system	Highly viable
2. Hydraulic fill of densely populated urban zones	Highly viable
3. Adjustment of shrimp farming activities	Viable with barriers
4. Establishment of a Biophysical Monitoring and Climate Change Surveillance Program	Viable with barriers
5. Establishment of withdrawal lines, buffer zones, and urban protection borders	Viable with barriers
6. Preservation and reforestation of the mangrove ecosystem	Viable with barriers
7. Adjustment of the Sewage System (Guayaquil)	Major barriers
8. Adjustment of the Clean Water Supply System (Guayaquil).	Major barriers

The results of the viability analysis indicate that the measures for the adaptability of clean water supply and sewage systems show major barriers and incompatibilities, and because of that they were discarded and work has focused on the six remaining measures.

Definition of the adaptation measures

Establishment of a Biophysical Monitoring and Climate Change Surveillance Program

Geographical area: The entire area of the inner gulf of Guayaquil and the lower Guayas river basin.

Support for the measure: To tackle climate change, adequate and timely information on the different indicator variables, whether oceanic, climatological, or biological, is necessary. In addition, the analyses and studies of these variables will permit detecting and evaluating the trends in time series.

This information will serve to help implement various strategies, plans, and projects that are proposed to tackle preventively the adverse effects generated by climate change.

Institutions involved: It involves multi-disciplinary and participatory work with the technical and scientific support of the principal institutions involved in the subject of climate change such as INOCAR, INAMHI, and INP.

General objective: Establish a biophysical monitoring and surveillance program for early warning purposes with respect to climate change and to act with greater speed in the implementation of adaptation strategies.

Results:

- Greater institutional capacity in the participating organizations (INOCAR, INP, and INAMHI).
- Operating data bases of the biophysical parameters associated to climate change.
- Studies and research published and presented.
- Operating web site and other available means of dissemination in order to inform the community and raise its awareness.
- Network of operating monitoring stations, functioning soundly.

Adjustment of the Sewage System for the city of Guayaquil

Geographical area: City of Guayaquil

Support of the measure: The sewage system of the city of Guayaquil is comprised of four subsystems (Parson's Norte, Parson's Sur, Argentina, and White), whose common convergence points are the pumping stations of Guasmo and El Progreso, which then pump the discharged water into the Guayas and Daule rivers, respectively. It should be mentioned that less than 50% of the city is covered by the system and, in some sectors of the city, it is mixed with the clean water service system.

The LANM would affect the pumping stations, flooding houses, commercial premises, hospitals and industry, with the resulting disease and economic losses affecting more than 2 million persons.

The measure intends to address the deficiency in the Sewage System for the city of Guayaquil; nevertheless, there are actions under way (Salado Estuary Recovery Plan, Program to Control Industrial Pollution and Other Sources of Pollution) that ensure that the measure will surely be applied and will contribute to reducing the impacts stemming from the LANM.

Institutions involved: Canton Clean Water and Sewage Utility of Guayaquil (ECAPAG), Municipality of Guayaquil.

General objective: Minimize the impacts caused by the LANM scenarios and protect the city of Guayaquil from an outbreak of disease by providing it with an optimal and adequate sewage system for the disposal of household waste, runoff, and industrial waste.

Results:

- Ensure more than 90% coverage for runoff and sanitary service for the city in a period of no more than five years.
- Endow the city with an effective domestic and industrial waste treatment system.
- Provide Guayaquil with a sewage system that can respond to impacts from the LANM, El Niño events, and river overflowing.
- Set up an efficient sewage system, whose points of discharge are not affected by the LANM, as well as ensure that the corresponding discharge has the least impact on the ecosystems directly in their sphere of influence.

Adjustment of a Clean Water System for the City of Guayaquil

Geographical area: City of Guayaquil

Support of the measure: Guayaquil's clean water system has its intake center in the sector of La Toma on the right bank of the Daule River, whose water resource comes from the middle-lower basin of this river. Close to 80% of the city has clean water supply, but in this system it has been detected that about 30% has legal installations, 60% relies on illegal connections, and about 10% is supplied by tank trucks that carry the water especially to the marginal urban sectors.

The impacts coming from climate change would affect the quality and quantity of this water source, since the intrusion of salt water in the intake systems would alter the availability of fresh water, making it more difficult and expensive to treat.

The measure intends to minimize the impacts that could stem from the intrusion of the saline segment up to the water intake sites for subsequent treatment.

Institutions involved: Canton Clean Water and Sewage Utility of Guayaquil (ECAPAG), Municipality of Guayaquil.

General objective: Minimize the impacts caused by the LANM scenarios, preventing the city of Guayaquil from suffering from clean water shortages and the rising expense of water because of the difficulty of treating it.

Results:

- An optimal clean water system whose coverage would be greater, with a modernized treatment and distribution system.
- Cover more than 90% of the city with clean water service in a period no greater than seven years.
- Endow the city with an effective resource distribution system.
- Provide the city of Guayaquil with a water treatment system that responds to LANM impacts.

Mangrove preservation and reforestation

Geographical area: Estuary zone of the Gulf of Guayaquil (Yaguachi-Taura segment, Salado estuary, Naranjal-Huaquillas, Puná Island, Guayas River, and the archipelago of Jambelí).

Support of the measure: Since the sixties, mangrove resources have been exposed to high pressure, owing to the progressive increase in shrimp-farming areas, the expansion of the city's outer limits, and the use of these resources for different purposes.

The felling of mangroves has led to the migration or disappearance of species that are scientifically important, undermined the role that mangroves play in keeping the balance of nature and, along with that, provoked the loss of the environmental services they generate.

According to 1991 data from CLIRSEN, mangroves covered 141,410 hectares in the gulf of Guayaquil, accounting for 79% of the nation's total. By 1996, however, this area had been reduced to a total of 121,444 hectares. Of the 1,214 km2 of mangroves existing at present, it is estimated that 532.7 km2 will be affected by LANM2, which accounts for 44% of the total area (Table 15).

The measure intends to maintain and expand current mangrove coverage, as well as focus attention on preserving the resources and ensuring their sustainable exploitation.

Institutions involved: Ministry of the Environment, Coastal Resource Management Program, DIGMER, Port Captaincies – UCV, and NGOs, which with support from the community can

contribute to the preservation of the mangroves and their resources.

General objective: Reforest the mangroves of the areas affected by the LANM with different mangrove species and preserve current mangrove areas.

Results:

- Safeguard and sustain the different environmental services offered by the mangroves, whether economic or ecological.
- Better results joining the efforts of communities with those of the institutions involved.
- Conservation and sustained development of the different resources drawn from the mangroves.
- Educate and raise the awareness of the coastal communities about their participation in the sustained management of mangrove resources.

Adjustment of Shrimp-Farming Activities

Geographical area: Estuary zone of the gulf of Guayaquil (Yaguachi-Taura segment, Salado estuary, Naranjal-Huaquillas, Puná island, Guayas River and archipelago of Jambelí).

Support of the measure: the shrimp industry is the country's third largest export item, and the gulf of Guayaquil is one of the most important shrimp production areas. In 1999, US$616,942.11 worth of shrimp were exported, according to data from the National Water Farming Chamber. As indicated, the measure is aimed at adequately rehabilitating the retaining walls to withstand flooding caused by the rising sea level, because the impact caused by LANM2 would cover close to 355.2 km^2 of water farming production areas ,leading to huge losses for the sector.

The proposed measure would be aimed especially at the perimeter walls of the shrimp farms facing the estuary, with the knowledge that the average cost of 1 km^2 of shrimp ponds amounts US$1 million (Ecuador-Netherlands Project, 1999).

In addition, one has to take into account that the shrimp farms located in the province of El Oro are less technified than those of the province of Guayas; therefore one has to ensure in the best way possible the effectiveness of the protection systems that will be installed in these farms.

Institutions involved: DIGMER, National Water Farming Chamber, and private companies.

General objective: Ensure shrimp production and protect private-sector investment by protecting the walls against floods generated by the LANM.

Results:

- Definition of the most vulnerable zones in order to act immediately.
- Serve as a model for shrimp producers.
- Shrimp ponds protected from LANM.
- Promoting new and improved technologies.

Establishment of withdrawal lines, buffer zones, and urban protection borders

Geographical area: Urban seaboard strips of the cities of Guayaquil and Machala, as well as eventually in Posorja and Jambelí.

Support of the measure: A strip of approximately 1,200 km^2 will be affected by the overflowing stemming from a one-meter LANM. On these strips, there are highly consolidated urban residential centers, where the social and economic impact of a rising sea level by one meter would be quite severe. In the industrial sector, the impact would be of the same magnitude if it is kept in mind that the city of Guayaquil alone accounts for more than 40% of the country's industrial activity (CAAM, 1996).

Institutions involved: Municipalities of Guayaquil, Machala, and Santa Rosa, DIGMER, PMRC and community groups living in risk areas who will be directly affected by this measure.

General objective: Protect existing investment and new residential or production projects being developed in the urban zones of the cities of Guayaquil, Machala, and eventually other cities at high risk of sustaining floods caused by the LANM.

Results:

- Zoning and planning the development of risk zones in urban areas in the geographical area where this measured will be implemented.
- Reduction of risk for the infrastructure already installed or to be built in the zones affected by LANM.
- Reduction of the impacts on the quality of living of the inhabitants of the areas at risk so that they will not be affected by the occurrence of LANM.

Adjustment and maintenance of the road drainage system

Geographical area: The entire road network of the provinces located in the lower Guayas river basin and the golf of Guayaquil Guayaquil.

Support of the measure: The country's roads, especially in the area of study, tend to be badly damaged by the intensity of the rainfall during the rainy season, which is even more severe when there are ENSO events and flooding due to LANM.

The ENSO event of 1997-1998 led to direct damage of the road infrastructure, amounting to various million U.S. dollars, because the losses were not merely limited to damage to the asphalt pavement but also involved indirect consequences stemming from the event.

Because of this, the measure intends to contribute to building up the road infrastructure with the installation of a road drainage system involving the building of lateral ditches, sewage pipes, and bridge protection and lateral embankments, thus protecting the investment made in the roads.

Institutions involved: Ministry of Public Works, provincial councils, and regional corporations such as CORPECUADOR.

General objective: Optimize and rehabilitate the road drainage infrastructure and promote its stability, effectiveness, and permanence.

Results:

- First-order and second-order road network and soundly built bridges benefiting from maintenance.
- New specifications that include risks due to climate change, formulated and in force.
- Lateral ditches and shoulders built and adapted for climate change events.
- Lateral protection and embankment works for built bridges.

Hydraulic fill of densely populated urban zones

Geographical area: The most densely populated urban zones at high risk of sustaining flooding owing to rising sea level, especially in the Suburbio Oeste and Isla Trinitaria in the city of Guayaquil.

Support of the measure: The population at risk in 1996 in Suburbio Oeste and Isla Trinitaria amounted to about half a million persons and could increase by about 50% by the year 2010. The extension of the area at risk of flooding owing to LANM2 is about 80 km^2, and it is estimated that the commercial value of this endangered land could amount to US$36 million by the year 2010.

The high demographic density of this residential zone, which is fully consolidated, along with the cultural values of the community involved, makes it virtually impossible to propose any population resettlement.

Because of this, the protection of the zone by means of a hydraulic fill is being proposed; it involves a cost of about half a million U.S. dollars per kilometer, which would mean a total

million U.S. dollars per kilometer, which would mean a total amount of US$40 million to protect the entire endangered zone. This figure, compared with the commercial value of the endangered land, plus the cost of social externalities, justifies the application of this measure.

Institutions involved: Municipality of Guayaquil, DIGMER, environmental nongovernmental organizations and community groups residing in the zone where the measure will be applied.

General objective: Protect the physical integrity of the properties built on the land at high risk of sustaining flooding stemming from the rise in sea level in the marginal urban area of the city of Guayaquil.

Results:

- Updated municipal land registry records.
- Protection of almost 80 km^2 of the densely populated zones of the city of Guayaquil.
- Reduction of risk for the infrastructure built or to be developed on the areas to be affected by LANM on the Isla Trinitaria and Suburbio Oeste of the city of Guayaquil.
- Reduction of impacts on the quality of life of the inhabitants of the zones at risk so that they will not be affected by the occurrence of LANM.

ADAPTATION STRATEGIES

Adaptation and maintenance of the road drainage system

- Redesign and implement the norms for designing and building drainage works and bridges, including safety margins that consider rising rainfall and inflows caused by climate changes.
- Promote concession processes for road maintenance.
- Build up coordination levels between the central government, sectional organizations, and concession holders.

Hydraulic fill of densely populated urban zones

- Incorporate into the State's policies the need to have sectional organizations become responsible for local development plans and the protection of densely populated urban zones at risk of being affected by LANM.
- Incorporate into municipal design and construction norms, safety margins in order to minimize the impacts on the infrastructure already or to be developed in zones at risk of being affected by LANM.
- Give incentives to municipal management to apply land titling programs in areas at risk of being affected by LANM.

- Identify and secure financial assistance to implement projects for the protection of urban zones at risk owing to LANM.
- Promote the dissemination of risks of being affected LANM by means of public education programs in urban areas.

Adaptation of shrimp farming activities

- Learn about the LANM risk zones of shrimp farms in the area of the gulf of Guayaquil and develop a replicable demonstrative land titling project in the zone.
- Educating the business sector about climate change risks.
- Adaptation of the physical facilities of the shrimp farms.

Establishment of a biophysical monitoring and climate change surveillance program

- Supply technical assistance, installations, and training that are needed to research institutes.
- Design and implement a comprehensive biophysical information system.
- Build up coordination levels between the organizations involved in researching and handling information.
- Ensure economic resources permitting the implementation of the program.
- Disseminate the information generated to all civil society entities.

Establishment of withdrawal lines, buffer zones, and urban protection borders

- Give incentives for research to determine areas at risk because of LANM.
- Incorporate in municipal design and construction norms safety margins in order to minimize the impacts of LANM.
- Identify and secure financial assistance from international institutions for the eventual relocation of housing and generate alternative production activities.
- Promote the establishment of industrial parks.
- Promote the dissemination of risks by means of public education programs in urban zones.

Mangrove preservation and reforestation

- Promote the granting of concessions to traditional communities for the sustainable use of mangrove areas.
- Promote scientific research in order to tap the resources of mangrove ecosystems using a sustainable approach.

- Promote the creation of an updated geographical information system that contains an inventory of the mangrove areas.
- Incorporate a component that promotes the reforestation of mangroves into the Mangrove Use and Management Plan.
- Build up coordination levels between organizations that are involved in managing the mangroves.

CONSTRAINTS

As a result of the study in the seacoast sector, various constraints and obstacles that affect its implementation have been detected. Among the most important the following can be indicated:

- Shortage of bibliographical material, since existing material is scattered.
- Certain constraints in the access to certain information.
- Difficulty in conducting an economic assessment of measures because of the shortage of information available.
- Insufficiency of the equipment and material used for gathering the information.
- Lack of resources to gain access to Internet services.
- Existence of a limited number of specialists working on the topic of climate change in the seacoast sector.
- Impossibility of gaining access to experiences and technologies of other countries that have conducted LANM studies (example, aerial video).
- Shortage of education and public awareness-raising programs on the subject of climate change.
- Insufficient participation of higher education centers in climate change programs.

▶ WATER RESOURCE SECTOR

The watersheds extend over an area of 50,791 km^2.

The vulnerability to climate change to which Ecuador's water resources are exposed in the watersheds of the rivers of Esmeraldas, Portoviejo, Chone, Jama, Briseño, Pastaza (up to the Agoyán Project), Paute (up to the Daniel Palacios dam), Mira, Carchi, and Napo (lower basin of Quijos River up to the Quijos station in Baeza and the lower basin of the Jatunyacu river up to the hydrometric station of Jatunyacu after it joins the Iloculin River).

The above-mentioned watersheds extend over an area of 50,791 km^2 and are located in the provinces of Esmeraldas, Pichincha, Manabí, Cotopaxi, Tungurahua, Chimborazo, Cañar, Azuay, Carchi, Imbabura, and Napo, corresponding to the regions of the coast, sierra, and Amazon region. They do not extend to the entire Amazon region because it is

considered to be a sparsely populated zone with little water resources.

In the above-mentioned watersheds, the availability, requirements, vulnerability, and adaptation were determined, applied under the climate change scenarios proposed and formulated in the study "Research and Application of Climate Change Scenarios in Ecuador."

WATER RESOURCES BALANCE

The balance comes from a comparison of the availability or supply of surface water resources with the demand for water for the years 2000 (baseline) and 2010. The availability was calculated by running the WATBAL model for the baseline and climate change scenarios.

In this evaluation, the balance presents values of water resource surpluses and/or deficits in percentages, especially in the basins where there are hydraulic projects, a situation that becomes even more severe during dry periods, above all in those scenarios that show drops in rainfall.

Baseline scenario

It can be concluded that there is a water deficit with respect to demand in the months corresponding to the dry periods.

On the basis of the results of the water resource balance corresponding to the baseline scenario, it can be concluded that there is a water deficit with respect to demand in the months corresponding to the dry periods. The case appearing in the Pastaza river basin, where there is a deficit throughout the year because of overexploitation of this resource, should be highlighted (Table 18).

Table 18: Water resource balance (%). Baseline scenario. Year 2000

CUENCAS	AREA Km^2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESMERALDAS	22,007	866	1,372	2,896	4,714	688	93	**-52**	**-72**	**-53**	**-4**	1	448
PORTOVIEJO	2,208	552	1,253	923	585	235	245	112	2	**-30**	**-38**	**-41**	63
CHONE	2,683	347	932	1,212	781	292	244	138	61	28	21	40	261
JAMA	1,289	308	1,319	1,548	1,348	507	335	130	1	**-19**	**-49**	**-69**	**-36**
BRISEÑO	355	136	598	886	486	179	143	33	**-6**	**-21**	**-40**	**-62**	**-38**
PASTAZA (Agoyán Station)	7,983	**-56**	**-58**	**-46**	**-43**	**-40**	**-17**	**-15**	**-31**	**-42**	**-50**	**-61**	**-63**
PAUTE (Amaluza Station)	5,015	**-3**	7	96	162	149	241	234	158	76	74	11	-4
MIRA	4,960	478	497	522	556	439	328	283	247	292	411	408	381
CARCHI	365	79	63	193	254	143	**-7**	**-52**	**-71**	**-15**	175	223	186
NAPO(Papallacta Project)	3,926	**-34**	**-34**	**-10**	1	20	39	58	22	2	**-22**	**-30**	**-33**

Months with shortage of water rsources

The fully defined low-water periods correspond to the hydrological regimes of the coast (July to October), the sierra (June to September), and the Amazon region (October to March).

Scenario 1: rise in temperature by 1° C, decline in rainfall by 15%

When analyzing the horizon to the year 2010, this scenario is critical because of the decline in rainfall and the rise in temperature (Table 19).

There will be a rise in the deficit and a worsening of runoff periods.

Compared to the baseline scenario, it can be observed that, in the face of climate change, there will be a rise in the deficit and a worsening of runoff periods, which are more critical in the basins of the Esmeraldas, Pastaza (Agoyán Project), and Napo (Papallacta Project) rivers.

Table 19: Water resource balance (%). Scenario 1. Year 2010

RIVER BASINS	AREA Km²	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESMERALDAS	22,007	588	988	1,988	3,166	528	47	-59	-79	-64	-28	-25	323
PORTOVIEJO	2,208	317	774	640	406	156	156	58	-19	-45	-52	-54	18
CHONE	2,683	233	697	884	563	196	160	80	19	-5	-10	4	176
JAMA	1,289	213	980	1,206	1,058	398	252	86	-18	-35	-59	-75	-49
BRISEÑO	355	86	454	697	384	136	104	13	-20	-33	-49	-68	-48
PASTAZA (Agoyán Station)	7,983	-63	-65	-56	-54	-55	-39	-36	-51	-57	-59	-68	-74
PAUTE (Amaluza Station)	5,015	-17	-13	31	91	81	149	139	83	32	19	-11	-17
MIRA	4,960	358	365	379	400	314	233	198	170	198	281	279	256
CARCHI	365	21	3	108	154	69	-48	-85	-100	-56	90	145	112
NAPO(Papallacta Project)	3,926	-51	-50	-40	-25	-24	-6	0	-24	-39	-45	-48	-60

Months with shortage of water resources

Scenario 2: Rise in temperature by 1°C, rise in rainfall by 20%

This scenario is of less concern than the previous one, since the low-water periods are not as severe in terms of their possibility of ensuring supply to meet demand; nevertheless, high deficit values will be maintained, with the largest problems coinciding with those in the river basins mentioned in scenario 1 (Table 20).

Table 20: Water resource balance (%). Scenario 2. Year 2010

RIVER BASINS	AREA Km²	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESMERALDAS	22,007	985	1,569	3,219	5,086	851	130	-37	-67	-42	15	23	603
PORTOVIEJO	2,208	584	1,309	1,044	651	255	246	102	1	-31	-38	-40	69
CHONE	2,683	442	1,193	1,492	968	374	312	183	84	45	37	58	325
JAMA	1,289	453	1,772	2,015	1,717	639	426	174	18	-3	-38	-62	-19
BRISEÑO	355	207	801	1,143	615	231	188	54	8	-9	-30	-57	-25
PASTAZA (Agoyán Station)	7,983	-50	-47	-28	-23	-26	4	7	-21	-30	-34	-49	-58
PAUTE (Amaluza Station)	5,015	16	45	154	278	240	357	320	212	123	110	57	56
MIRA	4,960	419	442	472	514	400	288	247	212	258	384	384	358
CARCHI	365	88	75	224	285	167	4	-45	-64	-1	209	281	228
NAPO(Papallacta Project)	3,926	-30	-28	-12	10	11	39	47	12	-11	-19	-24	-41

Months with shortage of water resources

Scenario 3 is the most critical for the water resources, if there is a climate change. The values of the deficit are the highest.

Scenario 3: rise in temperature by 2° C, decline in rainfall by 15%

This scenario is the most critical for the water resources, if there is a climate change. The values of the deficit are the highest in the river basins mentioned in scenario 1 (Table 21).

Table 21: Water resource balance (%). Scenario 3. Year 2010

RIVER BASINS	AREA Km²	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESMERALDAS	22,007	573	950	1,909	3,044	502	38	**-62**	**-81**	**-67**	**-33**	**-30**	303
PORTOVIEJO	2,208	317	774	639	404	155	153	57	**-20**	**-46**	**-52**	**-54**	17
CHONE	2,683	237	696	882	561	194	158	79	17	**-7**	**-11**	2	173
JAMA	1,289	211	972	1,186	1,039	387	245	81	**-22**	**-38**	**-61**	**-76**	**-51**
BRISEÑO	355	86	453	693	380	134	102	12	**-21**	**-34**	**-50**	**-69**	**-50**
PASTAZA (Agoyán Station)	7,983	**-63**	**-66**	**-58**	**-55**	**-57**	**-40**	**-38**	**-52**	**-58**	**-61**	**-69**	**-75**
PAUTE (Amaluza Station)	5,015	**-19**	**-16**	26	84	74	140	131	76	26	13	**-16**	**-22**
MIRA	4,960	356	365	377	398	312	230	195	167	195	279	274	253
CARCHI	365	19	1	106	151	67	**-49**	**-87**	**-101**	**-57**	88	142	108
NAPO (Papallacta Project)	3,926	**-52**	**-51**	**-40**	**-25**	**-25**	**-6**	0	**-24**	**-40**	**-46**	**-49**	**-61**

Months with shortage of water resources

Scenario 4: rise in temperature by 2° C, rise in rainfall by 20%

This is the least unfavorable scenario because, for all the river basins, there will be higher rainfalls, which would generate a rise in supply and reduce the deficit compared to demand over time and in terms of amount (Table 22).

Table 22: Water resource balance (%). Scenario 4. Year 2010

RIVER BASINS	AREA Km2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESMERALDAS	22,007	964	1,519	3,128	4,938	816	119	**-42**	**-70**	**-46**	8	16	577
PORTOVIEJO	2,208	584	1,309	1,043	648	253	243	101	0	**-32**	**-39**	**-41**	68
CHONE	2,683	441	1,192	1,489	964	371	309	180	82	42	35	55	321
JAMA	1,289	450	1,760	1,987	1,693	625	418	168	13	**-7**	**-41**	**-64**	**-22**
BRISEÑO	355	207	799	1,138	610	227	185	52	6	**-11**	**-32**	**-58**	**-27**
PASTAZA (Agoyán Station)	7,983	**-51**	**-48**	**-30**	**-25**	**-28**	1	4	**-23**	**-32**	**-36**	**-50**	**-59**
PAUTE (Amaluza Station)	5,015	13	39	142	266	230	347	311	204	116	102	51	49
MIRA	4,960	419	442	470	512	398	286	244	209	256	379	381	353
CARCHI	365	82	70	217	276	160	1	**-48**	**-67**	**-5**	203	273	220
NAPO (Papallacta Project)	3,926	-31	-28	-12	10	11	38	46	11	**-11**	**-20**	**-24**	**-42**

Months with shortage of water resources

It should be emphasized that, in the basins where hydropower projects are located, there will be a decline in shortage values in terms of supply, and there is even the possibility of having months with surplus values after having met the demand for water, as in the case of the Pastaza River basin (Agoyán Project).

VULNERABILITY OF KEY HYDROPOWER DAMS

The Agoyán Project (Pastaza river basin) would be affected by a 23% drop in inflows, basically during the low-water period.

The study is complemented by an economic analysis of power capacity and/or demographic service. Considering the two scenarios that have a decline in rainfall, it turns out that the Agoyán Project (Pastaza river basin) would be affected by a 23% drop in inflows, basically during the low-water period, and the Paute Project (Paute river basin) would only be providing between 43% and 45% of average power capacity, meaning a deficit of about 27% compared to energy production under normal conditions.

The Paute Project (Paute river basin) would be only providing between 43% and 45% of average power capacity.

For the case of the climate change scenarios that consider a rise in rainfall, there would be an improvement in the supply of water resources for hydropower generation; thus, the Agoyán Project would meet 100% of its needs and the Paute Project would improve by about 79% the possibility of supplying average power capacity, on the basis of which energy production could increase by about 48% on average, without making any additional investments, since the station has installed capacity.

From the study of the inflows defined in the four scenarios, for the river basins as a whole, although the percentage of increase or decline in them was examined, what would happen inside each lower river basin should be specifically identified. Therefore an analysis more adapted to the reality of demand should be undertaken since these demands will ultimately decide the critical deficiency in the areas of the study, as well as the solutions to be implemented in the future, whether over the short or medium term, in order to provide for them.

MITIGATION ASSESSMENT

In the context of adaptation and mitigation in the country, a methodological process has been conducted in various phases over time and in the framework of different projects and with different sponsorship and characteristics. Specifically in the area of mitigation, the process has been as follows:

1. Elaboration of the greenhouse gas inventory.
2. Evaluation of mitigation in the energy, forestry, and agricultural sectors, which generated mitigation measure proposals.
3. Viability analysis and environmental, economic, and social impact assessment of the application of the mitigation measures suggested in the previous studies in the energy, agricultural, and forestry sectors, using a methodology specifically developed for this purpose.

4. Proposal of strategies in order to overcome barriers and obstacles that hamper the implementation of the prioritized measures.

5. Proposal of project profiles in order to really implement mitigation measures in the face of climate change, while helping to ensure the country's sustainable development.

▶ ENERGY SECTOR

General remarks

Ecuador has an energy potential sustained by various renewable and nonrenewable sources of energy. In 1990, the energy potential that was identified and that could be developed technically and economically amounted to about 8,319.3 x 10^6 toe, based on hydroenergy and crude oil and complemented by biomass, geothermal energy, coal, and natural gas. Alternative sources such as solar and wind energy are options that have highly favorable conditions in the region but have not as yet been systematically assessed.

In 1990, energy production based on primary sources amounted to 17,697 ktoe, the most important sources being oil and gas (90.9%) and biomass (6.2%), with only a slight share of hydroenergy, solar and wind energy. Energy supply from secondary sources in that same year amounted to 6,280 ktoe, involving a high share of oil products (90.6%) and electricity (8.8%), which in turn can be broken down as follows: hydroenergy (76.7%), thermoelectricity (21%) and cogeneration (2.3%).

Demand came from the following subsectors: transportation (38.3%), residential (26.4%), industry (20.5%), agriculture, fishing, and other (9.2%), services (3.3%), and public services (2.4%).

Energy consumption in 1990 amounted to 5,372 ktoe. Demand came from the following subsectors: transportation (38.3%), residential (26.4%), industry (20.5%), agriculture, fishing and other (9.2%), services (3.3%), and public services (2.4%).

Methodological aspects. The study "Greenhouse Gas Mitigation" corresponding to the energy sector included essentially three stages: a) characterization of the energy sector and its GHG emissions, b) evolution of energy supply and demand under scenarios with and without the introduction of mitigation measures, and c) determination of GHG emission levels and the costs of the mitigation measures that were proposed.

The energy supply and demand forecasts were carried out by using a simulation and optimization model known as the Long-Range Energy Alternatives Planning System (LEAP). On the basis of the baseline scenario, which characterized the evolution of the sector based on the demographic context, macroeconomic aggregates, and technical coefficients, the forecast included a mitigation scenario, which included different energy source substitution alternatives, the introduction of more energy-efficient technologies for production and consumption, and energy conservation and saving practices.

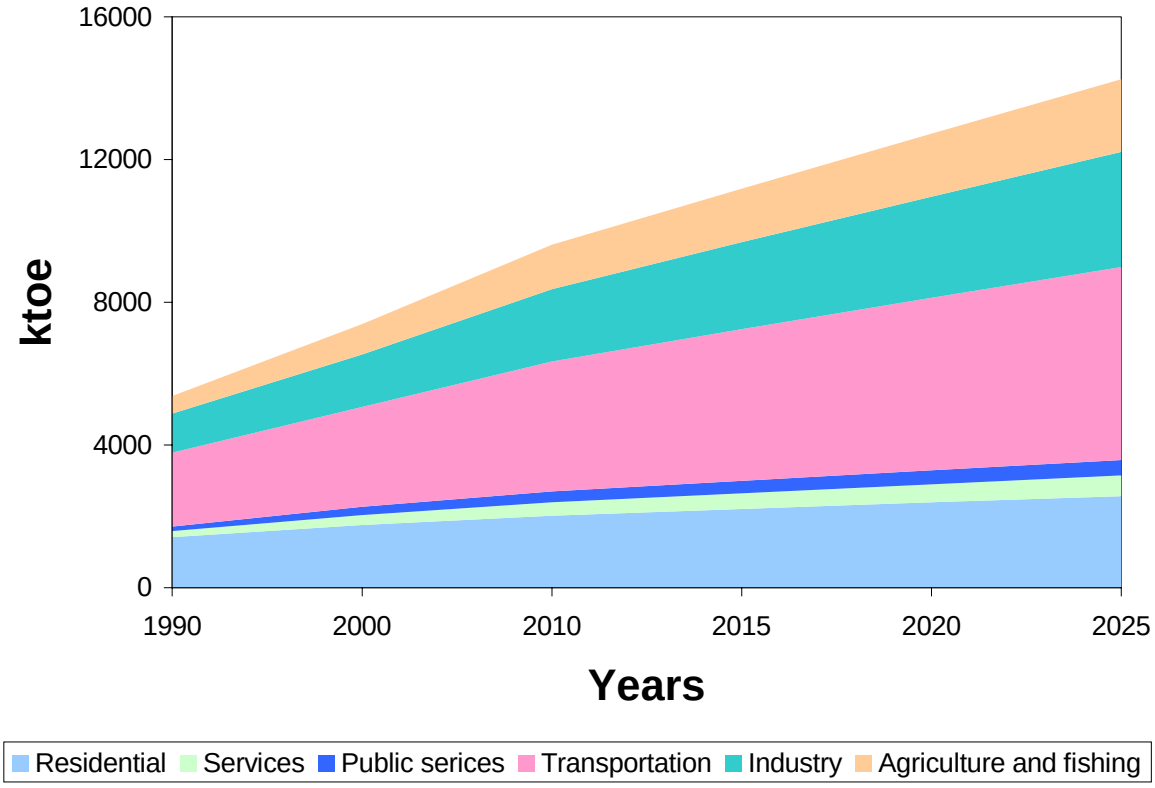
IMPORTANT RESULTS

Final demand for energy

The inclusion of mitigation measures would induce the average rate of increase to fall from 2.8% to 2.2% during this period.

Final demand for energy forecast in the baseline scenario for the period 1990-2025 would involve an annual average growth of 2.8%. The inclusion of mitigation measures would induce the average rate of increase to fall from 2.8% to 2.2% during this period. Therefore, the percentage difference of final energy demand between the baseline and mitigation scenarios would grow gradually, from 5.2% in 2005 to 19.5% in the year 2025. In the mitigation scenario, the per capita energy consumption that is forecast would be 0,55 toe/inhab, significantly less than the 0.68 toe/inhab that is forecast if no mitigation measures are applied.

Chart 14: Demand by sector, baseline scenario



Final demand with the inclusion of mitigation measures by sector reflects differentiated declines.

Final demand with the inclusion of mitigation measures by sector reflects differentiated declines. Thus, the most significant drop would appear in the agriculture and fishing, transportation and public services sectors (Charts 14 and 15). As for the energy sources, the mitigation measures would exert a major impact on the percentage drop of the demand of wood resources, solar energy, and hydrocarbons (Charts 16 and 17).

Chart 15: Demand by sector, mitigation scenario

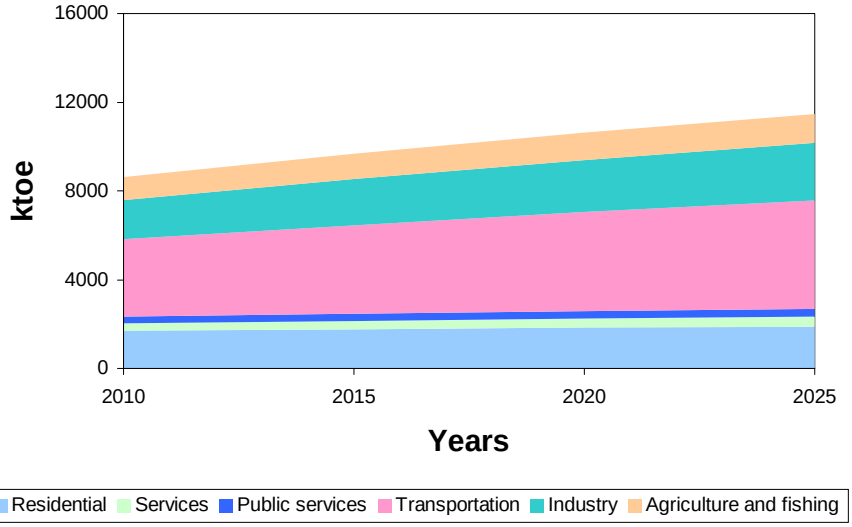


Chart 16: Demand by source, baseline scenario

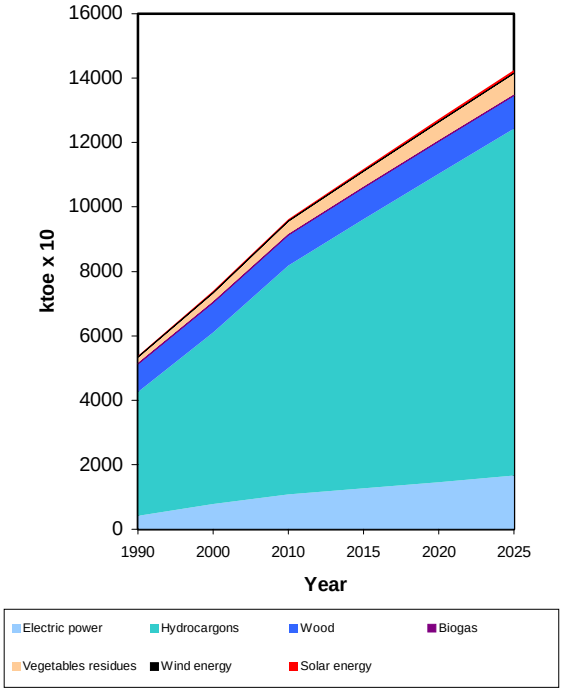
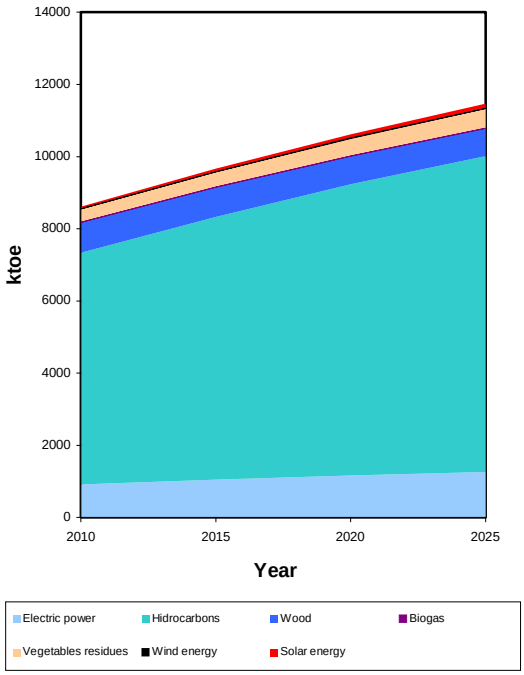


Chart 17: Demand by source, mitigation scenario



In terms of demand for oil and gas, the measures envisaged in the mitigation scenario would permit increasingly higher declines over time compared to the baseline scenario: 9.7% in 2010, 15.7% in 2020, and 18.7 % in 2025.

The rise in demand for electricity would require, as at present, the start-up of thermoelectric stations. The mitigation measures (electric power conservation and substitution) would represent declines in electric power demand in the following percentages: 14% in 2010, 17.5% in 2015, 20.8% in 2020, and 24.1% in 2025.

Energy supply

The energy requirement for electric power generation would have an annual growth rate of 4.1%. With mitigation measures, this rate would decline to an annual average rate of 2.6%; at the same time, the share of the different sources in the electric power supply matrix would be redistributed.

The generation of electric power stations would record a growth of 3.9% per year according to the baseline scenario and 2.9% with mitigation measures.

Because of the above, the generation of electric power stations would record a growth of 3.9% per year according to the baseline scenario and 2.9% with mitigation measures. The most important percentage variations of electric power generation would take place mainly in the thermoelectric and nonconventional stations.

Chart 18: Electricity production, baseline scenario

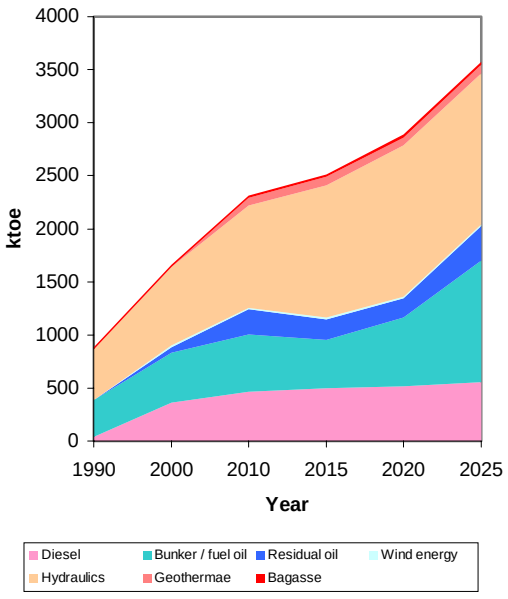
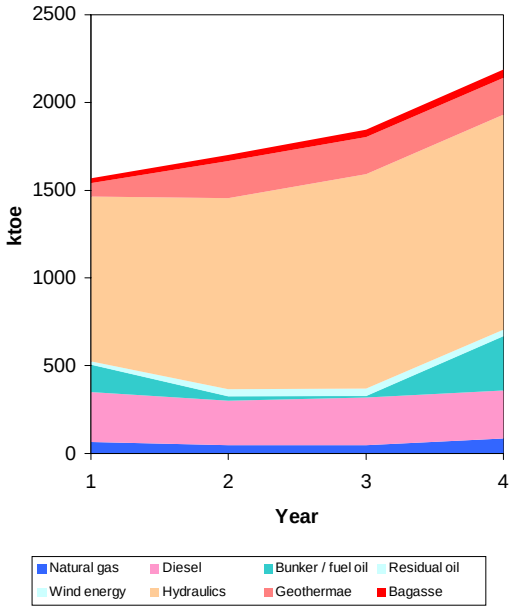


Chart 19: Electricity production, mitigation scenario



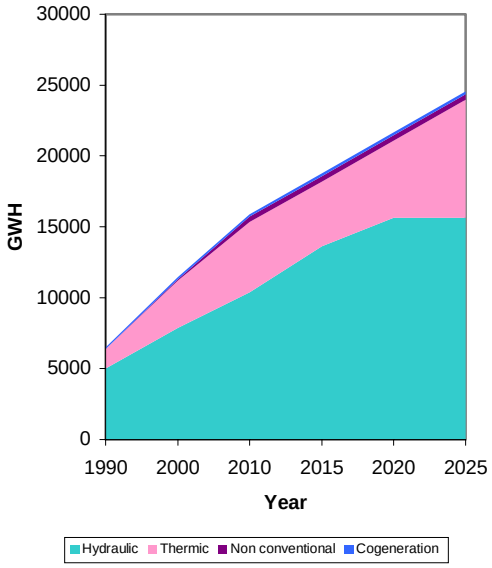


Chart 20:
Type of electric power stations, baseline scenario

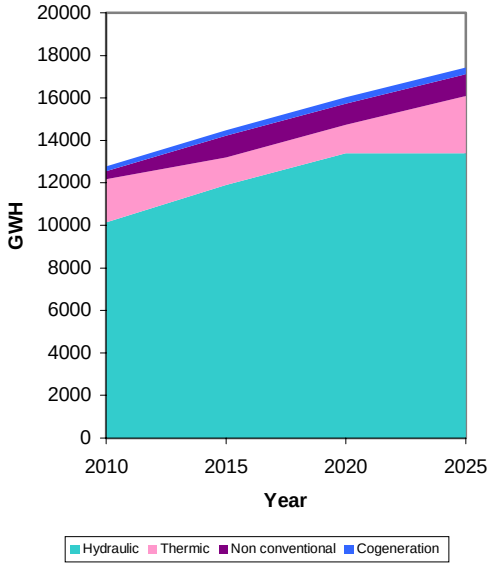


Chart 21:
Type of electric power stations, mitigation scenario

IMPACT OF MITIGATION MEASURES ON CO_2 EMISSIONS

The measures included in the mitigation scenario would permit reducing emissions coming from energy demand by an average of 9.6% in the year 2010 and by 18.5% by the year 2025, compared to emission levels forecast for those years.

The measures included in the mitigation scenario would permit reducing CO_2 emissions coming from energy demand gradually by an average of 9.6% in the year 2010 and by 18.5% by the year 2025, compared to emission levels forecast for those years. The percentage variations are more significant in the residential sector and the agriculture, fishing, and other sector.

In the mitigation scenario, it is estimated that CO_2 emissions from energy supply, which include the electric power generation, oil production and refining, and natural gas production and treatment subsectors, amount to about 34.6% in the year 2010 and to 47.1% in the year 2025, below the emissions forecast in the baseline scenario.

Chart 22: CO_2 Emissions (Gg). baseline scenario

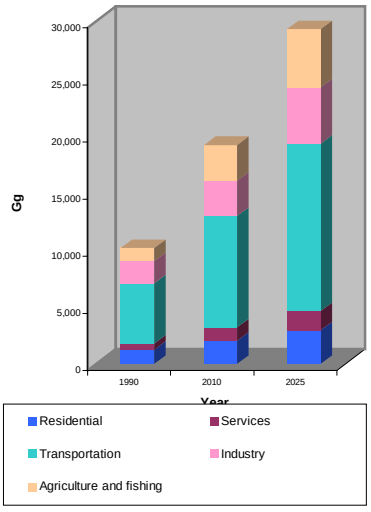


Chart 23: CO_2 Emissions (Gg), mitigation scenario

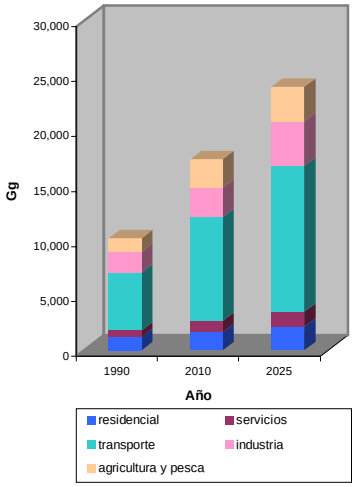


Chart 24: CO_2 Emissions (Gg), baseline scenario

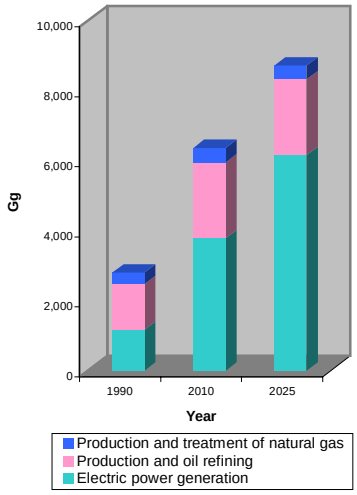
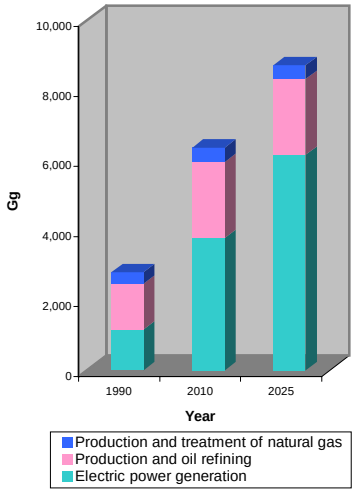


Chart 25: CO_2 Emissions (Gg), mitigation scenario



ENVIRONMENTAL, ECONOMIC, AND SOCIAL ASSESSMENT OF THE APPLICATION OF MITIGATION MEASURES

To analyze the measures in the framework of the present study, the general listing of the mitigation measures analyzed in the previous study and the other measures that are now considered to be feasible for implementation was used.

According to the methodology, priority was given to the measures that most contribute to the objective of reducing greenhouse gas emissions in the energy sector and that are feasible to implement, from technical, economic, and social standpoints. On the basis of this analysis, 13 measures were proposed.

The assessment of the 13 measures that were proposed indicate that they are highly compatible (Ic) with the plans and laws of the energy sector and the environment.

The assessment of the 13 measures that were proposed indicate that they are highly compatible (Ic) with the plans and laws of the energy sector and the environment.

The assessment of the 13 measures that were proposed indicate that they are highly compatible (Ic) with the plans and laws of the energy sector, the environmental sector, and international country efforts for

sustainable development, climate change, and clean technologies (Table 23).

Table 23. Viability and impact assessment

MEASURE/INDEX	Iv	Iap	Isp
SUPPLY SECTOR ELECTRICITY SECTOR			
Energy generation using mini hydropower stations	High	Moderately positive	Moderately positive
Electric power loss reduction	High	Highly positive	Somewhat positive
OIL SECTOR			
LPG recovery using associated natural gas	High	Highly positive	Somewhat positive
Electric power generation using residual natural gas	High	Somewhat positive	Somewhat positive
DEMAND SECTOR RESIDENTIAL SECTOR			
Substitution of incandescent luminaires	High	Somewhat positive	Somewhat positive
Use of solar energy for water heating	High	Moderately positive	Moderately positive
Rural electrification with photovoltaic solar energy	High	Moderately positive	Moderately positive
Promotion and dissemination of improved stoves in the rural sector	High	Moderately positive	Somewhat positive
COMMERCIAL AND SERVICES SECTOR			
Substitution of luminaires in street lighting	High	Moderately positive	Moderately positive
Substitution of incandescent luminaires	High	Moderately positive	Moderately positive
INDUSTRIAL SECTOR			
Optimization of combustion in boilers	High	Moderately positive	Moderately positive
TRANSPORTATION SECTOR			
Use of compressed natural gas in motor vehicles	High	Moderately positive	Moderately positive
AGRICULTURAL AND LIVESTOCK SECTOR			
Biogas program	High	Moderately positive	Somewhat positive

Ic = Compatibility index
Ipb = Weighted barrier index
Iv = Viability index
Isp = Weighted socioeconomic importance
B/C = cost-benefit
Iap = Weighted environmental importance

As for existing institutional, technological, and sociocultural barriers, the results indicated that almost all the measures show a low or insignificant barrier index (Ipb).

Because of this, a high viability index (Iv) is obtained for all the measures, which means that it is viable to apply the selected measures.

With respect to the environmental and socioeconomic indices (Iap, Isp) of the measures, the results show that the environmental impacts are positive, because the reduction of emissions brings benefits in terms of health and the environment; several of them contribute to raising the standards of living of the population and sustainable socioeconomic development in general.

With respect to the financial analysis, it should be indicated that the cost-benefit economic indicators (with the environmental externalities and benefits) of virtually all the measures meet the criteria from the economic evaluation of the projects and demonstrate the viability of their implementation.

The projects stemming from the prioritized measures generate different magnitudes of reductions in emissions; for example, the project with the highest impact in terms of greenhouse gas reduction is the one aimed at tapping the associated natural gas of the oil fields in the northeastern zone of Ecuador (680,961 tons per year) (Table 24).

Table 24. Emission reduction by project

PROJECT	Reduction of CO_2 emissions (Ton / year)*
SUPPLY SECTOR	
ELECTRICITY	
• Energy generation by means of small hydropower plants (SHP)	8.760
• Reduction of electric power losses	386.100
HYDROCARBONS	
• LPG recovery from associated natural gas	680.961
• Electricity generation using residual natural gas	40.217
DEMAND SECTOR	
RESIDENTIAL	
• Substitution of incandescent luminaires	159.646
• Use of solar energy for water heating	8.405
• Rural electrification with photovoltaic solar energy	842
• Promotion and dissemination of improved stoves in the rural sector	12.880
COMMERCIAL AND SERVICES	
• Substitution of luminaires in street lighting	77.852
• Substitution of incandescent luminaires	85.561
INDUSTRIAL	
• Optimization of combustion in boilers	60.984
TRANSPORTATION	
• Use of compressed natural gas in motor vehicles	102.094
AGRÍCULTURE AND LIVESTOCK	
• Biogas program	202

* Annual reduction since the project has been fully implemented.

Definition of mitigation measures

- ### Supply sector

Energy generation by means of small hydropower plants

Objective: Develop, as part of a rural energy supply program, small hydropower plants in those cases where prior studies are at the feasibility stage or at a more advanced stage and therefore are susceptible to being built over the short term.

Reduction of electric power sector losses

Objective: Reduce the levels of losses in the distribution stage of electricity, not only the nontechnical losses (or black losses) in order to increase electricity billing by the distribution utilities but also the technical losses that imply a decline in electricity generation (less installed capacity) or increase in available energy.

Tapping associated natural gas in the oil fields of the northeastern zone of Ecuador

Objective: Ensure the higher development of associated natural gas by using this depletable resource more rationally in order to reduce the emissions stemming from the burning or flaring of associated gas and reducing the imports of liquefied petroleum gas (LPG) with the resulting foreign currency savings for the country.

- ### Demand sector

Substitution of incandescent luminaires for more efficient luminaires for the residential users

Objective: Substitute nationwide 100-W incandescent lamps for more efficient luminaires (20-W compact fluorescent lamps) in energy consumption of about 75-80%, which in turn means reducing the power capacity of thermoelectric generation and the resulting greenhouse gas emissions, especially at peak hours of the power sector's load curve.

Use of solar energy for water heating

Objective: Promote and install solar systems for water hEating in the provinces of the sierra of Ecuador, in order to diminish thermoelectric power generation and liquefied petroleum gas requirements, thus achieving a considerable decline of greenhouse gas emissions.

Rural electrification with photovoltaic solar energy

Objective: Install photovoltaic systems for housing and basic services for the rural sector where supplying electricity from the distribution grid turns out to be technically complex and economically unfeasible.

Promotion and dissemination of improved stoves in the rural sector

Objective: Promote in rural zones the building of improved stoves and the dissemination of firewood-saving practices so as to contribute to the reduction of greenhouse gas emissions and save firewood.

Substitution of luminaires in street lighting

Objective: Substitute mercury street lighting luminaires for high-pressure sodium vapor lamps and as a result reduce greenhouse gas emissions because of better thermoelectric generation at peak hours.

Substitution of incandescent lamps with more efficient luminaires in the commercial and services sectors

Objective: Substitute 100-W incandescent bulbS for 20-W compact fluorescent lamps in the commercial and services sectors and therefore reduce greenhouse gas emissions and save energy for the users and power capacity for the electric power system.

Optimization of combustion of the boilers to generate vapor

Objective: Optimize in the industrial sector the combustion of industrial boilers that consume diesel and bunker to generate vapor, through the installation of economizers and automatic timers, in order to obtain fuel savings and reduce GHG emissions.

Conversion of motor vehicles to compressed natural gas (CNG)

Objective: Substitute traditional fuels for natural gas in motor vehicles, by converting taxis and buses for public transportation, which would contribute to improving the efficiency of motor vehicles and reducing greenhouse gases.

Biogas program for the agricultural and livestock sector of the country

Objective: Install biodigesters in order to generate biogas for use in households or in production processes, which would permit substituting the use of fossil fuels and thus reducing the emission of effluent polluting the environment.

MITIGATION STRATEGIES

The principal strategies proposed are described below.

General

- Identify, analyze, and implement permanently in the energy sector actions and/or activities aimed at tackling problems stemming from climate change and environmental preservation.

- Secure national and international technical cooperation to tackle problems involving climate change and environmental preservation.

- Include in energy and environmental sector plans and programs actions that will facilitate the development of renewable sources of energy and the efficient use of energy resources.

- Promote the development of renewable sources of energy, the use of clean technologies, and environmental preservation.

Regulatory

- Include in energy sector regulations and especially in the Law Governing the Electric Power Sector aspects involving the application of efficient use of energy and the promotion of renewable sources of energy.

Promoting national capacity

- Build up institutional capacity and coordination of the energy sector in order to tackle problems involving climate change and environmental preservation.

- Build up national technical consulting and service capabilities, as well as the technological development of efficient use of energy, renewable sources of energy, the environment, and clean technologies.

- Carry out a process to raise awareness, educate, and change habits in order to create an energy-saving culture and train a new generation of producers and consumers.

- Create and/or build up an information and technical assistance center on the development of renewable sources of energy and their practical applications, as well as the application of energy efficiency and the environment.

Standardization

- Undertake a program for energy standardization that considers the efficient use of energy in the manufacturing and/or import of energy-consuming appliances/equipment and housing programs, industrial facilities, commercial premises, etc., as well as the standardization of systems for developing renewable sources of energy.

Financing

- Channel through the State financial resources for the development of projects in the energy sector that contribute to reducing greenhouse gases.

- Identify and establish organizational and financial schemes and/or mechanisms that guarantee the sustainability of renewable energy and energy efficiency projects.

CONSTRAINTS

During the process of implementing studies and assessments, constraints and obstacles were found, among which:

- The information available in the energy sector, especially in the oil sector, is insufficient in some cases and, in others, there is no consistency between the data generated by the different institutions focusing on the topic, which produces a certain degree of uncertainty.

- Most of the information from the different sectors of energy demand and supply has not been updated. Especially in the transportation sector, the information available in the institutions in charge of this area is not uniform for the different types of transportation.

- The impossibility of testing in the field the information available in the sector is a constraint preventing any guarantee of the accuracy of the values used.

- Considering the dynamics in scientific, technological, and methodological breakthroughs for analyzing different actions in this sector, it is evident that training in climate change received by the staff who conduct the studies has been scattered and insufficient.

There are constraints in terms of access to information and experience in the use of certain types of technological alternatives.

- There are constraints in terms of access to information and experience in the use of certain types of technological alternatives.

- The lack of knowledge and sensitivity of some energy sector authorities prevent broader participation and support for the actions that have been carried out on the subject of climate change.

▶ AGRICULTURAL SECTOR

The assessment of mitigation in the developed agricultural sector generated, among other results, the proposal of policies and measures to tackle climate change in the country.

In addition, with the results obtained and the new government policy, the agricultural sector proposed the promotion of various mitigation measures.

The above-mentioned proposal was presented to different players and country authorities, who selected four as a result of a viability discussion and analysis process: grazing land management, management of manure in biodigesters, use and management of crop waste through composting, and implementation of an education and training system.

ENVIRONMENTAL, ECONOMIC AND SOCIAL ASSESSMENT OF THE IMPLEMENTATION OF MITIGATION MEASURES

According to the assessment process used, the measures that are considered are highly viable. In all cases, the social barriers are moderate, but can be overcome and are due to the limited schooling of

The measures are considered to be highly viable.

the farmers, their low income, their ignorance of technological alternatives, and likely resistance to changes in their traditional practices. All the measures are highly compatible with international commitments and national policies, plans, and programs (Table 25).

Table 25. Viability and impact assessment

Measures	Viability	Impacts	
		Environmental	Socio-economicos
1. Grazing land management	High	Low positive	Low positive
2. Management of manure through biodigesters	High	Low positive	Low positive
3. Use of rice husk waste using compost heaps	High	Low positive	Low positive

In the three cases, environmental and socioeconomic impacts are positive, although some irrelevant negative impacts were identified.

The high viability of all the measures implies that, for their application, there are virtually no important barriers.

Environmental and socioeconomic impacts are "low positive" in the three measures, that is, the measures have a positive environmental and socioeconomic sustainability.

Definition of mitigation measures

Improve the diet of cattle by means of grassland management

Objective: Improve the diet of cattle, balancing their diet with leguminous and graminaceous foods, which would improve their digestive processes and reduce methane emissions.
At the same time, the change to more productive fodder species will favor the stable or semi-stable management of the cattle, which would lead to higher profitability.

Management of manure through biodigesters for the elimination of methane

Objective: Undertake integral management of cattle manure using biodigesters aimed at tapping the energy (methane gas) from the decomposition of waste and producing solid and liquid fertilizer.

Use and management or residues from rice harvests through compost heaps and recycling processes

Objective: Reduce methane emissions through the management and use of harvest residues and waste by installing compost heaps or beds. Thus, the recycled or compost biomass will im-

prove the physical and chemical properties of the soil, regulate and stimulate plant nutrients, and increase productivity.

MITIGATION STRATEGIES

- Prioritize agricultural and livestock territorial ordering and zoning actions as a tool to support the management of grazing lands, manure, and rice harvest residues.
- Promote, through international organizations, the acquisition of technical know-how, technology and financing that are appropriate for the management of grazing land, manure, and rice husks.
- Establish and/or consolidate the association of small and medium agricultural and livestock producers in order to facilitate their participation in political, economic, and environmental decision-making groups.
- Incorporate into the curriculum of medium and advanced agronomy establishments environmental studies regarding the agricultural and livestock sector and its linkage to global warming problems.
- Facilitate access to agricultural/livestock credit for those activities that promote the sustainable management of existing resources.

▶ FORESTRY SECTOR

General remarks

Deforestation in Ecuador of humid native forests (90%) and dry native forests (10%) emits 12,247,500 tons per year of CO_2 into the atmosphere.

The emissions of carbon dioxide produced annually by deforestation are estimated to be 47% of the national total; in this percentage are included the activities of change in the use of forest lands (burning and biomass composition), conversion of grazing land into cropland, and the abandonment of cultivated land.

Methodological aspects

For the assessment of mitigation in the forestry sector, the COMAP and COPATH models were used. According to the methodology, forest baseline and mitigation scenarios were generated to the years 2010 and 2030. In the study an average deforestation rate of 106,500 hectares per year and an intervention in the protected forests of 21,300 hectares per year have been used.

MAIN RESULTS

The projected baseline scenario indicates that, under conditions without mitigation, the forest surface would decline by 18.6% in the year 2010 and by 37.1% in the year 2030.

The projected baseline scenario indicates that, under conditions without mitigation, the forest surface would decline by 18.6% in the year 2010 and by 37.1% in the year 2030; whereas the natural areas would decline by about 10.4% in the year 2010 and by 20.7% in the year 2030.

With this scenario and compared to 1990, a 29% increase in forest surface would be achieved by the year 2010 and 76% by the year 2030.

The forestry scenario with mitigation is considering an annual reforestation rate of more than 30,000 hectares per year and no intervention in protected natural areas. With this scenario and compared to 1990, an 29% increase in forest surface would be achieved by the year 2010 and 76% by the year 2030, with a conservation of protected natural areas of 11.7% and 26.2% in the years 2010 and 2030, respectively.

ENVIRONMENTAL, ECONOMIC AND SOCIAL ASSESSMENT OF THE IMPLEMENTATION OF MITIGATION MEASURES

From the mitigation study nine measures were determined, and their environmental, economic, and social impacts, on the basis of their implementation potential, were evaluated and are presented according to their feasibility in Table 26.

Table 26. Total feasibility matrix of mitigation measures

Mitigation measures	Level of viability	Level of impacts	Financial viability	Level of feasibility
Green belts of the cities	High	Positive	High	High
Management of protective forests of the watersheds	Medium	Positive	High	High
Consolidation of the National Protected Areas System	High	Positive	Medium	High
Productive forest plantations	High	Positive	Medium	High
Protective forest plantations	High	Positive	Medium	Medium
Sustainable management of fragile ecosystems	Medium	Positive	Medium	Medium
Promotion of woodland/grazing land systems	Medium	Positive	Medium	Medium
Promotion of agricultural/forestry systems	Medium	Positive	Medium	Medium
Sustainable management of native forests	Medium	Positive	Low	Medium

The measures proposed are compatible with the laws, regulations, and general plans of the forestry and environmental sectors and with international climate change and sustainable development efforts

The measures proposed are compatible with the laws, regulations, and general plans of the forest and environmental sector and with international climate change and sustainable development efforts. In addition, they show no significant technical or institutional barriers; nevertheless, there are some social barriers in the campesino communities, which means that the viability level is high and medium.

Mitigation measures for the forests have an positive environmental and socioeconomic impact. The financial environmental analysis determined that, with the exception of the sustainable management of native forests, the financial viability shows a high and medium level, as long as an appraisal of externalities is considered (environmental services and carbon sequestration).

The feasibility level is high and medium for all the measures being proposed.

Definition of the mitigation measures

Sustainable forestry management of native forests

Objectives: Give incentives for the application of sustainable forestry management systems to ensure the conservation of natural forests and environmental services with the participation of the communities.

Productive and protective forest plantations and green belts for cities

Objective: Establish productive and protective forest plantations permitting an increase in carbon sequestration and addressing the imbalance between deforestation and forestation, providing environmental services to rural and urban zones, meeting industrial demand and raising the standard of living of the population.

Consolidating the national system of protected areas and sustainable management of fragile ecosystems

Objective: Consolidating the national system of protected areas and fragile ecosystems, by applying sustainable management policies, strategies, and plans that contribute to conserving the diversity of species and genetic resources that are endangered, supply environmental goods and services, guarantee the permanence of cultural values of the traditional settlements in protected areas and fragile ecosystems.

Management of protective forests in watersheds

Objective: Generate plans for the management of plants that protect the highlands in watersheds that contribute to water production, by maintaining their quality, preventing their pollution by sediments, protecting them from soil erosion, ensuring their function as a taker of humidity and becoming CO_2 sinks.

Promotion of agroforestry and woodland/grazing land systems

Objective: Give incentives and increment the use of forestry species for multiple purposes in the agricultural/livestock space, permitting an improvement in environmental conditions and CO_2 sequestration to improve social, economic, and cultural conditions of rural communities.

MITIGATION STRATEGIES

Sectoral:

- Promote enforcement of the Forestry and Environmental Law and its regulations.
- Coordinate forestry sector activities nationwide between the Ministry of the Environment, other public and private organizations, and the communities involved in order to avoid the overlapping of actions.
- Look for mechanisms for the financing of the mitigation measures that are proposed by paying for environmental services, CDM projects, and international cooperation.
- Promote dissemination, awareness-raising, and training activities to the communities on the use of forest goods permitting an orientation of sustainable development and the conservation of environmental quality.

Specific strategies

- Apply systems for the sustainable management of native forests in order to conserve natural and environmental resources and mitigate climate change impacts.
- Ensure the viability of the establishment of protective forest plantations, on the basis of territorial ordering of forests to improve environmental and biodiversity conditions, through the development of economically profitable activities.
- Promote the formation and conservation of forest plantations in critical peripheral areas of the country's cities, in order to minimize erosion processes and recover the stability of mountain flanks and critical zones, with the participation of the municipalities, schools, and the army.
- Implementation of the Strategic Plan for the National System for Protected Areas and the protection of fragile ecosystems.
- Enforce the existing legal framework for the National System of Protected Areas and Fragile Ecosystems.
- Promote the political negotiation at the highest decision-making levels of the State and sectional governments, as well as the coordination with nongovernmental organizations and dwellers of the rural areas involved.

Chapter 4

Climate change adaptation and mitigation project profiles

The previous chapters have clearly shown the major effort made by Ecuador to implement the UNFCCC, which is now culminating with the presentation of the National Communication and the submittal to the international community of 39 project profiles that would make it possible to apply the adaptation and mitigation measures that were evaluated and prioritized in the framework of the entire process that was developed.

Ecuador hopes that, over the short term, it can secure resources to design and implement projects, enforce the Convention, and support sustainable development.

The country hopes that, in the context of international cooperation and in compliance with the commitments made by the countries under the UNFCCC, we will be able to secure resources to design and implement the projects, implement the Convention, and support sustainable development.

The National Communication presents a concise description of the project profiles, whereas the versions with greater detail can be found in the support studies.

ADAPTATION PROJECT PROFILES

▶ FORESTRY SECTOR

The forestry sector proposed nine project profiles.

Community production activities to obtain non-timber products in the remanent dry forests of the canton of El Carmen

The project will be implemented in the canton of El Carmen, province of Manabí, in a potential area of 5,000 hectares and for a five-year period. The project's most important objectives are to promote the development, conservation, and rational use of native forests through the planning and application of sustainable management systems for forests in order to ensure the conservation of natural forests as a genetic bank and biological corridor and to optimize the process of adapting forestry ecosystems.

The principal results are the application of non-timber product development systems in 30 campesino communities that own the native forests; raw material from the native forests by 10 organized community microbusinesses; a 1% decline in the volumes of timber extracted from community forests; market promotion and liberalization; the existence of a demonstrative parcel by community; the reduction of the deforestation rate; and the conservation of remanent native forests, biological resources, and environmental services.

This project provides social and environmental benefits. In financial terms, if externalities are viewed as environmental services, the economic profitability is long term and it will be the beneficiary communities that will be receiving this income.

Sustainable management of forest plantations in the provinces of Cotopaxi and Tungurahua

The project, which covers an area of 20,000 hectares, will be implemented in the provinces of Cotopaxi and Tungurahua, over a 20-year period. The principal objectives are to contribute to reducing the imbalance between forestation and deforestation in the country by establishing plantations based on territorial forest ordering in order to favor the adaptation of forest ecosystems to climate change and improve the living conditions of the rural population.

The principal results are: the plantation of 20,000 hectares under management; the establishment of 15 forest companies that belong to the community not only financially but also socially; the establishment of an inter-institutional data base that would provide information on location, species, growth, yield, volume, and management systems for different types of plantations; and the existence of a forest producers' organization in areas with a concentration of plantations.

The internal rate of return of 28.8% indicates that the financial viability is acceptable.

Integral sustainable rural development in the microwatersheds of the province of Loja

The project will be implemented in the province of Loja, in an area of 20,000 hectares over a 10-year period. Among its principal objectives, there is the implementation of a pilot program for the integral rural development of the province in order to conserve and restore microwatersheds and their resources.

The principal results are: ensure that integrated farms that have been installed promote an adequate management of the soil and reduce by 50% erosion levels in comparison to traditional land use practices; the existence of 8,000 hectares of forest plantations for biomass protection and conservation in order to retain carbon and maintain the region's microclimate; and the construction of infrastructure projects in 20 communities that contribute to the environmental control of erosion, the reservoir and water distribution, and maintenance of the road network.

The project generates social and environmental benefits, if one considers the value of soil protection, that is, each project component contributes to reducing erosion processes.

Sustainable management of the Cajas moorland

The project will be implemented in the province of Azuay in an area of 10,000 hectares, with a 10-year duration. The principal objectives are

the conservation of the moorland ecosystem because it generates environmental goods and services such as: soil protection, carbon sequestration, storm control, habitat for flora and fauna wildlife, germ plasm reserve, landscape and leisure tourism, and scientific research.

The principal results are: definition of a zoning for the moorland of Cajas; environmental maintenance and services for the moorland over the medium and long term, especially for carbon sequestration; consolidation of community production activities in five campesino activities; consolidation of buffer zones in fragile ecosystems; and the implementation of five micro-community management plans.

The project is profitable if one takes into account a long-term duration and if the generation of environmental services is quantified, in addition to the economic income generated by payments for the area's use for research and conservation purposes. The social and economic development of the population is promoted.

Protection plantations in the province of El Oro

The project will be implemented in the province of El Oro, in an area of 10,000 hectares over a 20-year period. The principal objectives are to install forest masses in critical areas in the province of El Oro, for the purpose of protecting the water regime, reducing erosion, and using the forest as a carbon sink.

The principal results are 5,000 hectares per year of protective forest plantations offering environmental services such as soil and water protection and CO2 sinks; 30 community nurseries trained in forestry techniques; improvement of the living conditions of community inhabitants; and the sequestration of 8.1 tons of carbon per hectare.

The project generates economic benefits that are equivalent to the extraction of nontimber products. In addition, it generates environmental benefits such as carbon sequestration by means of the trees. The analysis of the measure leading to this project shows acceptable financial indicators, with an internal rate of return of 33.4%.

Establishment of community agroforestry systems in the province of Tungurahua

The project will be implemented in the province of Tungurahua, in an area of 50,000 hectares over a 15-year period. Its most important objectives are: favoring the adaptation of biotic elements to climate change, especially the forestry sector, by means of plantations and the maintenance of native species of trees and shrubs in areas exclusively set apart for agricultural production of annual crops.

The principal results are: the plantation of 10 million tress in agroforestry systems; the establishment of 50 community nurseries with an approximate production of 200,000 saplings; the application of agroforestry systems by 50 communities; the improvement of living quality of rural inhabitants; an increase in plant cover and biomass to sequester a higher amount of carbon; and the sequestration of 2.6 tons of carbon per hectare per year.

The implementation of the project generates benefits, among which the availability of firewood for self-consumption and the fertilization of soil around the trees. As for the environmental benefits, there is the sequestration of carbon.

Establishment of woodland/grazing land systems in the rural cattle areas of Manabí

The project will be implemented in the province of Manabí, over a surface area of 20,000 hectares over a 15-year period. The principal objectives are: promote the plantation and maintenance of trees and shrubs in the cattle areas in order to reduce change from forest land use to grazing land and thus favor the adaptation of biotic elements to climate change.

The principal results are: the plantation of 4 million trees in woodland/grazing land; the establishment of 20 community nurseries with a production of about 200,000 saplings; the training of 20 participating communities; the increase in soil fertility; the restoration of the ecological landscape; and the sequestration of 16,600 tons of carbon per year.

The project generates benefits for the community as a result of the firewood produced by an average of US$100 per hectare over a 15-year period, the fodder grown by US$36 per hectare per year, and carbon sequestration.

Forest protection against fires in the green belts of the metropolitan area of the city of Quito

The project will be implemented in the metropolitan area of the city of Quito, over a surface are of 20,000 hectares for a 10-year period. The most important objectives are to establish a forest plan against fires maintaining the green belts and thus reducing the release of CO_2 into the atmosphere triggered by the impact of forest fires.

The principal results are: the decline in the number of forest fires in green belt areas; raising the awareness of the urban population in Quito, especially elementary and middle school students; implementation of the Five-Year Forest Protection Plan; protection against fires in 20,000 hectares of green belts, avoiding the emission of greenhouse gases; and the sequestration of 5.2 tons of carbon per hectare per year.

It is felt that avoiding the loss of timber volume of the plantations will be the principal benefit stemming from the implementation of the project. Another environmental benefit that is considered is the amount of carbon that is stored from the impact of the plantation and that is maintained as a result of preventive work.

Comprehensive anti-desertification programs in zones vulnerable to climate change

The project will be implemented in the provinces of Manabí, El Oro, and Loja, in an area of 20,000 hectares over a 10-year period. The principal objectives are the implementation of a comprehensive plan in

the rural communities of the vulnerable zones of Manabí, El Oro, and Loja, which would contribute to reducing the pressure on natural resources and promote social, economic, and environmental development, compatible with the critical areas of the provinces.

The principal results are the establishment of 8,000 hectares of protection forest plantations; the building of infrastructure projects in 20 communities; and the establishment of eight community microbusinesses.

The project generates social and environmental benefits, the latter including soil protection, the control of sediments, and reforestation. Its financial viability is acceptable if one takes into consideration the value of environmental services.

▶ AGRICULTURAL SECTOR

The agricultural sector proposes six project profiles.

Agro-ecological zoning and suitable seasons for sowing and harvesting

A zoning system is being proposed for hard corn, soybean, and rice crops in the lower parts of the Guayas river basin and, in addition, the zoning of potato and dry tender corn crops in the Guayllabamba river basin. The project will be implemented over a 12-month period.

Agro-ecological zoning will permit a modification of the current pattern of inadequate use of natural resources and low agricultural/livestock productivity in order to be able to adapt to likely climate change, taking into account previous vulnerability studies.

Furthermore, this project aims at having an agro-ecological zoning system that contributes to rationalizing and adequately managing the increments of cultivated surfaces expected for the years 2010 and 2030 by diversifying crops.

The estimated budget for the implementation of the project amounts to US$1 million, of which 64% corresponds to the establishment of the Geographical Information System, 31.6% to the characterization of biophysical resources, and 4.4% to the identification of the agro-ecological requirements of crops, and an update of the sowing and harvesting calendar

Introduction to higher-yield varieties

The projects proposes the introduction of higher-yield varieties of hard corn, soybean, and rice in the lower parts of the Guayas river basin and potato and dry tender corn in the Guayllabamba river basin. The project will be carried out over a 12-month period.

This project will permit designing strategies for the dissemination and adaptation of new varieties for small and medium-sized farmers and

make available new crop species and varieties adapted to local climate conditions and eventual environmental changes.

The implementation of this project will bring the following benefits: an increment in agricultural and livestock productivity compared to traditional varieties and an adequate management of sustainable production systems, avoiding processes of degradation affecting the production base and causing severe environmental deterioration problems.

The estimated budget for the project's implementation is US$1,608,000. The highest share, that is, 62.2%, is for the introduction and dissemination of high-yield varieties, 31.1% for the incorporation of plant improvement standards, and the remaining 6.7% for the other activities being envisaged.

When conducting the financial analysis, a positive net present value is obtained, which means that the project is economically viable. Furthermore, the projects has an IRR of 14%, without considering externalities, and an IRR of 18% considering externalities, which indicates that the project is profitable.

Installation of irrigation systems

The project will be implemented in the lower parts of the Guayas river basin and in the Guayllabamba river basin. Coverage is for 80,000 hectares and the project is for a 12-month period.

It proposes the installation of irrigation systems that will serve as tools to reduce the water deficit for agricultural/livestock purposes, with the designing of strategies to improve irrigation water management and the implementation of master irrigation plans in regional development corporations.

In addition, in the pessimistic climate change scenario and assuming current and traditional yields, it is estimated that rice and potato crops will decline, which means higher rainfall will be required. For this case, the optimization of irrigation is all the more important to achieve the production levels forecast to the years 2010 and 2030.

The estimated budget for the project's implementation is US$943,200, whose largest percentage, that is, 64%, is for the transfer of irrigation system management to the farmers, 16% for designing strategies to improve irrigation water management, and the remaining 20% for the other activities that are being proposed.

Adequate use of fertilizers

The project will be implemented in the lower parts of the Guayas and Guayllabamba rivers, over a 12-month period.

The indiscriminate use of fertilizers and the excessive application machinery bring with them economic and environmental problems, which over the medium and long term lead to a deterioration of environmental conditions, with negative impacts on agricultural/livestock production.

In order to counter this situation, this project is being proposed, with the following benefits: reducing production costs by reducing the excessive use of fertilizers; reducing the deterioration of the environment and improving soil conservation by avoiding the accumulation of nutrients that are not necessary for the growth of the crop; and raising the awareness of, and educating, those involved in agricultural production about the economic, social, and environmental benefits generated by the rational use of fertilizers.

The estimated budget for the project's implementation amounts to US$966,000, of which 54% is for the recommendations for the suitable application of fertilizers, 20% for the exchange of information on soil fertility, 12% for the establishment of crop rotation strategies, and the remaining 14% for the identification and analysis of the types of fertilizers and the assessment of their use by the beneficiaries.

In this project, the IRR, without considering externalities, amounts to 22% and with externalities 55%. In addition, the project shows a positive net present value, which indicates that the project is economically viable.

Implementation of a pest and disease control system

The project will be implemented in the lower parts of the Guayas and Guayllabamba river basins in the provinces of Guayas and Pichincha, respectively. Its duration is for 12 months.

Agriculture creates, establishes, and maintains agro-ecosystems where species diversity is highly limited; this is due to the fact that man, by applying modern technology packages, artificially eliminates all inter-specific competition in order to favor the growth of a small number of cultivated plants.

This project will permit reducing the impacts coming from the pollution of the soil and surface and ground water generated by the indiscriminate use of pesticides and herbicides.

The estimated budget for the project's implementation amounts to US$1.3 million, of which 54% is for the identification of areas free of pests and disease, 24% for the environmental impact assessment of pesticides in the agricultural/livestock sector, 15% for the dissemination of comprehensive control information, and the remaining 7% for the identification and analysis of the economic threshold of pests and the design of a phytosanitary campaign.

Research on the climate variability and change in Ecuador

The project will be implemented in the entire country and in all the country's natural regions and will take place over five years. Its most important objectives are to research and monitor the relations and processes that control climate variability and change in Ecuador, define the various scenarios that permit an evaluation of the vulnerability and adaptation n the different socioeconomic sectors, and obtain climate forecasts for the different sectors such as health, fishing, agriculture, and tourism.

The products to be obtained are: a monthly climate variability assessment and monitoring bulletin and an annual study on climate change trends in Ecuador; at least four climate change scenarios will be defined for the country and seasonal forecasts with an adequate level of reliability will be provided.

For the implementation of the project, an estimated amount of US$600,000 is needed. It is expected to generate major social, environmental, and economic benefits for the country, especially with respect to the reduction of losses from the incidence of adverse climate phenomena, when adequate and reliable forecasts become available investment costs will be recovered and offset by the benefits that will be obtained.

MITIGATION PROJECT PROFILES

▶ ENERGY SECTOR

The energy sector presents 13 mitigation project profiles.

Tapping solar energy for water heating in the residential sector

The projects will be implemented in the provinces of the Andean region of Ecuador over a 10-year period. Among its fundamental objectives, there is the decline of greenhouse gas emissions through the tapping of solar energy for water heating in the residential sector, as well as the reduction of conventional energy consumption (oil products) and the decline of electric power capacity demand.

As a result, 5,000 solar systems for water heating for household use will be installed, electric power equivalent to 98 GWh will be saved, electric power system capacity will be reduced by 20 MW per year, and there will be a reduction of emissions by 73,000 tons of CO_2.

Investment for purchases and installations will amount to US$3.5 million. In addition, a dissemination, training, and demonstration program, amounting to US$400.000, will be included. The project's economic benefit/cost index is 1.62 without considering environmental benefits and externalities. If the benefit related to the reduction of CO_2 emissions is considered, this same index could amount to a value of 3.

Substitution of luminaires for other more efficient street lighting systems

The project will cover the country's three largest provinces for a five-year period. Among its principal objectives there is the reduction of greenhouse gas emissions, electric power consumption, and electric power capacity demand, as a result of the substitution of luminaires for other more efficient street lighting systems.

As a result, there will be a substitution of 334,000 125-W mercury lamps for 70-W high-pressure sodium lamps, an electric power saving of 272 GWh, and a 62-MW reduction of capacity, and a reduction in emissions by 201,000 tons of CO_2.

The implementation of this project requires a total initial investment by the power utilities for the purchase of luminaires of about US$25 million during the period analyzed. The economic benefit/cost index is 1.96, without considering environmental benefits and externalities. If the benefit from the reduction of CO_2 emissions is considered, this index could amount to a value of 2.4.

Substitution of luminaires in the country's commercial and services sector

The project focuses on three cities of Ecuador, those with the highest number of users, and will be developed over a five-year period. Its principal objectives are the reduction of greenhouse gases, energy saving, and the reduction of the system's coinciding power capacity, as a result of the substitution of incandescent 100-W luminaires for 20-W compact fluorescent lamps.

The principal results are the substitution of 454,000 100-W incandescent light bulbs for efficient 20-W efficient luminaires in the commercial and services sector, the saving of 116 GWh of electric power at the end of the period being analyzed, and the reduction of power capacity by 30 MW and emissions by 86,000 tons of CO_2.

For the substitution of luminaires in the commercial and services sectors, a total initial investment by the users on the order of US$4,087,660 is required; of this amount, US$350,000 are for a dissemination and training program. The economic benefit/cost index is 2.79 without considering environmental benefits and externalities. If the benefit from the reduction of CO_2 emissions is considered, this index could amount to a value of 3.9.

Biogas program for the country's agricultural and livestock sector

The project will be implemented in three provinces of Ecuador over a 15-year period. Among its principal objectives, there is the reduction of greenhouse gas emissions as a result of the substitution of fossil fuels for biogas as an energy source in the agricultural and livestock sectors and the availability of organic fertilizer to replace the chemical fertilizers that are used in the agricultural sector.

The principal results are: the construction of 40 biogas plants, as well as the substitution of 225 gallons of gasoline and 896 kg of liquefied petroleum gas (LPG), currently being consumed for electric power generation, cooking, and food refrigeration, per year stemming from the operation of each biodigester. When these fossil fuels are no longer used, then 2,680,740 kg of CO_2 will no longer be emitted, once all the biodigesters are installed.

The estimated cost for the program's implementation is about US$60,000, of which the implementation of the information campaigns

will account for a value of US$20,000. The implementation of the project shows favorable results, since the economic benefit/cost index amounts to 1.00 without considering environmental benefits and externalities. If the benefit stemming from the reduction of methane emissions is considered, this index could amount to a value of 2.9.

Optimization of combustion in boilers for steam generation in the industrial sector

The project will be implemented in the provinces of Pichincha and Guayas, which together account for about 65% of all the country's manufacturing establishments, and will take place over a 10-year period. The most important objectives are to reduce the greenhouse gases produced from the use of fossil fuels in steam generation in the industrial sector, by reducing the consumption of these fuels with the installation of equipment optimizing the combustion in boilers.

The principal results are: increased efficiency in an average of 14% of the boilers for industrial use with capacities equal to or greater than 100 BHP; annual saving in fuel consumption amounting to 2 million gallons of diesel and 3 million gallons of bunker; and the reduction of emissions amounting to 61,000 tons of CO_2 per year coming from the industrial sector.

The estimated cost of the investments required for the implementation of the project, amounting to US$1.4 million, will come from industry. In addition, the dissemination, training, and demonstration program, which is part of the Project, amounts to US$100,000. The cost-benefit ratio, in the case of diesel-fired boilers, may be as high as 5.6 whereas in the boilers using bunker it may be 3.9, when considering the environmental benefits.

Promotion and dissemination of improved stoves and firewood-saving practices

The project will be implemented nationwide over a 10-year period. Its most important objective is to diminish energy intensity and greenhouse gas emissions associated to the use of biomass resources for the cooking of food n the rural residential sector.

The principal results are: the building of 10,000 improved stoves in the rural sector; a saving of 48,000 tons of firewood; the reduction of 70,000 tons of CO2 emissions and other associated environmental impacts, such as deforestation and soil erosion; and the contribution to improving health and living conditions of the rural population involved in the project and ensuring sustainable development.

The budget is estimated at US$400,000, of which the building accounts for US$80,000. Implementation of the planning, organization, promotion, dissemination, training, demonstration, and follow-up actions and/or activities accounts for the remaining 80% of the budget, in view of the effort that will be required to dismantle existing sociocultural barriers.

The project shows a cost-benefit ratio of 9 when environmental benefits and externalities are not considered. If the benefit stemming from the reduction of CO2 emissions, this index will amount to 19.

Rural electrification with photovoltaic solar systems

The project will be implemented throughout the country in rural sectors of border zones and the Amazon region and in towns that are far from electric power grids, for a 10-year period. The principal objectives is to reduce greenhouse gas emissions by promoting, disseminating and installing photovoltaic solar systems in order to meet the basic requirements for electricity in households, educational centers, and health centers in rural areas.

The most important results will be the installation of 5,000 photovoltaic solar systems, the reduction of emissions on the order of 8,400 tons of CO_2, at the end of the period being analyzed, and the contribution to improving the health and living conditions of the rural population involved in the project.

The total budget that has been estimated for the implementation of this project is US$5.1 million. Owing to the high cost of the initial investment for the installation of this type of system, the financial analysis concludes that the cost-benefit ratio, without considering environmental benefits and externalities, is 0.2. If the cost of the technology needed to reduce CO2 emissions is considered, this same index, to reach a value of 1.00, should considered a cost per ton of CO2 of over US$100, which is very high for purposes of negotiating on the carbon market. This project is justified, however, by the priority to be granted to socioeconomic objectives for remote rural zones in Ecuador.

Electric power saving in the residential sector by substituting luminaires

The project will be implemented in Ecuador's three largest cities over a seven-year period. The principal objectives are to reduce greenhouse gas emissions, energy consumption, and coincident power capacity of the electric power system by substituting luminaires in the residential sector and contributing to the formation of a new rational-use-of-energy culture.

The most important results are: the substitution of 2.5 million 100-W incandescent light bulbs for 20-W efficient luminaires in the residential sector; electric power savings of 770 GWh and 220 MW of power capacity by the end of the period being analyzed; a total reduction of emissions amounting to 680,000 tons of CO2 by the end of the period; and a contribution to the formation of anew rational-use-of-energy culture n the residential sector.

The investment requires is on the order of US$23 million. In addition, the cost of the Dissemination and Training Program amounts to US$4.2 million. The cost-benefit ratio is 2.79, without considering environmental benefits and externalities. If the benefit from the

reduction of CO2 emissions is considered, this same index may be as high as 3.1.

Energy generation by means of small hydropower plants

This is a pilot project that will be benefiting communities from three provinces of Ecuador and will take place over a five-year period. Its principal objective is to reduce the emission of greenhouse gases, with the implementation of small hydropower stations, contributing to the improvement and development of the small towns in the different production processes.

The most important results are the installation of 1,360 kW distributed among four projects, the saving of about 907,000 gallons of diesel per year and the decline of a total of 8,800 tons of CO2 per year.

Total investment for the project amounts to US$3.2 million. Owing to the high cost of the investment, the cost-benefit ratio is equal to 1.00 when only incremental benefits are considered. When environmental benefits coming from the decline of GHG emissions are considered, the cost-benefit ratio may be as high as 1.9. The country has prioritized the socioeconomic objectives for the rural areas, and therefore the project is more attractive.

Reduction of power losses in the electric sector

The project envisages actions in 19 power distribution utilities in the country over a three-year period. Its principal objective is to reduce the production of greenhouse gases as a result of the implementation of actions aimed at controlling electric power losses, stemming from the decline of electric power generation from thermoelectric stations and a better energy marketing process.

Its most important results are: a 2.4% decline in technical losses and a 5% decline in nontechnical losses in power distribution; a drop of 369 GWh per year and 60 MW of installed capacity; the reduction of emissions by 385,000 tons of CO2 per year owing to the reduction of technical and nontechnical losses; and the increase in billing for power distribution utilities.

The investments required to reduce the level of technical losses amount to about US$109 million. As for the nontechnical loss reduction program, its investment cost amounts to US$19 million. The cost-benefit ratio is 1.71, without considering environmental benefits, and could be as high as 2.71 when the drop in carbon emissions is included.

Recovery of liquefied petroleum gas (LPG) from associated natural gas

The project covers 22 oil fields located in the country's northeastern area, and it is estimated that it will take 18 months to implement. The principal objectives are to reduce greenhouse gases by reducing the

burning or flaring of association natural gas in the oil fields of the country's northeastern region and to recover LPG through the installation of five recovery plants.

The principal results include the installation of five liquefied petroleum gas recovery plants, the recovery of 710 tons per day of LPG, and the reduction of emissions by 686,00 tons of CO2 per year.

The project's total cost is about US$67 million. The implementation of the project indicates a cost-benefit ratio on the order of 2.5, without considering environmental benefits and externalities. When considering the benefit involved in reducing CO2 emissions, this index may be as high as 4.

Electric power generation using residual natural gas

This project envisages the use of residual gas stemming from natural gas processing in the majority of the northeastern fields of the Amazon region. The principal objectives are: reducing the production of greenhouse gases by substituting thermoelectric stations that currently use diesel as feedstock to generate electricity for thermoelectric stations that use residual gas coming from associated natural gas treatment plants from the oil fields of the northeastern region of the country in order to meet the area's demand for electricity.

As a result, two thermoelectric stations are installed, one for 12 MW and another for 23 MW, that is, a total installed capacity of 35 MW, as well as the reduction of emissions at the end of the forecasting period amounting to 53,000 tons of CO_2 per year.

The total cost of the project would be over US$35 million (93.45% for the initial investment, 1.87% for the feasibility study, and 4.67% for the engineering). The cost-benefit ratio amounts to 1.3 when environmental benefits and externalities are not considered. If the benefit stemming from the reduction of CO_2 emissions is considered, the index may be as high as 1.42.

Using compressed natural gas in motor vehicles

The project will be implemented in the city of Guayaquil over a 15-year period. The principal objectives are: reduction of GHG coming from motor vehicle transportation; the efficient development of a depletable energy resources; and the decline in operating and maintenance costs of the motor vehicles because of their consumption of higher-quality fuel.

The most important results are: the conversion of 2,000 buses and 4,000 taxis of the motor vehicle fleet; a saving of 50,000 boe per year owing to the substitution for compressed natural gas; and a reduction of 100,000 tons of CO_2 per year.

The estimated cost of the investments required for the implementation of the project amounts to US$3.4 million. In addition, a dissemination and training program is envisaged, for US$100,000. For

the taxis, the cost-benefit ratio is 1.05, without externalities. If costs of reducing each ton of CO_2 is taken into account, this ration could rise to 1.21. The indices for the buses and public transport vehicles are 1.1 and 1.27, respectively.

▶ FORESTRY SECTOR

Eight mitigation project profiles are suggested for the forestry sector.

Sustainable forestry management of the native forest of the Chachis on the Cayapas River

The project will be implemented in the province of Esmeraldas in an area of 20,000 hectares over a 15-year period. The most important objectives are the installation of sustainable forest management systems for the native forests in order to ensure the conservation of natural resources and maintain environmental services and thus avoid the emission of CO_2 and other greenhouse gases.

The principal results are: sustainable forest management of 20,000 hectares of native forests belonging to the Chachi communities on the Cayapas River, the training of 10 Chachi communities and their participation in sustainable forestry management of the native forest; improvement of the socioeconomic conditions of the participating communities; the marketing and development of 10 alternative nontimber products; and the storage of 30,000 tons of carbon in the native forest.

The financial analysis indicates that the project is economically viable, as it indicates a cost-benefit ratio amounting to 2.28 and an internal rate of return of about 14%, taking into consideration the benefits of the carbon that is stored. This shows that the project if profitable.

Building up the National System for Protected Areas of Ecuador (SNAP)

The project has a nationwide coverage because it focuses on all the SNAPs, which are comprised of 4,669,800 hectares, and will extend over 30 years. Its principal objectives are: to preserve and conserve in the National System of Protected Areas the representativity of the ecosystems that have the highest biodiversity and the habitats of species that are endangered or at risk of extinction; maintain environmental functions, especially the carbon stored in the biomass; and raise the socioeconomic level of the communities that live in, and next to, the protected areas.

The principal results are: the technical and efficient management of the country's National System for Protected Areas, that is, 4,669,800 hectares of protected areas under management programs; the storage of

93.96 million tons of carbon in the protected areas; the training of campesino communities involved in the management of the SNAP; improvement of the socioeconomic conditions of the participating communities; and a comprehensive appraisal of the National System for Protected Areas that has already been started.

Financially, the project is profitable, since it shows a cost-benefit rate of 1.63 and an internal rate of return (IRR) 29%.

Management of protective forests of the watersheds of the canton of Puyango

The project will be implemented in the province of Loja, in the canton of Puyango and will extend over a surface area of 10,000 hectares and for a period of 20 years. Among its principal objectives, it will protect and manage the protective forests of the watersheds of the canton of Puyango in order to maintain the water regime, water and soil quality, and atmospheric carbon sequestration (CO2), and incorporate the organized community into forest management activities and ensure their participation in the socioeconomic benefits derived therefrom.

The principal results are: sustainable management for 10,000 hectares of protective forests of the watersheds of the canton of Puyango; the conservation of 1,000 hectares of protective forests n their natural state; storage of 105,000 tons of carbon that have not been emitted into the atmosphere in the native forest; the training of 10 communities in the sustainable management of the protective forest; the improvement of socioeconomic conditions of the participating communities; and the management of 10 nontimber products with sustainable criteria.

The financial analysis indicates that the projects is feasible as the cost-benefit ratio is 2.91 and the internal rate of return(IRR) is 73%, when considering the benefit from the stored carbon. These indicators show that the project is profitable.

Establishment of agroforestry systems in the canton of El Carmen

The project will be implemented in the province of Manabí, in the canton of El Carmen, over an area of 50,000 hectares and a period of 15 years. The principal objectives are to combine annual or perennial crops with plantations of some tree species, in order to optimize production per unit of surface, maintain the recycling of nutrients, improve fertility, and reduce soil erosion, respecting the ecological, economic, and social conditions of the region.

The most important results are: the establishment of 3,300 hectares per year of agroforestry systems; the reduction of the soil erosion rate of the agricultural sectors; improvement of the environmental conditions of 50,000 hectares of the canton of El Carmen; improvement of the socioeconomic conditions of the campesino families; consolidation of agroforestry practices in the agricultural sector of the canton; and the sequestration of 1.75 million tons of CO2 from the atmosphere.

The financial analysis indicates that the project is economically viable as it has a cost-benefit ratio that is higher than one (1.81) and an IRR of 28%, considering externalities.

Establishment of woodland/grazing land systems in the canton of Guamote

The project will be implemented in the province of Chimborazo, canton Guamote, over an area of 50.000 hectares and a 15-year period. The most important objective is to combine grazing land with plantations of some multipurpose tree species in order to optimize cattle production, maintain nutrient cycles, increase the carbon stored in the biomass, and protect the soil, preserving the region's ecological, economic, and social conditions.

The principal results are: the establishment of 3,300 hectares per year of woodland/grazing land; an upgraded protein intake capacity of the cattle; the planting of 10 million tress in the grazing land of the canton of Guamote; the improvement of the quality of living of the communities; 1.75 million tons of carbon sequestered from the atmosphere; and the consolidation of woodland/grazing land practices in the livestock activities of the canton of Guamote.

Financially, the project is feasible since it shows a cost-benefit ratio that is higher than one (1.65) and an IRR of 23%, which indicates that the project is profitable.

Productive forest plantations in the canton of Balzar

The project will be implemented in the province of Guayas, canton Balzar, over an area of 10,000 hectares and a 10-year period. The fundamental objectives will be to contribute to increasing the surface area of productive forests in order to meet needs for protection, industrial and handicraft demand for wood, and contribution to the sequestration of CO2 from the atmosphere and the improvement of the living conditions of the rural population.

The principal results are: the establishment of 10,000 hectares of productive forest plantations; the training and participation of communities in productive forest plantations; a proposal for incentives to manage and maintain the environmental services coming from the productive forest plantations aimed at small and medium-sized landowners; improvement of the socioeconomic conditions of the participating communities; and the sequestration of 1.75 million tons of carbon from the atmosphere.

The financial analysis indicates that the project is viable since it has an IRR of 30% and a cost-benefit ratio of 4.34.

Protective forest plantations in the canton of Bolívar

The project will be implemented in the province of Carchi, in a 500-hectare area for a period of 30 years. The principal objectives are to

promote the establishment of protective forest plantations with clear use and development objectives for soil and water protection and maintenance of ecological functions, such as carbon storage and, at the same, meeting the socioeconomic needs of local communities.

The principal results are: 5,000 hectares planted on degraded land of the urban parish of Bolívar; at least 10 campesino communities trained and involved in the plant production and the establishment of protective forest plantations; improvement of the socioeconomic conditions of the participating communities; and 525,000 tons of carbon stored in the protective forest plantations and which will not be emitted.

The financial analysis indicates that the project is viable, with a benefit/cost rate of 1.39 and an IRR of 21% when considering the carbon obtained by fixing.

Green belt for the city of Guayaquil

The project will be implemented in the province of Guayas over a 400-hectare area and a period of 15 years. The most important objective is to increase the formation and conservation of a green belt as a surrounding protective area for the city with the highest population in the country, as well as promote urban tree planting to mitigate the impacts from the accumulation of greenhouse gases.

The principal results are: 400 hectares of protective forest plantations to form a green belt around the city; the location of various projects of local and national interest next to the protected green belt; the establishment of leisure and environmental education areas; and the sequestration of 42,000 tons of carbon from the city's atmosphere.

The project has an internal rate of return of 21%, an indicator that shows that the project is profitable without considering externalities.

▶ AGRICULTURAL SECTOR

A schematic presentation of the three potential project profiles that have been identified is provided below.

Improvement of the diet of cattle by means of grazing land management

By improving the diet of cattle by providing for the balanced dosage of fodder and grasses, the project seeks to reduce by 15% to 20% methane gas production stemming from enteric fermentation, which has been identified by various studies as the principal source of methane emissions.

The pilot project will be developed over a 50-hectare area with 60 heads of cattle. Afterwards, the experience will be replicated in the provinces of the inter-Andean valleys.

Manure management through biodigesters

The present project is aimed at tapping methane emissions generated by cattle manure with the installation of biodigesters, preventing the gas from being discharged into the atmosphere and, at the same time, permitting the production of energy and organic fertilizer.

Manure management also involves all those other activities that are developed around it, generating goods and services, such as the use of solid fertilizer (Biosol) coming from the biodigesters, the application of liquid fertilizer (Biol) as a foliage accelerator, and the use of biogas as an energy generation in the rural sector.

Use and management of rice harvest waste or residues with compost heaps and recycling processes

The present project is aimed at reducing methane emissions through the management and use of harvest residues and waste. The pilot project that is being proposed intends, on the one hand, to eliminate or at least reduce methane gas emissions by processing this residue by means of the installation of compost heaps or beds and, on the other hand, to obtain a product that can mean additional income from the sale of the compost.

In the case of the use of recycled or composted biomass o the same plot of land, the physical and chemical properties of the soil will be improved and productivity raised.

Chapter 5

National requirements

The results obtained and the lessons learnt during the implementation of the Climate Change Process in Ecuador have permitted the systematization of the principal requirements in different areas of activity to address climate changes problems in a framework of national priorities of a country interested in ensuring its sustainable development. The listing below does not exclude any other options.

It should be indicated that the other chapters contain the principal constraints found in the sector studies and assessments that were carried out.

CAPACITY BUILDING

- Formal and continuous training on climate change, specifically on the proposal and adoption of adaptation and mitigation measures.
- Formulation of the Climate Change Action Plan over the medium and long term, including means and strategies to insert the topic in national planning.
- National capacity building to assess the country's technology development and transfer needs.
- Implementation of a Geographical Information System on climate change.
- Action programs to jointly implement climate change, biodiversity, desertification, and other related conventions.
- Climate change dissemination and public awareness-raising campaigns.
- Definition of national strategy on the clean development mechanism (CDM), including training in project design and formulations.
- Implementation of national excellence centers for research and training.
- Formation and training of national staff for international environmental negotiations.
- Support for strengthening the focal point, the National Climate Committee and the Climate Change Units and related topics.

VULNERABILITY ASSESSMENT AND ADOPTION OF ADAPTATION MEASURES

- Formulation and implementation of adaptation projects on the basis of the profiles presented in the relevant chapter.
- Development of vulnerability and adaptation assessments in sectors not yet considered because of the lack of resources such as health,

fishing, fragile ecosystems including mountain zones, as well as geographical zones with erosion problems that are prone to droughts and desertification process and to the occurrence of natural disasters and flooding, etc.

- Complementation of studies in the agricultural sector, including new and important crops and enlarging the geographical coverage of assessments already made.
- Implementation of the adaptation analysis in the water resource sector and in the coastal marine zone of the lower Guayas river basin.
- Broadening the analysis to cover the entire coastal marine sector of the country.
- Update and enlargement of the coverage of studies on the detection of the change from the standpoint of climate, glaciology, oceanography, geology, etc.
- Update of climate change scenarios for the country.
- Adjustment of the methodologies for assessing vulnerability and adapting to national conditions.

ASSESSMENT OF THE IMPACT OF RESPONSE MEASURES IN THE COUNTRY

- Training of staff n the use of adequate methodologies adapted to the country's reality.
- Assessment of the impact of the measures of response on the country's socioeconomic and environmental dependence on its oil activities
- Formulation of a plan of action to face the impact of response measures.

ASSESSMENT OF MITIGATION AND ADOPTION OF MEASURES

- Improvement in the quality of the data and update of those already existing in the energy, forestry, and agricultural sectors.
- In-depth economic assessment of mitigation measures.
- Research and recording of energy consumption and end-use, especially in the industrial and rural residential sector.
- In-depth analysis of the development potential of associated gas and biodegradable waste.
- Determination of the carbon potential of the principal forest species.
- Formulation of mitigation projects on the basis of the profiles proposed in the relevant chapter.

GREENHOUSE GAS INVENTORY

- Development of an information system that supports the periodical elaboration of the inventory.
- Definition of national emission factors.
- Reduction of the uncertainty of certain data in the energy, forest, and agricultural sectors and/or generation of the information required.
- Development of national emission forecasting.
- Access to national and global information on emission methodologies and factors.

CLIMATE CHANGE MEASUREMENT SYSTEM AND DATA COMPILATION

- Implementation of specific measurement systems for climate, glaciers, oceans, etc.
- Establishment of a specific climate data base.
- Update of instruments for the current meteorological and hydrological network.
- Improvements in the understanding, monitoring, and research of El Niño – Southern Oscillation events (ENSO).

ONGOING NATIONAL COMMUNICATON IMPROVEMENT PROCESS

- Building up national capacity to prepare future national communications.
- Sustainability over time of trained technical staff.
- Exchange of experiences and knowledge between the countries of one same region and between them.
- Search of means and strategies to include the topic of climate change in national planning.
- Build up national capacity to evaluate and define in detail its requirements for technology, methodologies, resources, equipment, etc.
- Implementation of programs to involve civil society in the Climate Change Process in Ecuador.

- Including the global climate change study in the curriculum of formal primary, secondary, and university education systems.
- General and focused studies on dissemination and awareness raising about climate change and its direct and indirect impacts on the country.
- Focused awareness raising programs for those in charge of political decision making and managers and leaders of spoken and written media.