CLIMATE CHANGE AND DEVELOPMENT IN LATIN AMERICA AND THE CARIBBEAN

OVERVIEW 2009

JOSELUIS SAMANIEGO
COORDINATOR

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ECLAC
gtz
COP15
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UN CLIMATE CHANGE CONFERENCE 2009

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Economic Commission for Latin America and the Caribbean (ECLAC)

The preparation of *Climate Change and Development in Latin America and the Caribbean. Overview 2009*, was coordinated by Joseluis Samaniego, Director of the Sustainable Development and Human Settlements Division of ECLAC. Valuable input was provided by Hugo Altomonte, Officer-in-Charge of the Natural Resources and Infrastructure Division; Adrián Rodríguez, Economic Affairs Officer in the Division of Production, Productivity and Management; Jean Acquatella, Economic Affairs Officer in the Natural Resources and Infrastructure Division; Marianne Schaper, Economic Affairs Officer in the Sustainable Development and Human Settlements Division; Hugo Guzmán, Coordinator of the Office of the Executive Secretary; the consultants Eduardo Sanhueza and Karina Martínez and reviewers Rudolf Buitelaar, Officer with the Programme Planning and Operations Division, and Osvaldo Kacef, Director of the Economic Development Division.

Thanks are also due to Heloisa Schneider, Economic Affairs Officer in the Division of Production, Productivity and Management, and Carlos de Miguel and Humberto Soto, Environmental Affairs Officers in the Sustainable Development and Human Settlements Division, for their contributions to this updated version of the document.

Financing for this document was provided by the German Agency for Technical Cooperation (GTZ) and the Government of Denmark.

United Nations Publication

LC/L.3140

Printed in United Nations, Santiago, Chile

2009-515

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Foreword

In recent years, the problem of climate change has captured an unprecedented level of attention. This has mobilized the international community to agree on mitigation actions, boosted technological innovation efforts to develop the necessary tools to address the causes of the problem and generated growing concerns about the potentially negative impacts of this phenomenon on countries' economic and social development. This issue has even been included, together with the Millennium Development Goals, on the agenda of priorities of the United Nations Secretary-General.

The overriding concern worldwide is, rightly, to tackle the root of the problem, greenhouse gas emissions (GHGs), before the feedback loops in the system become irreversible. The release of GHGs into the atmosphere and their build-up over the past few centuries has raised concentrations to such a point that the Earth's temperature is rising to dangerous levels.

The international regime agreed to under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol limits the emission of GHGs, but only in the developed countries. The use of the atmosphere as a sink for anthropogenic GHGs is thus only partially regulated, and the regime is still far from ensuring climate security.

It was not until 2007 that quantitative targets and deadlines were set for attaining climate security, which, as Bárcena points out, is a global public good that must be protected (Bárcena, 2008 and 2009a and b; *El Universal*, 2008). The Stern Review on the Economics of Climate Change and the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) provided fresh input to make limit-setting possible (Stern, 2006). The IPCC dispelled the uncertainty as to the responsibility of human activity for climate change and the damage that this phenomenon could potentially cause under different scenarios. The Stern Review, meanwhile, in addition to providing estimates of the global costs of mitigation, showed that any delay in taking action would result in more substantial losses in terms of welfare and global output and steered the discussion towards the establishment of very low discount rates in the future and the need to act immediately.

This report examines what has become the standard for climate security in the industrialized countries and some emerging economies: capping GHG concentrations in the atmosphere at between 500 and 550 parts per million (ppm) of CO_2e, which would suppose a global temperature rise of between 2.5°C and 3.5°C. Above this level, all systems would be facing changes of such a magnitude that the possibilities of adaptation would be slim.

GHGs in the atmosphere are currently increasing at approximately 2.5 ppm of CO_2e per year, and the concentration level is about 430 ppm of CO_2e. At this rate, the 550 ppm concentration limit will be reached by the middle of this century, and emissions will still be increasing. Time for stabilizing concentrations at safe levels is therefore running out fast.

The situation in Latin America and the Caribbean is different from that of the developed countries. The latter are the main source of the emissions creating this new global reality and they are suffering some consequences; whereas the countries of Latin American and Caribbean region have contributed little to this situation and are suffering the consequences to a disproportionate extent. By region, the Latin American and Caribbean region is the second lowest emitter in the world (after Africa). In terms of per capita emissions, however, its levels exceed those of both Asia and Africa. Nevertheless, the Latin American and Caribbean region is one of the most vulnerable to climate change for several reasons: many of its countries are island States or have coastal lowlands and are located in the hurricane belt; others depend on the thaw of the snow and ice deposits in the Andes to supply water to their urban and agricultural sectors; and several are at high risk from major disasters such as floods and forest fires.

These geographical features, together with the situation of Latin America and the Caribbean in the global economy, are precisely why it is so necessary to carry out a specific analysis of the impacts of climate change on the region.

Until quite recently, the discussions were focused on the environmental impact of this phenomenon and only in the past few years has attention turned to the economic implications. This book of the Economic Commission for Latin America and the Caribbean (ECLAC), which seeks to help bridge the gap between the environmental and economic spheres, presents an initial analysis of the most relevant information on the region available in 2009. It also underscores some economic aspects of climate change and their implications for Latin America and the Caribbean, in particular the link with international trade, the negative effects on public finances and the future constraints on high-carbon economic development. Climate change will hamper development because resources will be lost or will have to be reallocated to adaptation to its negative impacts. However, this phenomenon also offers the world an opportunity to pursue a better quality of development through more investment in technologies that can mitigate some of the negative environmental impacts of the development process.

Economic decision-makers in the Governments of the region need to be made aware of these issues; indeed, the better prepared they are, the less pressure they will be under in terms of unforeseen expenses and loss of revenues and the better the economic governance of the country in question. In short, this book seeks to provide Latin American and Caribbean Governments with input for analysing the relationship between climate change and development.

This text stresses the importance of finding mechanisms for appropriately distributing the costs of climate change. It also points out that major changes are on the way in the global context in which the countries of Latin America and the Caribbean operate and that steps will have to be taken to ensure that the carbon footprint is factored into trade and future-investment decisions.

The information presented in this book will be complemented in the near future with the results of studies on the economics of climate change that are being carried out in different countries across the region (Brazil, Mexico and some Central American, South American and Caribbean nations). As new data is incorporated, these studies will provide an increasingly accurate picture of the costs of adaptation at the national and sectoral level and of the potential gains of mitigation. Information on most of the countries of Latin America and the Caribbean should be available in 2010, which will enhance the analysis of the issue from the regional perspective.

The literature reviewed in the preparation of this book included recent international works on climate change covering Latin America and the Caribbean, such as the 2030 scenarios published by the International Energy Agency, the Fourth Assessment Report of the IPCC and the reports prepared by the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP).

These documents stress the importance of adaptation as a strategy for the region, highlight the possible gains of mitigation, with and without carbon markets, and underscore the need to protect public finances against the effects of physical or economic disasters that could bring down income levels or drive up expenses.

In concluding, I should like to express my appreciation to Joseluis Samaniego, Director of the Sustainable Development and Human Settlements Division of ECLAC, for coordinating the preparation of this document; to the Division of Production, Productivity and Management, under the leadership of Mario Cimoli, for its inputs on the impacts on the primary sector; and to the Natural Resources and Infrastructure Division, under Hugo Altomonte, for its collaboration on issues relating to the energy sector.

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Introduction

Chapters I and II examine the expected biophysical impacts of climate change and the consequences as regards production systems and health in the region. Attention is drawn in particular to the widespread negative impacts that are expected within the inter-tropical belt. Highly important species, such as maize, are expected to reach the limits of biological resistance to temperature change; the snows and glaciers of the Andes are expected to melt; water supply will become a problem across vast areas; and the risk of epidemics will increase. In short, these chapters discuss the huge vulnerability of the primary sector and of its related production and fiscal linkages. Only a few high-latitude subregions of South America are likely to record production gains.

Chapter III looks at the crucial issue of adaptation to climate change. Action in this area is still rather impromptu (UNEP/SEMARNAT, 2006) and reactive (UNFCCC, 2007) insofar as it tends to focus on the handling of natural disasters and the subsequent recovery efforts. Adaptation implies absorbing the losses expected in the primary sector and in public revenue and anticipating the expenditures that the public sector will have to make to tackle the negative and potentially concurrent direct consequences of climate change, such as droughts, floods, epidemics, heatwaves and infrastructure damage. The problem of Latin America and the Caribbean in relation to climate change is fundamentally one of adaptation, rather than of GHG emissions mitigation.

Developing the capacity for adaptation poses challenges, such as the quantification of the necessary resources, the apportionment of costs among public and private stakeholders (producers and consumers), the localization and targeting of the required measures and the fostering of the necessary awareness or knowledge of the issue among the country's economic, social and environmental authorities.

This chapter shows that poor adaptation increases the risk that private-sector production losses caused by gradual climate changes or extreme events may be passed on to public finances through compensation measures if these entail public expenditures that use municipal, subnational, national or (in the case of cooperation for disaster relief) international funds. Such losses would then be compounded by those induced by the decline in economic activity and the fall in public revenues.

Adaptation is a task for both the private and the public sector. For the former, it involves the creation and use of economic risk mitigation and forward-looking mechanisms that limit future carbon emissions in certain countries and export markets and in national investment. For the public sector, it entails, above all, protecting fiscal revenue and public spending in order to preserve fiscal equilibria and economic governance.

If adaptation leads to the internalization of those costs by private parties (through insurance mechanisms, for instance) the expected additional costs will remain in the private sphere. This will not prevent a costs distribution struggle between producers and consumers, and poor adaptation on the part of producers could push up prices.

Poor adaptation would certainly result in increased pressure on the different levels of public finance and more unstable markets. From this perspective, progress on adaptation will require an effort to protect the structure of public finance and the stability of the private sector in the interests of macroeconomic stability.

Chapter IV looks at the region's adaptation to the indirect consequences of climate change, that is those that result from the developed world's mitigation measures. The developed countries are trying to reduce the production of emissions and shrink their carbon footprint, while also protecting their production sectors from international competition. The emissions embedded in the exports of the Latin American and Caribbean region, from either production or transport, may trigger restrictions in destination markets. This chapter gives an account of the main carbon-footprint-related initiatives undertaken in 2009. In addition to the imposition of restrictions on international trade, the region may face an influx of emissions-intensive industries, which would hinder the shift towards a lower-carbon production structure. The distinction between net importers and net exporters of carbon in international trade, that is, between net producers and consumers of virtual carbon, is also pointed out in this chapter.

Generally speaking, the region is technology taker, so it must also dismantle barriers to the dissemination of technologies that minimize the carbon footprint and promote the elimination of international trade restrictions in the short term. As a complement to this, the assessment of new investments should factor in the cost of emissions and other environmental burdens from a life cycle perspective, and regional accords should be sought to promote the sharing of best practices and regulations to protect both the environment and competitiveness.

Chapter V considers the future of the energy sector in Latin America and the Caribbean and observes that there is reason for concern from the point of view of emissions from fossil fuel consumption. Between 1973 and 2005, Latin America's share in final primary energy consumption rose from 3.7% to 5.0% of the world total and final energy consumption tripled in industry and transport. Transport is also the largest culprit in the increase in oil consumption between 1971 and 2005. This is owed, to some extent, to a plateau in the improvement in the energy intensity of transport, which is practically at the same level today as it was in 1980.

Latin America and the Caribbean will continue to be a major consumer of fossil fuels, at least in the first half of the twenty-first century. The rise in oil prices leads to consumption of higher-carbon fuels with a more stable supply, and the region does not have a history of spontaneous improvements in either energy consumption or emissions reduction. Switching to a cleaner energy path will take more powerful incentives on the international front and, domestically, greater efforts to realize the economic potential of greater energy efficiency, since the region offers major opportunities for progress in this area.

The main incentives at this point are local environmental improvements, more economical fuel use and the smaller investment needed to increase the energy supply. The latest advances in wind, thermal, marine and solar energy have occurred outside the region and, like in previous cases, Latin America and the Caribbean will be a technology taker. According to the International Energy Agency, investment in energy efficiency could produce significant economic gains in all the countries of the region, except in Mexico.

Chapter VI looks at the mitigation of GHG emissions and the opportunities available, analyses the main sources of emissions and summarizes the mitigation policies and tools being applied in some of the Latin American and Caribbean countries. Per capita emissions have risen practically across the board. Agriculture, land-use changes and energy consumption are the main sources of emissions, accounting for around 30% apiece. The combined emissions of waste and industrial processes account for less than 10%.

GHG emissions in Latin America and the Caribbean, including those from land-use changes, were equivalent to 11.78% of the world total in 2000. The long-term objective at the global level is to stabilize emissions at around 20 gigatons. Latin America and the Caribbean produces 3.1 gigatons of emissions. The region's share of the atmospheric commons is very unlikely to be much bigger in the future, given the increases in those of the Asian giants and the developed world. Accommodating economic development to this environmental space will be a huge challenge. The region must invest more in clean technologies if it is to maintain its share in the atmospheric environmental service in the context of the long-term global effort. Part of this effort is facilitated by the Clean Development Mechanism (CDM) and part is financed with the benefits deriving from energy efficiency. Latin America and the Caribbean must take advantage of the time still available to it to begin this upgrading.

The region stands out for the large proportion of its emissions that are generated by loss of forest cover resulting from the expansion of the agricultural frontier. There are few areas in which adaptation and mitigation measures coincide —and forest conservation is one of them. Another example is payment for the environmental services provided by the conservation of large portions of water basins, which reduces vulnerability to hydrometeorological disasters (adaptation) and mitigates the emissions from deforestation and forest degradation. Adaptation and mitigation also coincide in the proper management of solid waste and waste water in the case of flooding.

The Kyoto Protocol contains very weak incentives to conserve forests and improve land management, however. Small-scale afforestation and reforestation are eligible, but conservation is not. It was agreed at the meeting held in Bali in December 2007 to include forest conservation in the next package of agreements (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, or REDD).

The region has been gradually falling behind Asia in terms of the number of projects and emissions reductions under CDM, and the mechanism today represents only a marginal stimulus for improving energy and land use. Only an overhaul of the carbon market and its mechanisms will provide the positive incentives needed to bring about a change in this regard. Cities are a major source of emissions, for example, but do not participate as such in carbon markets.

This chapter reviews the projects registered under CDM to supply mitigation and notes that there are few in the areas of fuel switching and energy efficiency. Most of the projects in the region are in agriculture (methane from agro-industrial residues), renewable energies (biomass) and landfills.

CDM raises the internal rate of return of projects by between 0.5% and 3.5%. But the mechanism does not yet mobilize sufficient investment to contribute to significant structural transformations in the energy sectors of most countries in the region. From 2004 to the present, CDM has contributed some US$ 7 billion directly and leveraged approximately US$ 1 billion in investment worldwide.

Chapter VII analyses the international context and observes that, although the region did not undertake reduction commitments during the first commitment period of the Kyoto Protocol (2008-2012), this may change in the future. In the international negotiations, Brazil and Mexico have been signalled as intermediate development countries that should assume some kind of commitment in the form of nationally appropriate mitigation actions (NAMA). The international situation may evolve far enough to adopt criteria by which the countries undertake quantitative commitments to: (a) limit emissions according to a combination of indicators, such as per capita income and levels of emissions; (b) include emissions-intensive sectors, whether located in developing or developed countries (such as the cement, automobile and paper industries); (c) introduce international trade restrictions based on the GHGs embedded in the production or transport of merchandise; and (d) impose national or international taxes on the carbon content of fossil fuels, including those used in international transport.

These four possibilities would mean changes in the national or sector-specific development strategies of the countries of the region. Whether emissions are restricted as a function of GDP growth (Chile or Trinidad and Tobago), because of the export specialization in energy-intensive environmentally sensitive industries (South America) or because of the great distance from the centres of consumption (Southern Cone), some countries and several sectors in the region will inevitably face a carbon-restricted future. Hence, as well as purely national incentives for change, new conditions will be imposed upon the economic development of the Latin American and Caribbean countries.

Accordingly, it would be wise to avoid crossing emissions thresholds that could prompt carbon restrictions in the future.

International funds for adaptation are still scarce and most of the effort will continue to be financed from local resources in the short run. As things stand, the incentives offered by mitigation are too few and too narrow. Concerted international efforts, although rather uncertain today, may bring greater resources for adaptation. In the case of mitigation, the incentives could come from a thoroughgoing reform of carbon markets to encourage the adoption of public policies for lower-carbon development.

It is important to ensure that the effort to achieve climate security engages more developing countries. Future rules for access to the global atmospheric commons and their environmental services as a carbon sink will be key to evaluating present development strategies in terms of the carbon intensity.

The negotiations regarding the coming commitment periods under the Kyoto Protocol and the instruments that arise from them will be crucial to mitigate the economic impact of adaptation, modify carbon markets and turn them into more meaningful incentives for mitigation, secure economic reward for the environmental service provided by forest conservation and ensure access to the atmospheric commons according to the development needs of the region's economies, along with measures to increase energy efficiency and reduce the consumption of fossil fuels in order to provide leeway within the region's environmental space.

The economic challenge of climate change calls for the attention of economic decision-makers in Latin America and the Caribbean, including those in the area of infrastructure. This is a long-term challenge compounded by financial uncertainties and the shorter-cycle fluctuations of international food and energy prices. Decisions taken today will be enormously important in shaping future emissions trajectories and in the responsibilities that governments and societies will have to carry in the future.

I. Climate change in the region

This chapter briefly reviews the information available from the scientific community on possible alterations that could arise in Latin America and the Caribbean as a result of vulnerability to climate change. The greatest impacts are expected in the intertropical region and in Andean areas.

A. The advance of scientific knowledge and international negotiations

BOX I.1
CLIMATE CHANGE

Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC) defines this as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

In 1827, the French mathematician Jean Baptiste Fourier observed that certain gases in the atmosphere, particularly carbon dioxide (CO_2), caused it to retain heat. He saw this as comparable to what happened in greenhouses, and thus referred to it by the term *effet de serre* (greenhouse effect). Later, in 1860, the Irish physicist John Tyndall linked changes in atmospheric CO_2 concentrations to alterations in the climate system. This gave an important new impetus to research on the subject, with the result that in 1896 the Swedish physicist Svante Arrhenius, winner of the 1903 Nobel Prize in Chemistry, drew attention to the climatic implications of human activity, using a simple calculation to show that if the rapid advance of industry led to a doubling of the level of carbon gas (or carbon dioxide) in the earth's atmosphere, global temperatures would rise by some 6˚C.

It would be 80 years before the scientific community could collect enough data to corroborate these predictions. When they did, they issued an urgent warning to the international community at the first World Climate Conference, held in Geneva in 1979, about the need to adopt drastic corrective measures given that: (i) the average temperature of the planet had been rising rapidly, (ii) the information available indicated that this was due to human activities releasing greenhouse gases into the atmosphere, particularly CO_2, methane and nitrous oxide (N_2O), and (iii) the models used to explain this rise in temperature pointed to the possibility of alterations in the climate system that would considerably affect global welfare over a period of no more than 100 years.

In response to this appeal, in 1988 the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) set up the Intergovernmental Panel on Climate Change (IPCC). The function of this body, which is open to all Member States of the United Nations and WMO, is to conduct an exhaustive, objective, open and transparent analysis of the relevant scientific, technical and socio-economic information in order to reach an understanding of the risks entailed in climate change resulting from human activities, its possible repercussions and the prospects of adaptation to it. IPCC evaluations are chiefly based on scientific and technical studies published and submitted to a peer review system.

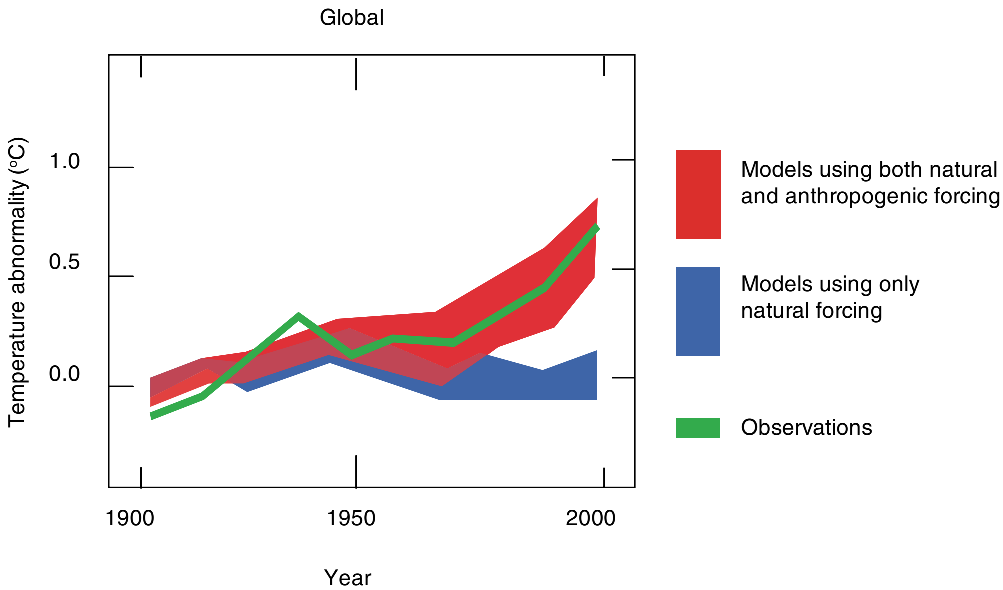
To carry out this work, the IPCC has been organized into three working groups:

- Working Group I assesses the physical scientific aspects of the climate system and climate change.
- Working Group II assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adapting to it.
- Working Group III assesses options for limiting greenhouse gas emissions and mitigating climate change.

The core messages of the IPCC in each of its reports have remained essentially unchanged: (i) the average temperature of the planet has increased in the past century, essentially because of the anthropogenic contribution of greenhouse gas (GHG) emissions and the diminution of natural sinks caused by global economic activity, (ii) if this behaviour continues, the average global temperature will increase over the present century to a level unprecedented in the earth's geological history of the past million years, with severe consequences for ecosystems, national economies and human welfare, and (iii) the longer the delay in implementing the necessary corrective measures, the greater the costs will be, but there is still an opportunity to apply them without significantly affecting the global economy (see figure I.1).

The first report of the Intergovernmental Panel on Climate Change (IPCC, 1990) was crucial to the decision by the United Nations General Assembly to begin the UNFCCC negotiating process. The second (IPCC, 1995) was the main input for the negotiations over the Kyoto Protocol, on which agreement was reached in 1997. The third report (IPCC, 2001) played a significant role in creating the conditions that ultimately led to ratification (approval, acceptance or accession) of the Kyoto Protocol and its implementation in 2005. Lastly, the most recent report (IPCC, 2007b) was crucial to the Bali accords (2008), particularly the decision to begin negotiations with a view to revising international agreements on the measures required after 2012.

FIGURE I.1
THE GLOBAL TEMPERATURE RISE



Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

The following table, which was prepared by the United Nations Environment Programme and the Secretariat of the Environment and Natural Resources of Mexico (UNEP/SEMARNAT, 2006), gives a timeline of the international negotiations on global warming that began in 1979.

TABLE I.1
TIMELINE OF INTERNATIONAL CLIMATE CHANGE NEGOTIATIONS

Year	Major events	Key aspects
1979	First World Climate Conference	Presentation of the first proofs that human activities are causing global warming, mainly because of the volume of greenhouse gas (GHG) emissions generated by the burning of fossil fuels (coal, oil and gas)
1980	World Climate Programme	The subject of global warming receives growing attention during the 1980s as a result of the first World Climate Conference
1988	United Nations General Assembly	Growing concern about climate change leads the United Nations General Assembly to pass resolution 43/53 entitled "Protection of global climate for present and future generations of mankind"
1989	The Intergovernmental Panel on Climate Change (IPCC) is set up	The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) set up the IPCC with a view to evaluating the scientific information available on climate change, assessing its social, economic and environmental consequences and formulating response strategies (mitigation and adaptation)
1990	First IPCC report	Sets out the evidence for potential climate change threats
1990	Second World Climate Conference (Geneva, Switzerland)	Agreement is reached on the preparation of an international instrument to regulate global climate change mitigation efforts and promote cooperation between countries to reduce GHG emissions, stabilize GHG concentrations in the atmosphere and develop adaptation capabilities

Table I.1 (continued)

Year	Major events	Key aspects
1990	United Nations General Assembly	The General Assembly agrees on the official launch of a negotiating process aimed at creating a framework convention on climate change and accordingly sets up the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC)
1992	Draft Framework Convention on Climate Change	After holding five sessions in two years, the INC approves the text of the Convention in May 1992
1992	First United Nations Conference on Environment and Development	At this first Earth Summit, held in Rio de Janeiro in June 1992, the Convention is opened for signature by participating heads of State. It is signed by 155 countries
1994	The United Nations Framework Convention on Climate Change (UNFCCC) comes into force	The terms of the Convention were that it would come into force once at least 50 of its signatories had presented their instruments of ratification, acceptance, approval or accession. This happened on 21 March 1994. As of February 2009, according to the UNFCCC web page, 192 of these instruments had been deposited
1995	First session of the Conference of the Parties to the Framework Convention on Climate Change (COP 1, Berlin)	Article 4 of the Convention provided that the first session of the Conference of the Parties would review the adequacy of the commitments accepted. COP 1 recognized that they were not sufficient to stabilize GHG concentrations in the atmosphere and the Berlin Mandate was agreed upon so that negotiations could begin on a protocol spelling out the quantitative commitments already accepted. The Ad Hoc Group on the Berlin Mandate was formed to draft this
1996	Second session of the Conference of the Parties (COP 2, Geneva)	Negotiations on the protocol begin
1997	Third session of the Conference of the Parties (COP 3, Kyoto)	After eight sessions, the Ad Hoc Group presented COP 3 with a draft Protocol containing a great deal of preliminary text. Nonetheless, on 11 December 1997 the Kyoto Protocol was approved by the Conference of the Parties
1998	The Kyoto Protocol is opened for signing	The Protocol was opened for signature by States Parties on 16 March 1998. To come into force, it had to be ratified (acceptance, approval or accession) by no fewer than 55 of the Parties to the Convention, including Annex I countries representing at least 55% of all such countries' 1990 carbon dioxide emissions
1998	Fourth session of the Conference of the Parties (COP 4, Buenos Aires)	This Conference approves the Buenos Aires Plan of Action, which lays down a working programme for implementation of the Kyoto Protocol
1999	Fifth session of the Conference of the Parties (COP 5, Bonn)	Work on implementing the Buenos Aires Plan of Action continues
2000	Sixth session of the Conference of the Parties (COP 6, The Hague, Part I)	Negotiations stall and work resumes in Bonn in 2001
2001	Sixth session of the Conference of the Parties (COP 6, Bonn, Part II)	Negotiations in Bonn lead to the Bonn Agreements, providing the basis for negotiation of the Marrakesh Accords
2001	Seventh session of the Conference of the Parties (COP 7, Marrakesh)	Work under the Bonn Agreements continues, implementation rules are developed for the Protocol and the Marrakesh Accords are finalized
2002	Eighth session of the Conference of the Parties (COP 8, New Delhi)	The Delhi Ministerial Declaration on Climate Change and Sustainable Development is agreed

Table I.1 (concluded)

Year	Major events	Key aspects
2003	Ninth session of the Conference of the Parties (COP 9, Milan)	Eligibility criteria and standards are agreed for forestry projects carried out under the clean development mechanism (CDM), these being limited to forestation and reforestation
2004	Tenth session of the Conference of the Parties (COP 10, Buenos Aires)	The Russian Federation deposits its ratification instrument for the Kyoto Protocol on 18 November 2004, allowing it to come into effect
2005	Kyoto Protocol comes into force on 16 February	Following ratification by the Russian Federation, the second condition for the Protocol to come into force is met, as it has been ratified by Annex I Parties representing 61.6% of such countries' 1990 emissions total
2005	Eleventh session of the Conference of the Parties to the UNFCCC and first Meeting of the Parties to the Kyoto Protocol (COP 11/CMP 1, Montreal), 28 November to 9 December	The Marrakesh Accords "package" is approved and the Kyoto Protocol becomes operative. Negotiations are opened on commitments from 2012 ("post-Kyoto") on the basis of Article 3, paragraph 9 of the Protocol
2006	Twelfth session of the Conference of the Parties to the UNFCCC and second Meeting of the Parties to the Kyoto Protocol (COP 12/CMP 2, Nairobi), 6 to 17 November	Discussions continue on a body to take charge of the UNFCCC financing mechanism and administer the special climate change fund
2007	Thirteenth session of the Conference of the Parties to the UNFCCC and third Meeting of the Parties to the Kyoto Protocol (COP 13/CMP 3, Bali), 3 to 15 December	After considering the scientific information provided by the IPCC and the levels of security desired, the Parties reach consensus on the human role in climate change; they therefore decide to take urgent measures to combat it and agree on the Bali Action Plan

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Environment Programme/Secretariat of the Environment and Natural Resources of Mexico (UNEP/SEMARNAT), *El cambio climático en América Latina y el Caribe*, Mexico City, 2006.

1. The commitments accepted

The object of the Convention has been to stabilize the concentration of greenhouse gases in the atmosphere at a level that forestalls dangerous anthropogenic interference with the global climate system. This level should be attained quickly enough to allow ecosystems to adapt naturally to climate change while safeguarding food production and sustainable economic development (UNFCCC, 2007b).

To carry out this mission, the UNFCCC created instruments aimed at reducing greenhouse gases globally while establishing a difference between the responsibilities of industrialized and developing countries. The governments signing the Convention committed themselves to:

- collecting and sharing information on greenhouse gas emissions, national policies and good practices;
- designing national strategies to address the problem of greenhouse gas emissions and adapting to the predicted effects, including provision of financial and technological assistance to developing countries; and
- cooperating on measures to prepare for and adapt to the effects of climate change.

In 1997, at the third session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 3) held in Kyoto (Japan), five years on from the drafting of the UNFCCC, a Protocol was agreed under which governments accepted binding commitments on greenhouse gas emissions and the creation of market mechanisms to facilitate compliance.

The Kyoto Protocol established individual emissions reduction and/or control targets for the countries listed in annex 1, which are the developed countries plus some transition economies. The sum of commitments was equivalent to a reduction of some 5% from the 1990 emissions total over the period from 2008 to 2012. The countries of Latin America and the Caribbean are not in annex 1.

The market mechanisms of the Kyoto Protocol include the trading of assigned amount units (AAUs) of carbon emissions between surplus and deficit countries in annex I, the trading of emission reduction units (ERUs) generated by investment projects from one annex I country to another, or joint implementation, and the purchase by annex I countries of certified emission reductions (CERs) deriving from projects implemented in developing countries and validated by the clean development mechanism (CDM) (UNFCCC, 1997).

2. Climate scenarios

Scientists developed sophisticated computing tools for climate modelling based on economic activity and associated global emissions of greenhouse gases, allowing them to develop illustrative scenarios (see box I.2) incorporating different assumptions about the future behaviour of sources and sinks.

BOX I.2
THE EMISSION SCENARIOS OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

An emission scenario is a representation of the possible future emission paths of substances that are potentially active in the atmosphere (greenhouse gases and aerosols, for example) and their relationship with a set of drivers such as population growth, socio-economic development and technological change.

In 1992, the IPCC presented a set of emission scenarios known as IS92, and these were used as the basis for climate projections in the second evaluation report (IPCC, 1995). *Emissions Scenarios. Summary for Policymakers. A special report of IPCC Working Group III* (IPCC, 2000) introduced new scenarios, the SRES scenarios, which were used as the basis for the climate projections included in the last two reports (IPCC, 2001 and 2007b). The authors identified six illustrative situations: A1B, A2, B1, B2, A1FI and A1T.

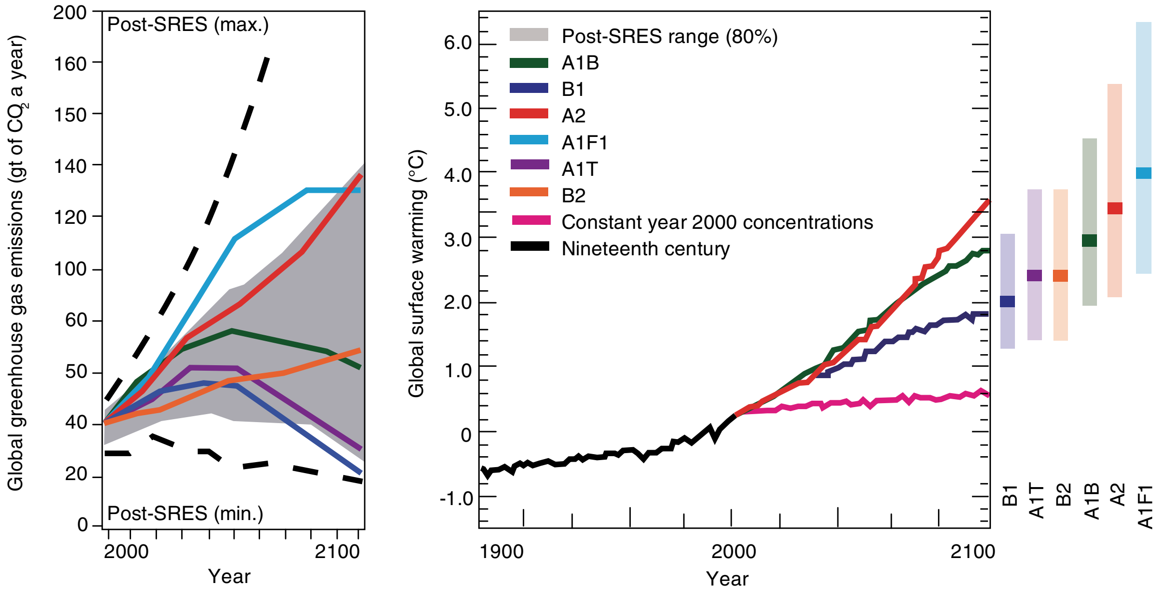
Scenario A1 assumes rapid demographic and economic growth combined with the introduction of more efficient new technologies; A1F1 assumes intensive use of fossil fuels; in A1T, non-fossil energy predominates; in A1B, balanced use is made of all kinds of sources; and scenario A2 assumes less economic dynamism, less globalization and high and sustained population growth.

Scenarios B1 and B2 include some level of emissions mitigation through more efficient energy use and better technologies (B1) and better located solutions (B2).

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

Figure I.2 shows the different IPCC scenarios (see box I.3) and the surface temperature ranges anticipated in each.

FIGURE I.2
GHG EMISSIONS SCENARIOS (IN THE ABSENCE OF ADDITIONAL CLIMATE POLICIES) AND SURFACE TEMPERATURE PROJECTIONS, 2000 AND 2100



Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.
Note: SRES = IPCC Special Report on Emission Scenarios.

Table I.2 gives the numeric results of temperature projections for the end of the century as per the IPCC scenarios.

TABLE I.2
PROJECTED SURFACE WARMING AND SEA LEVEL RISE BY THE END OF THE 21ST CENTURY

Case	Temperature change (°C at 2090-2099 relative to 1980-1999)[a]		Sea level rise (metres at 2090-2099 relative to 1980-1999)
	Best estimate	Likely range	Model-based range excluding future rapid dynamical changes in ice flow
Constant year 2000 concentrations[b]	0.6	0.3-0.9	Not available
B1 scenario	1.8	1.1 to 2.9	0.18 to 0.38
AIT scenario	2.4	1.4 to 3.8	0.20 to 0.45
B2 scenario	2.4	1.4 to 3.8	0.20 to 0.43
A1B scenario	2.8	1.7 to 4.4	0.21 to 0.48
A2 scenario	3.4	2.0 to 5.4	0.23 to 0.51
A1F1 scenario	4.0	2.4 to 6.4	0.26 to 0.59

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several earth-system models of intermediate complexity (EMICs) and a large number of atmosphere-ocean general circulation models (AOGCMs).

[b] Year 2000 constant composition is derived from AOGCMs only.

Statistical methods are supplemented by the expert opinion of the authors regarding the reliability of findings and projections. The scale developed by the IPCC for this purpose is shown in table I.3.

TABLE I.3
RELIABILITY OF RESULTS

Terminology	Degree of confidence in the accuracy of the results
Very high confidence	At least a 9 out of 10 chance of being correct
High confidence	At least an 8 out of 10 chance
Medium confidence	About a 5 in 10 chance
Low confidence	About a 2 in 10 chance
Very low confidence	A less than 1 in 10 chance

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

On the basis of the results simulated using these models and scenarios for the second half of this century, the fourth report of the IPCC (2007c) describes the possible effects of global climate change in the absence of adaptation measures. These are shown in table I.4, which also indicates the reliability of the projections on the scale discussed.

TABLE I.4
EXAMPLES OF THE MAIN EFFECTS OF PROJECTED GLOBAL CLIMATE CHANGE, BY SECTOR

Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for twenty-first century using SRES scenarios	Sector			
		Agriculture, forestry and ecosystems	Water resources	Human health	Industry, settlement and society
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves; frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor

Table I.4 (concluded)

Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for twenty-first century using SRES scenarios	Sector			
		Agriculture, forestry and ecosystems	**Water resources**	**Human health**	**Industry, settlement and society**
Heavy precipitation events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortages; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potential; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of death, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers; potential for population migrations; loss of property
Increased incidence of extreme high sea level (excludes tsunamis)[c]	Likely[d]	Salinization of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risks of death and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

Source: Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: Summary Report. Contributions of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, 2007.
Note: SRES = IPCC Special Report on Emission Scenarios.

[a] See table 3.7 of *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* for further details regarding definitions.

[b] Warming of the most extreme days and nights each year.

[c] Extreme high sea level depends on average sea level and on regional weather systems. It is defined as the highest 1% of hourly values of observed sea level at a station for a given reference period.

[d] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period (see table 10.6 of Working Group I, *Fourth Assessment Report*). The effect of changes in regional weather systems on sea level extremes has not been assessed.

B. Historical information on the effects of climate change in Latin America and the Caribbean

There is a dearth of climate change information based on long time series in Latin America and the Caribbean. Historical studies and analyses generally provide data on changes in temperature and precipitation, the increase in extreme weather events, the rise in the sea level and the loss of water stored in glaciers.[1] Table I.5 gives some examples of the repercussions observed over recent years in different systems.

TABLE I.5
EXAMPLES OF CLIMATE CHANGE EFFECTS OBSERVED IN LATIN AMERICA AND THE CARIBBEAN

Sector/area			
Settlement, industry and infrastructure	**Settlement, industry and infrastructure**	**Settlement, industry and infrastructure**	**Asentamientos humanos, industria e infraestructura**
Increase in extreme weather events in the past 40 years regionwide, such as ENSO episodes[a] (1982-1983 and 1997-1998) and the arrival of hurricane Catarina in Brazil (2004), an event unprecedented in the area			
Temperature increase (South America and the Caribbean)	Reduced precipitation (southern Chile, south-eastern Argentina and southern Peru)	Increase in diseases such as dengue and malaria (various regions)	Economic losses from extreme weather events (US$ 80 billion in 1970-2007)
Changes in land productivity (higher yields on soybean crops in South America, lower maize yields in Mexico and Central America)	Rise in precipitation (southern Brazil, Paraguay, Uruguay, north-eastern Argentina and north-eastern Peru and Ecuador)	Higher indices of morbidity and mortality (Plurinational State of Bolivia)	Increased vulnerability of human settlements affected by extreme weather events (Plurinational State of Bolivia, Peru, Mexico)
Increased degradation resulting from land use changes (all countries)	Rise in sea level (2-3 mm in Argentina in recent years)		Migration of people from the countryside to cities in vulnerable regions (Mexico and Central America)
Higher percentage of desertification (deforestation in Central America)	Decline in glacier mass balance (Plurinational State of Bolivia, Peru, Ecuador and Colombia)		
Reduction in forest cover (in Amazonia this decreased by 17.2 million ha in the 1970-2007 period)			
Rise in the number of endangered species in Mexico and Peru (4%), Ecuador (up to 10%), Colombia (11%) and Brazil (3%)			

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007 and United Nations Environment Programme (UNEP), *GEO Latin America and the Caribbean: Environment Outlook, 2003*, Mexico City, 2003.

[a] El Niño is a warm water current that periodically flows along the coast of Ecuador and Peru. It is associated with a fluctuation of the intertropical surface pressure pattern and circulation in the Indian and Pacific Oceans, known as El Niño Southern Oscillation (ENSO). When this occurs, the prevailing trade winds weaken and the equatorial countercurrent strengthens, causing warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This event has great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world. The opposite of an El Niño event is called La Niña (IPCC, 2001).

[1] For further details on observation studies in the region, see Magrin and others (2007) and national communications submitted by the countries to the UNFCCC.

Each of the countries of Latin America and the Caribbean has submitted at least its first national communication on greenhouse gas emissions to the UNFCCC.[2] These documents contain studies of the countries' climate vulnerability and possible future impacts. Each country uses its own emissions models and scenarios, making comparison difficult.[3] These analyses differ from regional studies mainly in being more precise; however, the two types of results are not mutually contradictory.

With the support of scientific and academic institutions, some countries in the region have conducted new studies of climate scenarios based on more elaborate models that have allowed them to improve on the accuracy of their original projections. This has been the case with Argentina and Chile, which are planning to include these observations in their second national communications.

Brazil, Mexico and Central America (Belize, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua and Panama) are also analysing climate scenarios to arrive at a more detailed understanding of their vulnerability in this area.

The World Bank used a Japanese computing technology known as the earth simulator, with a resolution of 20 km x 20 km, to conduct a study of climate scenarios in Mexico, Colombia and the Andes region in Peru and Ecuador. The results of this study provided a clearer picture of the vulnerability of these territories. In Mexico, the findings have been used as inputs for other research projects using regional models. In Colombia, the conclusions will be included in the second national communication to the UNFCCC and will underpin adaptation strategies in mountain regions and coastal areas. For the Andean region, the findings provide more specific information about the effects of climate change on glaciers, which will make it possible to identify and formulate the necessary adaptation measures (Vergara, 2007).

More detailed historical information is available, however, about the effects of climate change on the agricultural sector. For example, it is known that increased precipitation in the 1960-2000 period resulted in higher productivity for maize crops in southern Brazil (12%), Uruguay (49%), the Argentinean humid pampas (26%) and the Argentinean dry pampas (41%), as well as higher yields from Uruguayan pastures (7%). Conversely, higher temperatures reduced the productivity of wheat crops in southern Brazil (6%) and the Argentinean humid pampas (3%), but increased it in Uruguay (3%) and the Argentinean dry pampas (24%) (Magrin and others, 2007).

C. Expected physical effects

Figure I.3 illustrates temperature changes in four subregions of Latin America and the Caribbean during the 1906-2005 period and the projections for the current century, following some of the scenarios used by the IPCC.

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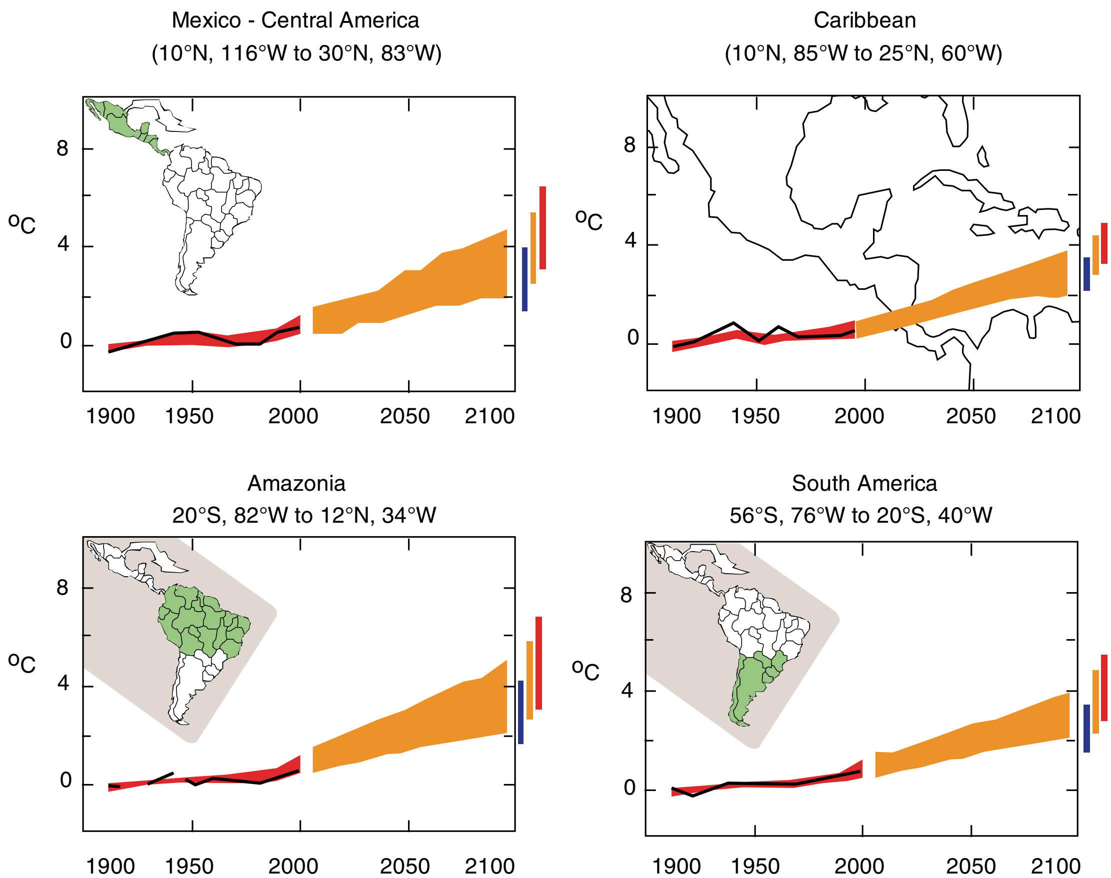
2 As of 13 October 2008, the following countries of the region had presented more than one national communication to the UNFCCC: Argentina (two), Mexico (three) and Uruguay (two).

3 The parties to the UNFCCC agreed to submit national reports on its implementation at the Conferences of the Parties (COPs). In accordance with the principle of "differentiated responsibilities" enshrined in the Convention, the required contents and submission deadlines of these national communications are different for the region, as its countries are not part of Annex I. The main items in any country's national communication are an inventory of greenhouse gas emissions and the measures taken to reduce them. There is also provision for including details about national circumstances, a vulnerability analysis (usually based on climate modelling results), financial resources and technology transfer, as well as climate change education, training and awareness among the public (UNFCCC, 2007b).

FIGURE I.3
TEMPERATURE ANOMALIES IN THE HISTORICAL RECORD FOR 1901-2005 AND PROJECTIONS FOR 2001-2100



Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.
Note: Temperature observations in the 1906-2000 period are represented by the black lines and simulations by the red bands behind them. Simulations based on climate models that include natural and anthropogenic forcing were used to obtain the results for the A1 PAR 2000-2100 scenario, shown by the wider orange bands. The three coloured lines at the ends of the charts represent the spreads for the changes projected from 2091 to 2100 in scenarios B1 (blue), A1B (orange) and A2 (red). The broken black line indicates observations presenting less than 50% of the area shown in the decade concerned.

Tables I.6 and I.7 give the numerical values for the projections in figure I.4. The figures show the expected increases in temperature and precipitation in the Amazonia region, for both the dry and wet seasons. They also show that there will be a considerable variation in rainfall in the Caribbean, ranging from a decline of 14.2% to an increase of 13.7% over the coming 20 years.

TABLE I.6
MESO-AMERICA, AMAZONIA AND SOUTH AMERICA: PROJECTED TEMPERATURE AND PRECIPITATION LEVELS

	Time of year	2020	2050	2080
		Temperature changes (°C)		
Meso-America	Dry season	+0.4 to +1.1	+1.1 to +3.0	+1.0 to +5.0
	Wet season	+0.5 to +1.7	+1.0 to +4.0	+1.3 to +6.6
Amazonia	Dry season	+0.7 to +1.8	+1.0 to +4.0	+1.8 to +7.5
	Wet season	+0.5 to +1.5	+1.0 to +4.0	+1.6 to +6.0
South America	Winter (JJA)	+0.6 to +1.1	+1.0 to +2.9	+1.8 to +4.5
	Summer (DJF)	+0.8 to +1.2	+1.0 to +3.0	+1.8 to +4.5
		Changes in precipitation (percentages)		
Meso-America	Dry season	-7 to +7	-12 to +5	-20 to +8
	Wet season	-10 to +4	-15 to +3	-30 to +5
Amazonia	Dry season	-10 to +4	-20 to +10	-40 to +10
	Wet season	-3 to +6	-5 to +10	-10 to +10
South America	Winter (JJA)	-5 to +3	-12 to +10	-12 to +12
	Summer (DJF)	-3 to +5	-5 to +10	-10 to +10

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.
Note: DJF = December, January and February; JJA = June, July and August.

TABLE I.7
CARIBBEAN: PROJECTED TEMPERATURE AND PRECIPITATION LEVELS RELATIVE TO THE 1961-1990 PERIOD

	2010-2039	2040-2069	2070-2099
		Temperature changes (°C)	
Caribbean	+0.48 to +1.06	+0.79 to +2.45	+0.94 to +4.18
		Changes in precipitation (percentages)	
Caribbean	-14.2 to +13.7	-36.3 to +34.2	-49.3 to +28.9

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.
Note: Results simulated using general circulation models and based on the emission scenarios of the IPCC Special Report (SRES).

The projections for the rise in sea level in the latest IPCC report put this at between 0.18 and 0.58 metres by the end of the century. However, some authors have calculated much higher values, considering that glacier melt in Greenland and Antarctica could be much greater than predicted, as the IPCC itself recognizes, and that this could occur over the coming century.

In the south-eastern area of South America, the average sea level has risen by between 1 and 2-3 mm a year over the past 10 to 20 years. In future, this is expected to have adverse effects on the following: (i) low-lying coastal areas (El Salvador, Guyana and the coast of the province of Buenos Aires), (ii) buildings and tourism (Mexico and Uruguay), (iii) coastal morphology (Peru), (iv) mangrove swamps (Brazil, Ecuador, Colombia and the Bolivarian Republic of Venezuela) and (v) the availability of drinking water on the Pacific coast of Costa Rica and Ecuador and in the River Plate estuary. The sea level rise is also very likely to affect Meso-American coral reefs (Mexico, Belize and Panama) (see table 1.8).

TABLE I.8
FUTURE IMPACTS AND VULNERABILITY TO CLIMATE CHANGE IN LATIN AMERICA: PEOPLE AND COASTAL SYSTEMS

Country/region	Climate scenarios	Effects/costs (people, infrastructure, ecosystems, sectors)
Latin America	HADC 3, SRES B2, B1, A2, A1FI; SLR (Nicholls, 2004)	Assuming uniform population growth, no increase in storm strength and no response to adaptation measures (constant protection), by 2080 the average number of victims of coastal flooding each year will probably range from one to three million in scenarios B and A, respectively. If coastal defences improve because of better adaptation measures, the numbers affected could be one million in the worst scenario (A1F1). If improvements to coastal defences took account of rising sea levels (adaptation took place), there would be no victims (Warren and others, 2006). The population at risk on flood-prone coastal plains will probably rise from 9 million in 1990 to 16 million (B1) or 36 million (A2) in 2080.
Coasts below sea level in Brazil, Colombia, Ecuador, El Salvador, Guyana and Bolivarian Republic of Venezuela	SRES A2, 38-104 cm	Mangrove swamps could disappear in the most exposed and marginal areas while expanding in areas of heavy sedimentation at high tide and in flood-prone river basins. Shrimp production will be affected, with the consequent decline in GDP.
El Salvador	SLR of 13-110 cm	Loss of between 10% and 27.6% of total coastal area (141 to 400.7 km²) (Government of El Salvador, 2000).
Guyana	SLR of 100 cm, projected using GCM	Over 90% of the population and the most important economic activities are situated in coastal areas, which are expected to retreat by as much as 2.5 km (Government of Guyana, 2002).
Meso-American coral reefs and mangrove swamps in the Gulf of Mexico	SST 1°-3°C warmer by 2080 according to SRES scenarios	The rise in sea temperature is expected to affect coral reefs and mangrove swamps, thus imperilling the conservation of numerous endangered species such as the green, hawksbill and loggerhead turtles (mainly carnivorous chelonians), the West Indian manatee and the American and Morelet's species of crocodile (Cahoon and Hensel, 2002).
Costa Rica, coast of Punta Arenas	SLR of 0.3 to 1.0 m	Sea water could penetrate 150 to 500 m inland in urban areas (Government of Costa Rica, 2000).
Ecuador (Guayas river system, associated coastal zone and city of Guayaquil)	Unchanged LANM0, moderate LANM1 and severe changes LANM2, with and without economic development	Losses of US$ 1.3 billion in shrimp cultures, mangroves, urban and recreational areas and drinking water provision and losses of US$ 1.04 billion on banana, rice and sugar cane cultivation. The evacuated and at-risk population would rise to 327,000 and 200,000 people, respectively. It is calculated that 44% of today's 1,214 km² of mangrove swamps will be affected under the LANM2 scenario (Government of Ecuador, 2000).
Peru	Intensification of ENSO events and rise in SST, possible SLR	Marine ecosystems and fisheries will be affected by increased wind stress, hypoxia and deepening of the thermocline, as anchovy spawning areas and fishing grounds are reduced. Flooding of infrastructure, homes and fisheries will cause damage estimated at US$ 168.3 million. Total losses in the eight coastal areas of Peru are put at US$ 1 billion (Government of Peru, 2001).

Table I.8 (concluded)

Country/region	Climate scenarios	Effects/costs (people, infrastructure, ecosystems, sectors)
Colombia	SLR of 1.0 m	Permanent flooding of 4,900 km^2 of low-lying coast, affecting some 1.4 million people; 29% of homes would be highly vulnerable; the agricultural sector would be exposed to the effects of flooding (with the loss of 7.2 million ha of crops and pasture, for example); 44.8% of coastal roads would be highly vulnerable (Government of Colombia, 2001).
Argentina (city of Buenos Aires)	Storm surges and SLR 2070-2080	Very low-lying areas where permanent flooding is likely are thinly populated at present. The main vulnerability is the possibility of exposure to extreme surges. Rapid erosion, with the resultant retreat of coastlines, will depend on the geological characteristics of the area. Existing measures to adapt to current storm surge conditions mean that the social impact of future permanent flooding is expected to be fairly modest.
Coastal areas of Argentina and Uruguay (west of Montevideo), provinces of Buenos Aires and Río Negro	SLR, climate variability, ENSO, storm surges (*sudestadas* or "south-easterlies")	In addition to coastal subsidence, there are factors such as *sudestadas* (very strong south-easterly winds along the shores of the River Plate) and freshwater flow (often associated with El Niño) that could accelerate the rise in the sea level. This could cause a range of environmental and social effects along the coasts of Argentina and Uruguay over the coming decades, such as coastal erosion and flooding. The lowest-lying areas (wetlands and sandy beaches with a wealth of biodiversity) will be highly vulnerable to the rise in sea level and storm surges. Loss of land would have a major effect on the tourism industry, which accounts for 3.8% of GDP in Uruguay.

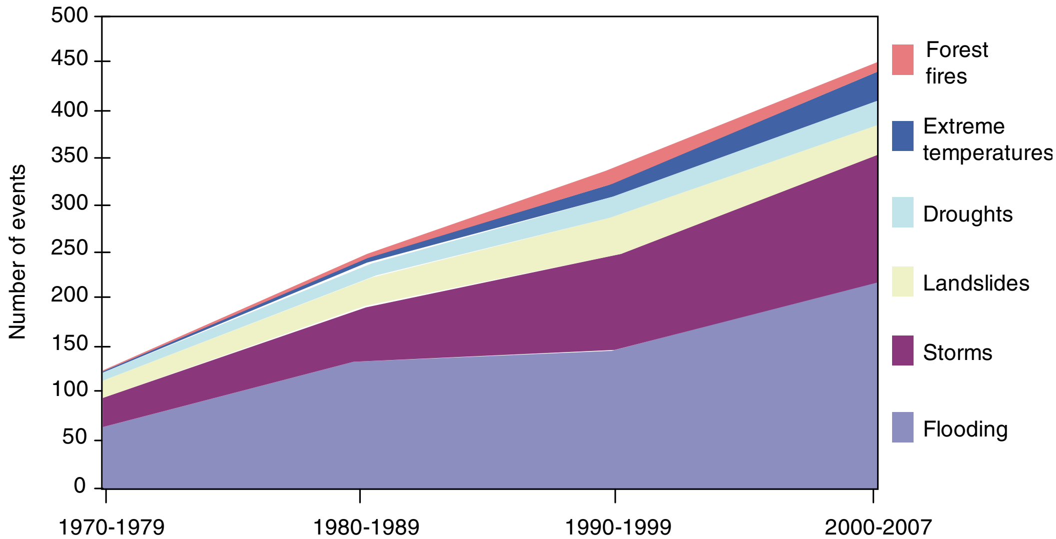
Source: G. Magrin and C.O. Canziani, *Evaluación de la vulnerabilidad e impactos del cambio climático y potencial de la vulnerabilidad en América Latina y el Caribe*, Lima, 2007.
Note: SLR = sea level rise; ENSO = El Niño-Southern Oscillation; SRES = IPCC Special Report on Emission Scenarios; GCM = general circulation model; SST = sea surface temperature.

D. Vulnerability to climate change

Because of their geographical and topographical characteristics, Latin America and the Caribbean are highly vulnerable to climate change.[4] The increase in extreme weather events has led to a 2.4-fold increase in flooding, droughts and landslides over recent years (see figure I.4) relative to the 1970-1999 and 2000-2005 periods (IPCC, 2007a). Many of them have been due to ENSO, which may in turn be influenced by global changes.

[4] Vulnerability is the "capacity to manage [climate] hazards without suffering a long-term, potentially irreversible loss of wellbeing". Associated with a high level of risk ("exposure to external hazards over which people have limited control"), it reveals the degree of development of a particular area or region, i.e., the immediate ability of the poor to cope with disasters caused by climate changes (UNDP, 2007).

FIGURE I.4
LATIN AMERICA AND THE CARIBBEAN: FREQUENCY OF HYDROMETEOROLOGICAL EVENTS, 1970-2007



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of the Emergency Events Database (EM-DAT) [online database] http://www.em-dat.net.

Apart from the great loss of human life, when an extreme weather event occurs a substantial amount of public resources are consumed in repair work. By way of example, an economic assessment of 19% of the events of this type that occurred in Latin America and the Caribbean from 2000 to 2005 showed that they generated losses totalling US$ 20 billion (Nagy and others, 2006). In the period from 1970 to mid-2008, economic losses from hydrometeorological events totalled some US$ 80 billion (see table I.9).

TABLE I.9
LATIN AMERICA AND THE CARIBBEAN: CUMULATIVE LOSSES FROM HYDROMETEOROLOGICAL EVENTS, 1970-2008

Type of event	Losses (millions of dollars)
Storm	42 374
Flooding	26 358
Drought	8 698
Landslide	2 006
Extreme temperatures	1 179
Forest fire	817
Total	81 435

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of the Emergency Events Database (EM-DAT) [online database] http://www.em-dat.net.
Note: Figures calculated on the basis of economic losses caused by hydrometeorological events in Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Plurinational State of Bolivia, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and Uruguay.

The Latin America and Caribbean region is an important carbon sink, being estimated to hold between 18% and 26% of all the carbon contained in the world's forest ecosystems, with figures of 11% for pastureland and 17% for agricultural ecosystems. Inappropriate management of these natural resources over time, however, has led to continual degradation.

The area of forest in the region declined in 1990-2000, mainly owing to the use of forested land for other purposes (expansion of agricultural, livestock and urban areas, building of roads and infrastructure, mining and, to a lesser extent but with a great impact on certain areas, logging for fuel and industry and intensive exploitation of certain species). Deforestation has had major indirect effects such as a reduction in the volume and quality of water resources, increased soil erosion and a loss of biological diversity and certain services such as carbon retention in biomass. Forest fires, many of them anthropogenic in origin, are another major cause of forest loss.

The region also presents areas of great water stress, owing to the concentration of human settlements in areas where water is not plentiful, the expansion of agriculture, population growth, urbanization, industrial growth and the decreased availability of underground water as catchment areas lose absorption capacity because of deforestation or the creation of urban infrastructure.

Ecosystems in coastal and marine areas are being subjected to growing pressures from contamination and degradation. Rapid extinction of animal species and plant varieties is another environmental problem in Latin America and the Caribbean, leading in turn to the loss of genetic diversity.

Besides these characteristics of environmental vulnerability, it is important to take account of the most recent socio-economic analyses, which show that a large percentage of people are living in extreme poverty (ECLAC, 2008b) and environmental stewardship is generally weak (UNEP, 2007).

E. Summary

- The scientific work done by the IPCC has allowed the international community to recognize that climate change is a problem of anthropogenic origin.
- The sea level will take time to rise in response to continental ice melt and thermal expansion, with the full effects coming through after 2100.
- According to the historical information available on alterations in natural systems, the effects of climate change in Latin America and the Caribbean have been substantial. Projections indicate that changes will be modest up to 2020 but will increase after 2050, and could be substantial even with a rise of just 1.5° to 2°C from the current temperature.
- The most substantial increase in temperature and precipitation is expected to take place in the Amazon region, in both the wet and dry seasons. In the Caribbean, a marked variation in rainfall is expected, with the range going from a decline of 14.2% to an increase of 13.7% over the next 20 years.
- The situation described is a matter for concern, as the region has limited experience with the management of natural resources and territory and also suffers from institutional shortcomings, which will make the effects of climate change even harder to deal with.
- Although there are some uncertainties attached to the information now available, existing studies are enough to justify certain measures to limit the future effects of climate change.

II. The sectoral effects of climate change

One important task that still lies ahead for most countries is to increase their knowledge of the economic effects of climate change on the individual sectors. For this reason, the present chapter is based mainly on secondary information from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, particularly the chapter on Latin America (Magrin and others, 2007), small islands (Mimura and others, 2007), food, fibre and forest products (Easterling and others, 2007) and industry, settlement and society (Wilbanke and others, 2007). Following a review of this and our own information, we present a summary of the main economic effects expected from climate change in Latin America and the Caribbean. As will be seen in the sectoral analyses, water stress is one cross-cutting factor.

A. The primary sector

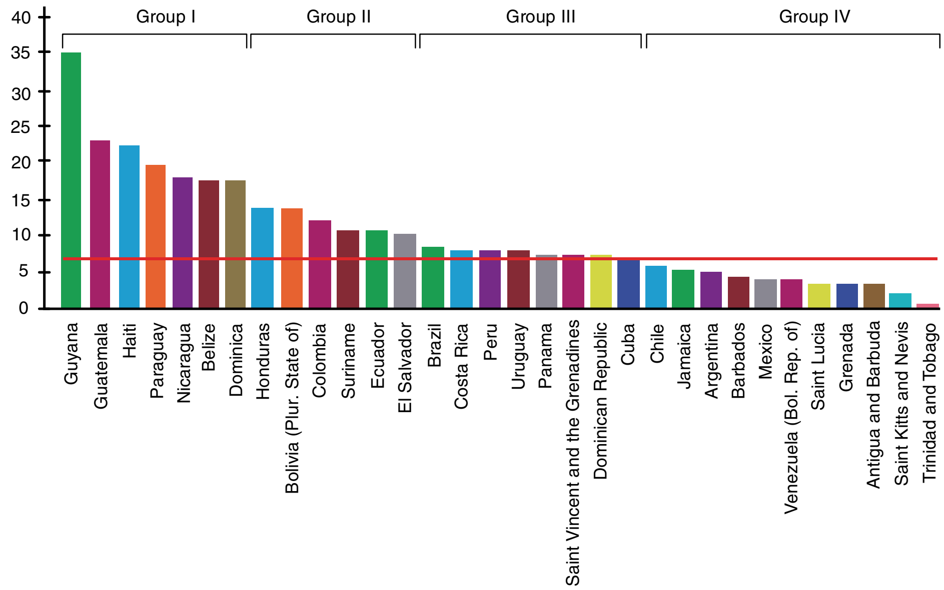
To determine what climate-driven shocks might affect the primary sector, we first need to examine its importance in the economy.

Since 2005, the contribution of agriculture to the region's economy as a whole has stabilized at around 6.3%, measured by agricultural value added as a share of GDP. However, there are large disparities between countries, with the share ranging from less than 1% in Trinidad and Tobago to almost 35% in Guyana.

As figure II.1 shows, the region's countries can be grouped into four categories by the size of their farm sectors. Agriculture's share of GDP ranges between 34.1% and 17.2% in the first group, 13.6% and 9.4% in the second, 13.5% and 6.9% in the third, and 6.4% and 0.7% in the fourth.

The farm sector contributes more to total exports than to GDP, with a share of over 20% in almost all the countries, the exceptions being exporters of oil (Mexico, the Bolivarian Republic of Venezuela and Trinidad and Tobago) and minerals (Chile and Peru) plus some small island States in the Caribbean. The farm sector is thus an important source of foreign currency.

FIGURE II.1
LATIN AMERICA AND THE CARIBBEAN (32 COUNTRIES): CONTRIBUTION OF AGRICULTURE TO GROWTH, 2005
(Agricultural value added as a share of GDP, percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), "Indicadores para el seguimiento de la agricultura y la vida rural, Plan Agro 2000-2015 (actualización 2007)", *Project documents*, No. 157 (LC/W.157), Santiago, Chile, 2007.

Agriculture has been very dynamic in recent years. Agricultural value added has grown faster than GDP in the region (3.2% as against 3% in the 2000-2005 period), mainly owing to the strong expansion of certain activities oriented towards external markets and higher-income segments of domestic markets. Examples are beef, soybean, sugar cane for human consumption (and, increasingly, biofuels) and, to a lesser extent, temperate and tropical fruits.

Agriculture plays a prominent role in most of the Latin American and Caribbean countries because of its contribution to GDP, employment, exports and economic dynamism generally. The farm sector also continues to play a vital role in producing food for domestic consumption and in the food security of the population, particularly in lower-income countries. These factors, and the dependency of farming activities on the weather, make this sector one of the most sensitive to climate change.

1. General effects

The main studies dealing with the effects of climate change on agriculture,[1] whether they involve historical observations (see chapter I, section B) or scenario modelling, all indicate that these effects will be asymmetrical and negative in most of the countries.

It is certain that rising average temperatures will enhance yields in cold environments (temperate regions, for example) and reduce them in hot ones (tropical regions).

[1] Climate change could affect the associated variables that are important to this economic sector (such as temperature, precipitation, solar radiation and carbon dioxide concentrations) in such a way that it is difficult to establish its net effects on crop yields. Again, in agriculture it is difficult to isolate the influence of climate from that of other factors such as management practices, technological change, the dynamic of prices and the market and public policies affecting it (subsidies, for instance). This is why the IPCC reports recognize the need for further study of the effects of climate change on certain sectors such as agriculture and forestry to demonstrate relationships of cause and effect.

According to the observations on Latin America and the Caribbean compiled in the Fourth Assessment Report of the IPCC, yields on some crops, particularly soybean and wheat and, to a lesser extent, maize, are expected to rise in temperate areas such as south-eastern South America. Increased heat stress and dryer soils are expected to reduce productivity in tropical and subtropical regions where crops are currently close to the heat tolerance limit to a third of current levels. It is also possible that salinization and desertification of agricultural land may increase in dry areas (central and northern Chile, Peruvian coast, north-eastern Brazil).

BOX II.1
SOME MAJOR IMPACTS OF CLIMATE CHANGE ON AGRICULTURE, FORESTRY AND ECOSYSTEMS, BY ORIGIN AND LIKELIHOOD OF OCCURRENCE

Resulting from the following climate changes	It can be said to be…	That the following effects will arise
Warmer and fewer cold days and nights and more frequent hot days and nights in most regions of the world	Practically certain	Increased yields in colder environments, decreased yields in warmer ones and increased insect outbreaks
More frequent warm spells/heatwaves in most regions of the world	Very likely	Reduced yields in warmer regions owing to heat stress, increased danger of wildfires
Frequency of heavy precipitation increases in most regions of the world	Very likely	Crop damage, soil erosion, inability to cultivate land due to waterlogging of soil
Area affected by drought increases	Likely	Land degradation, lower yields, crop damage and failure, increased livestock deaths and increased risk of wildfire
Intense tropical cyclone activity increases	Likely	Crop damage, windthrow of trees and damage to coral reefs
Increased incidence of extreme high sea level (excluding tsunamis)	Likely	Salinization of irrigation water, estuaries and freshwater systems

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers*, M.L. Parry and others (eds.), Cambridge University Press, 2007.

Although cereals are the staple food of much of the world’s population, little research has been done on the subject. We shall now present the main conclusions from some of the studies that have dealt with climate change and the agricultural sector in the region.

According to a study on maize production in a changing climate regime (Jones and Thornton, 2003), maize productivity among small producers in Latin America and the Caribbean could drop by an average of 10% by 2055. In Mexico, where maize is the staple food for rural families, the land area suited to this crop is expected to diminish, while yields in some areas such as Puebla, Veracruz and Jalisco are expected to decline substantially (Conde and others, 2004; Government of Mexico, 2006).

As regards rice, the information on Latin America compiled by the IPCC (Magrin and others, 2007) indicates that productivity will decline across the board, falling by between 3% and 16% in Guyana, about 31% in Costa Rica, 16% to 27% in Guatemala and between 2% and 15% in the Plurinational State of Bolivia.

Coffee is a striking case. It is calculated that by the turn of the century the land area suited to its cultivation in the state of São Paulo (Brazil) will have diminished by anywhere between 10% (if temperatures increase by 1°C and precipitation by 15%) and 97% (with increases of 5.8°C and 15%, respectively) (Pinto and others, 2002). In the Mexican state of Veracruz, coffee production will have declined by between 73% and 78% by mid-century (Gay and others, 2004). In the central zone of Costa Rica, conversely, the change in yields from this crop could range from a fall of 12.9% (if precipitation declines by 20%) to a rise of 30% (if minimum and maximum temperatures increase by up to 2°C and precipitation by 20%) (Government of Costa Rica, 2000).

2. The positive impact of carbon dioxide fertilization

A prominent theme in studies of climate change and agriculture is the effect of fertilization by high atmospheric concentrations of CO_2, which can mitigate the adverse repercussions of climate change on crop yields.

A global study (Parry and others, 2004) analysing this effect in different climate change scenarios for wheat, rice, maize and soybean in Latin America establishes a comparison between 1990 and the years 2020, 2050 and 2080 and highlights the positive consequences of CO_2 fertilization and their differing scale depending on the type of crop.

According to the results for three variants of the A2 scenario in the IPCC Special Report on Emissions Scenarios (see box I.3), by 2050 the productivity of these crops will have increased by between 2.5% and 10% in Argentina, fallen by the same amount in Central America and Mexico and declined by between 0% and 5% in the other South American countries.

Leaving aside the impact of CO_2 fertilization, yields would fall in all the countries owing to reduced precipitation and higher temperatures. The decline would be in the range of 10% to 30% in Mexico and Central America, 2.5% to 5% in Argentina and 5% to 10% in the other countries of South America. These trends are expected to intensify towards 2080, with productivity falling 10% to 30% in all the countries by then.

Another study illustrating the effects of CO_2 fertilization on soybean and maize crops in the Argentinean, Uruguayan and Brazilian pampas (see table II.1) concluded that this would favour soybean in particular (Giménez, 2006). Yields on this crop would increase substantially, with or without irrigation, by comparison with the non-fertilization scenario. In the case of maize, productivity changes resulting from CO_2 fertilization depend on irrigation, the effects being positive for unirrigated crops and negative for irrigated ones.

TABLE II.1
SOUTH-EASTERN SOUTH AMERICA: CHANGE IN AVERAGE YIELDS OF MAIZE AND SOYBEAN IN THE A2 SCENARIO OF THE SRES, WITH AND WITHOUT THE CO_2 FERTILIZATION EFFECT
(Percentages)

	2020		2050		2080	
	Without CO_2	With CO_2	Without CO_2	With CO_2	Without CO_2	With CO_2
Rainfed maize	-1.7	7.7	-0.7	10.8	-3.6	16.1
Irrigated maize	-4.3	-0.9	-11.4	-6.8	-17.6	-9.1
Rainfed soybean	-1.2	23.7	-3.2	41.7	-10.9	48.4
Irrigated soybean	-0.3	17.7	-0.5	31.7	-4.6	35.6

Source: A. Giménez, “Climate change and variability in the mixed crop/livestock production systems of the Argentinean, Brazilian and Uruguayan Pampas”, *A Final Report Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. LA 27*, Washington, D.C., System for Analysis, Research and Training (START), 2006.
Note: SRES = IPCC Special Report on Emissions Scenarios.

Few studies have been done on the region’s crops, however, and there is still uncertainty about the possible benefits of CO_2 fertilization. This is because there are many interactions that have yet to be documented (with nutrients, water, weeds, pests and other stress factors, for example) and thus cannot be incorporated into today’s models, so that further research is clearly needed (Parry and others, 2004, p. 66).

TABLE II.2
LATIN AMERICA AND THE CARIBBEAN: SUMMARY OF STUDIES ON THE IMPACT OF CLIMATE CHANGE IN THE AGRICULTURAL SECTOR, 2007

Study	Climate scenario	Yield impacts (percentages)				
		Wheat	Maize	Soybean	Rice	Other
			Meso-America			
Costa Rica	+2°C -15% precip. ($1XCO_2$)				-31	Pt: ↓
Guatemala	+1.5°C -5% precip +2°C +6% precip. +3.5°C -30% precip.		+8 to -11 +15 to -11 +13 to -34		-16 -20 -27	Ba: +3 to -28 Ba: +8 to -42 Ba: 0 to -68
Honduras	Hadley CM3-A2 (500 ppm) 2070 Hadley CM3-A2 (500 ppm) 2070			-21 0		
Panama	HadCM2-UKHI (IS92c-IS92f) 2010/2050/2100 ($1xCO_2$)		+9/-34/-21			
			South America			
Argentina, pampas	+1/+2/+3°C (550 ppm CO_2), I UKMO (+5.6°C) (550 ppmCO_2), I	+11/+3/-4 -16	0/-5/-9 -17	+40/+42/+39 +14		
Argentina, central	Hadley CM3-B2 (477 ppm) ECHAM96-A2 (550ppm) +1.5/+3.5°C ($1XCO_2$) +1.5/+3.5°C ($1XCO_2$) (2T)[c]			+21 +27 -13/-17 -19/-35		
Bolivia (Plurinational State of)	GISS and UK69 ($2XCO_2$) Incremental ($2XCO_2$) +3.5°C -20% precip. Optim.-pesim.($1XCO_2$) Optim.- pesim.($2XCO_2$) IS92a ($1XCO_2$)[a] IS92a ($2XCO_2$)[a]		-25 +50	-3 to -20 +12 to +59	-2 -15	Pt: +5 to +2[b] Pt: +7 to +5[b]
Brazil	GISS (550 ppm CO_2) GDLF UKMO	-33 -18 -34	-11 -11 -16	+26 +23 +18		
Guyana	CGCM1 2020-2040 ($2XCO_2$) CGCM1 2080-2100 ($3XCO_2$)				-3 -16	Sg: -30 Sg: -38

Table II.2 (concluded)

Study	Climate scenario	Yield impacts (percentages)				
		Wheat	Maize	Soybean	Rice	Other
Regional effects						
South-eastern South America	Hadley CM3-A2 (500 ppm) Hadley CM3-A2 (500 ppm), I	+9 to +13 +10 to +14	-5 to +8 0 to +2	+31 to +45 +24 to +30		
Latin America	HadCM2 (smallholders)			-10		
Latin America	HadCM3 A1F1 ($1XCO_2$) HadCM3 B1 ($1XCO_2$) HadCM3 A1F1 ($2XCO_2$) HadCM3 B1 ($2XCO_2$)	Cereal yields: -5 to -2.5 (2020) -30 to -5 (2050) -30 (2080) -10 to -2.5 (2020) -10 to -2.5 (2050) -30 to -10 (2080) -5 to -2.5 (2020) -10 to -10 (2050) -30 to +5 (2080) -5 to -2.5 (2020) -5 to -2.5 (2050) -10 to -2.5 (2080)				
Coffee						
Mexico, Veracruz	HadCM2 ECHAM4 (2050)	73% to 78% reduction in output				
Brazil, São Paulo	+1°C +15% precip. +5.8°C +1.5% precip.	10% reduction in suitable lands for coffee				
Costa Rica	Sensitivity analysis	Increases (up to 2ºC) in temperature would benefit crop yields				

Reduced productivity	Increased productivity	Productivity variations

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of G. Magrin and others, "Latin America", *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

Note: I = irrigated cereals; precip. = precipitation; Bn = bean; Pt = potato; Ba = banana; Sg = sugar cane.

[a] Values correspond to soybean sowing in winter and summer for 2010 and 2020.

[b] Increase every 10 years.

[c] 2T = doubled variance of temperature.

3. Increase in pests and diseases

One effect of climate changes is to increase the likelihood of infestations and diseases. Some studies (Ghini and others, 2008) have concluded that after 2050, by comparison with the 1961-1990 period, Brazil is likely to experience a substantial rise in infestations of coffee plantations by the coffee borer beetle. This increase would be greater under scenario A2 of the SRES than under B2 (see box I.2 in chapter I). In the case of wheat, studies point to a greater incidence in South America (Argentina, Brazil and Uruguay) of fusarium ear blight, one of the most dangerous of the diseases affecting this cereal. The risk of infection is associated with a larger number of rainy days in the autumn period.

4. Variations in water resources

It is calculated that 70% to 80% of the water currently extracted worldwide for productive purposes is used in irrigation (UNEP, 2007). In Guyana, Haiti and Uruguay, over 90% of water resources are employed for this purpose. Irrigation has increased in recent years, especially in Saint Lucia and Suriname. In Chile, Costa Rica, Ecuador, Guyana, Mexico and Peru, over 20% of arable land and permanent crops depend on irrigation. This tendency will intensify as a result of climate change, since it will increase the importance of irrigation as an adaptation mechanism.

According to the IPCC evaluation for Latin America (Magrin and others, 2007), demand for irrigation water in warm climates will increase, leading to greater competition for this resource between agricultural, domestic and industrial uses. The possible reduction in aquifer levels will increase the cost of the energy required to extract water for irrigation, while a lower volume of stored surface water could mean significant time lags before the supply of water responds to demand. The issue of intensified competition for water between different sectors because of climate change was addressed in a global study (Rosenzweig and others, 2004) that analysed factors such as rising demand due to population growth and economic development.

This study revealed that occasional problems with the supply of water for agriculture in northern Argentina could worsen, with major investment probably being required to mitigate them. In southern Brazil, conversely, the future availability of water for the farm sector seems to be assured. The study also included some simulations to determine the potential for expanding irrigated areas as an adaptation option. The results indicate that only Brazil could easily cope with an expansion of the irrigated area, while in other regions the reliability of the water system would be impaired.

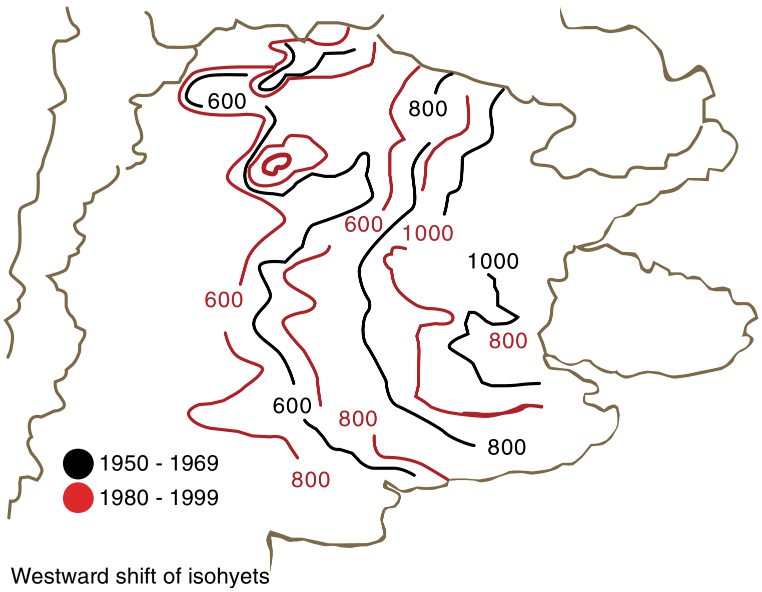
At the national level, little thorough research has been done on water availability for agriculture. Research of this type that has been done includes a study conducted in Chile (CONAMA, 2006) which concluded that, under an SRES A2 scenario (see box I.2 in chapter I), the average temperature in all the country's regions, but particularly the Andean ones, would rise by 2° to 4°, and that the increase would be greatest in summer. The consequence would be a shift of 300 to 500 m in the height of the 0°C isotherm from present levels. In the central area (30° to 40°S), precipitation would decline by some 40% across the board in low-lying areas, increasing towards the Andean foothills in summer. The economic implications of this reduction could be significant, considering that the central region contains the areas of highest agricultural productivity as well as the bulk of export agriculture and hydroelectric generating capacity for the country's electrical grid.

Another national study on the Argentinean pampas (Magrin, Travasso and Rodríguez, 2005) revealed that in the course of the twentieth century average annual precipitation had increased in the spring and summer months, minimum temperatures had risen over most of the year and maximum temperatures and radiation had fallen, particularly during the spring and summer months. The conclusion was that the higher productivity of soybean (38%), maize (18%), wheat (13%) and sunflower (12%) was due primarily to the rise in precipitation in the 1950-1970 and 1970-1999 periods.

Also documented in this region is a westward shift of isohyets[2] because of the increased rainfall (see figure II.2). This has helped agriculture to expand into areas where annual crops had not traditionally been planted. One result of this has been serious soil degradation that will have to be considered as a factor in future, since expected climate changes will probably lead to a new shift in the agricultural frontier (UNEP/SEMARNAT, 2006).

[2] Lines on a map connecting points that have the same amount of precipitation.

FIGURE II.2
ARGENTINEAN PAMPAS: WESTWARD SHIFT OF ISOHYETS



This phenomenon has led to a rise in productivity on the humid pampas and higher hydroelectric energy generation on the seaboard. However, negative effects include more frequent flooding, a reduction in energy and water levels in the Comahue and a substantial variation in the thickness of the Patagonian glaciers.

Source: United Nations Environment Programme (UNEP)/Secretariat of the Environment and Natural Resources (SEMARNAT), *El cambio climático en América Latina y el Caribe*, Mexico City, 2006.

5. Sea level rise and agriculture

There are currently very few studies analysing the possible effects of a rising sea level on the farming sector. Furthermore, their findings are difficult to extrapolate because they refer to specific locations.

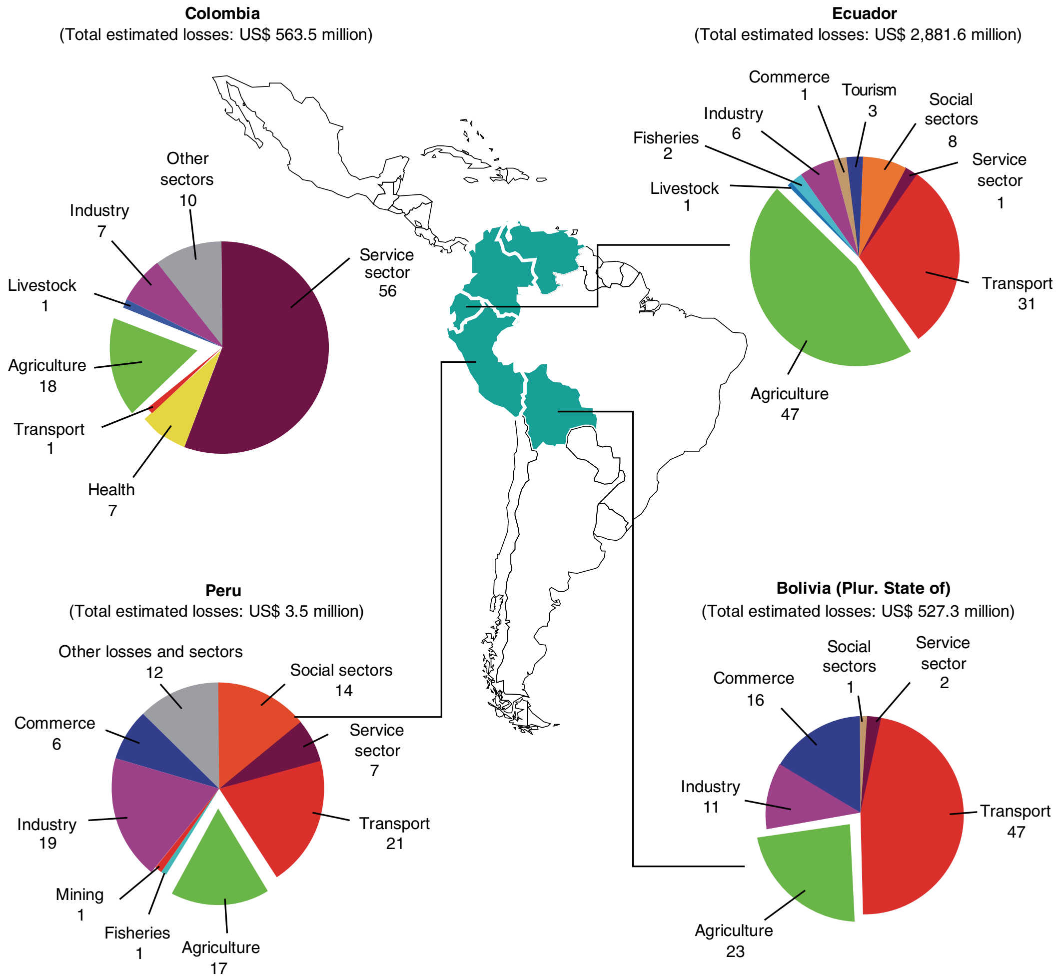
Only a few countries in Latin America and the Caribbean have addressed the issue in their national communications to the United Nations Framework Convention on Climate Change (UNFCCC), two of them being El Salvador and Colombia. The former reported that 10% to 27.6% of productive agricultural land in coastal areas could be lost with a sea level rise of between 13 and 110 cm (Government of El Salvador, 2000). In the case of Colombia, it is the agricultural area along the Caribbean coast that would be most damaged by the rise in sea level. Under a scenario of a 1 m rise, it is predicted that 39.2% of banana plantations, 6.8% of temporary crops, 1.2% of permanently sown fields and 9.7% of African palm plantations would be lost (Government of Colombia, 2001). The figures reveal how important it is for the subject to be studied in the other countries of the region.

6. Agriculture and extreme weather events

Historically, agriculture has been able to adapt to gradual climate changes, but extreme weather events pose a great threat to the sector. During the last quarter century, for example, the region has experienced two very severe El Niño Southern Oscillation (ENSO) episodes (1982-1983 and 1997-1998) plus other major phenomena such as hurricane Mitch, which inflicted great losses on the agricultural sector and increased its vulnerability to natural disasters (Magrin, 2007).

In the case of the 1997-1998 El Niño (see figure II.3), losses in the agricultural sector totalled about 20% in the Andean region: 17% in Peru, 19% in Colombia, 23% in the Plurinational State of Bolivia and almost 50% in Ecuador.

FIGURE II.3
COUNTRIES IN THE ANDEAN REGION: SECTORAL DISTRIBUTION OF EL NIÑO LOSSES, 1997-1998
(Percentages)

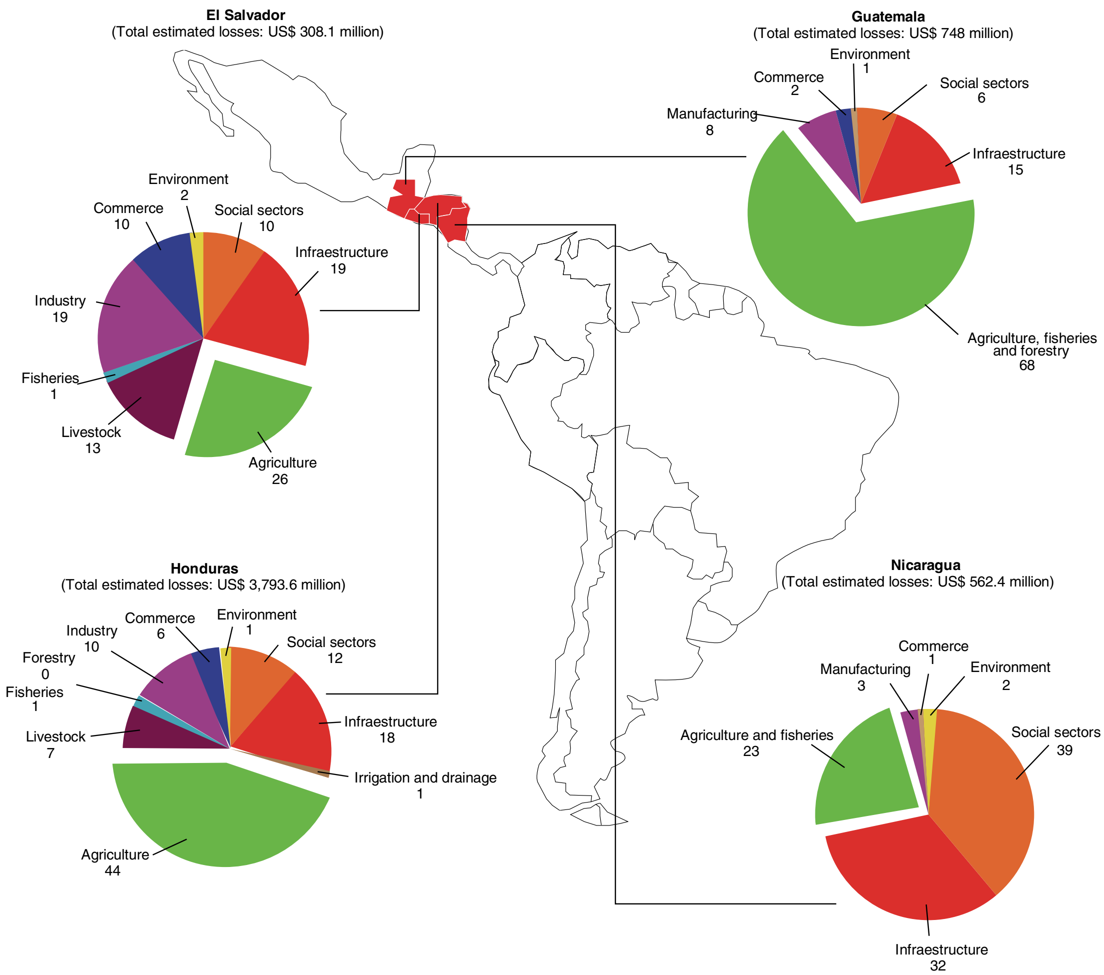


Source: Economic Commission for Latin America and the Caribbean (ECLAC), "Indicadores para el seguimiento de la agricultura y la vida rural, Plan Agro 2000-2015 (actualización 2007)", *Project documents*, No. 157 (LC/W.157), Santiago, Chile, 2007.

Figure II.4 illustrates the distribution of losses caused by Hurricane Mitch (1998) in Central America. The effects on agriculture were much larger in this case, owing to its great importance in the economy. In Guatemala and Honduras, two of the countries worst affected, losses in the agriculture, fisheries and forestry sector accounted for over half the total: 68% in the former and 52% in the latter.

This vulnerability is heightened by the very low level of insurance coverage in Latin America.

FIGURE II.4
CENTRAL AMERICA: SECTORAL DISTRIBUTION OF LOSSES CAUSED BY HURRICANE MITCH, 1998
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), "Indicadores para el seguimiento de la agricultura y la vida rural, Plan Agro 2000-2015 (actualización 2007)", *Project document*, No. 157 (LC/W.157), Santiago, Chile, 2007.

7. Food availability and security

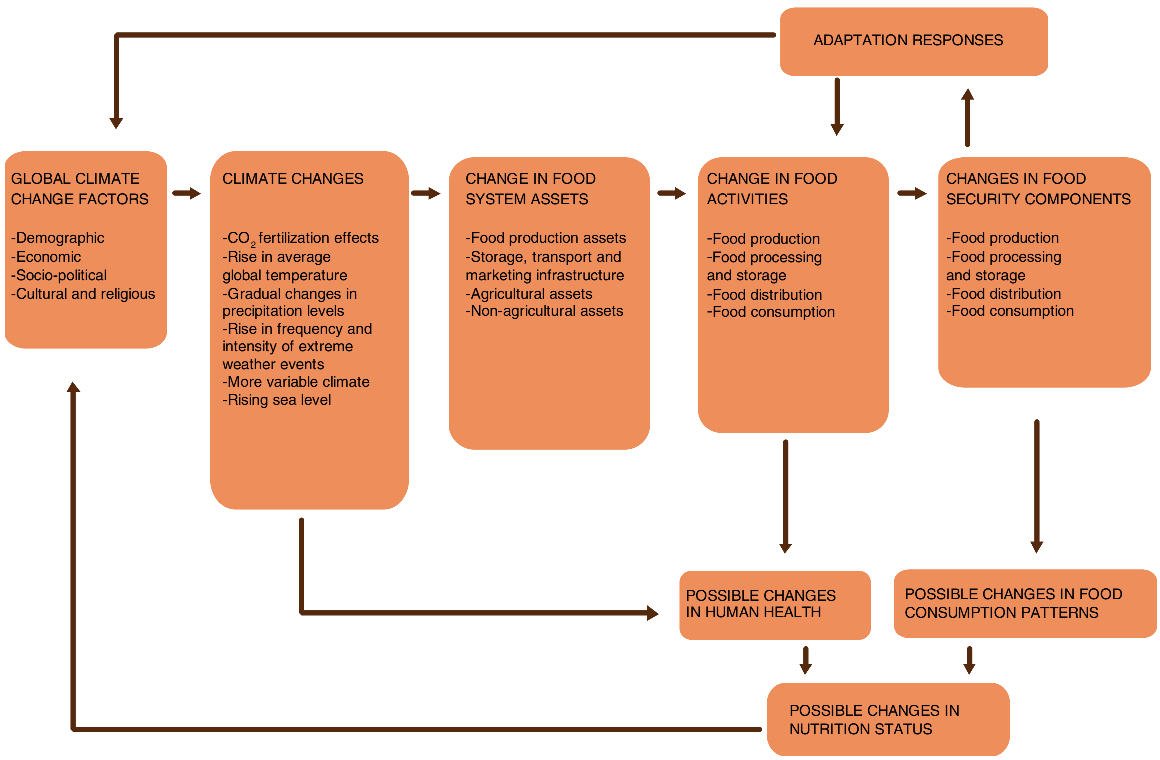
The projected decline in the productivity of livestock activities and certain important crops would have adverse consequences for food security. As Bosello and Zhang (2005) point out, on the basis of estimates for 2050, climate change pressures will probably lead to a reduction in the world supply of food, mainly owing to the effects of economic adaptation to new global productivity conditions. There are also likely to be major distributive consequences, as the most significant adverse repercussions will be concentrated in developing countries in the tropics. For its part, the IPCC (2007a) calculates, with medium confidence, that a 1° to 3°C rise in temperature would lead to an increase in the world's food production potential; a decline is forecast if this level is exceeded, however.

According to a study of global fluctuations in agricultural commodity prices (Brown and Funk, 2008), 30% of farmers in developing countries will have to cope with food insecurity and could be seriously affected. In Latin America and the Caribbean this situation is likely to occur right across countries such as the Plurinational State of Bolivia, Haiti, Honduras and Nicaragua.

There are analyses (Parry and others, 2004) predicting that the population at risk of hunger worldwide could increase to about 200 million by 2050 and almost 600 million by 2080, under scenario A2 of the SRES (see box I.3), leaving aside the effects of CO_2 fertilization. This would include about 26 million and 85 million people in the region in 2050 and 2080, respectively (Warren and others, 2006).

Some studies highlight the importance of the institutional context as one of the factors helping to mitigate or aggravate the effects of climate change (see diagram II.1). According to studies based on this approach, the dependency of developing countries on food imports and the socio-economic background against which climate shifts occur are more important to food security than biophysical changes, meaning that policies will play a crucial role in dealing with poverty (Schmidhuber and Tubiello, 2007).

DIAGRAM II.1
CLIMATE CHANGE AND FOOD SECURITY



Source: Food and Agriculture Organization of the United Nations (FAO), "Building adaptive capacity to climate change. Policies to sustain livelihoods and fisheries. New directions in fisheries", *A Series of Policy Briefs on Development Issues*, No. 08, Rome, 2007.

Another important study to have taken this comprehensive approach (Lobell and others, 2008) identifies the 12 regions of the world with the greatest food security problems, considering similarities in diet, agricultural production systems and the proportions of the population suffering from malnutrition, on the basis of estimates from the Food and Agriculture Organization of the United Nations (FAO). Three of these regions are in Latin America and the Caribbean and their most sensitive crops are listed as: (i) Central America and the Caribbean: sugar cane, cassava, maize, rice and wheat; (ii) Andean region: palm, soybean, sugar cane, cassava, potato, maize, barley, rice and wheat; and (iii) Brazil: soybean, sugar cane, cassava, maize, rice and wheat.

According to 95% of projections, sugar cane productivity will increase by 5% to 25% in Central America and the Caribbean and fluctuate by ±5% in Brazil and the Andean region. Where maize and cassava are concerned, the forecasts are for a decline in Brazil (also in 95% of projections), a variation of -2% to +10% in Central America and an oscillation of ±5% in the Andean region. Potato yields are expected to decline by up to 5% in the Andean region, where this crop is a very important staple in the diet of the poorest (Lobell and others, 2008).

B. Forestry

Exports from the region's forestry sector have been very dynamic since the late 1990s. FAO estimates put them at US$ 4 billion in 2004, all from South America, the only subregion that is a net exporter (Chile, Guyana and Brazil). The Caribbean and Central America are net importers of forestry products (FAO, 2007a). Table II.3 shows the situation by country. No data are available to determine whether exports are from native forests or forestry plantations.

TABLE II.3
LATIN AMERICA AND THE CARIBBEAN: IMPORTS AND EXPORTS OF FORESTRY PRODUCTS AS A SHARE OF GDP
(Percentages)

Country	Imports of forestry products					Exports of forestry products				
	1979-1981	1989-1991	1999-2001	2003	2004	1979-1981	1989-1991	1999-2001	2002	2004
Argentina	0.17	0.05	0.25	0.13	0.21	0.01	0.08	0.09	0.12	0.20
Bahamas	0.25	0.72	0.62	0.42	0.65	0.00	0.00	0.00	0.01	0.10
Barbados	1.09	0.94	1.30	1.04	0.97	0.00	0.00	0.00	0.01	0.02
Belize	0.73	0.72	0.89	0.48	0.49	0.60	0.44	0.52	0.40	0.31
Bolivia (Plurinational State of)	0.20	0.07	0.48	0.39	0.38	0.29	0.69	0.30	0.32	0.31
Brazil	**0.07**	**0.06**	**0.14**	**0.11**	**0.14**	**0.21**	**0.33**	**0.46**	**0.56**	**0.72**
Chile	**0.16**	**0.18**	**0.28**	**0.34**	**0.46**	**1.41**	**1.93**	**2.15**	**2.15**	**2.70**
Colombia	0.28	0.30	0.41	0.46	0.49	0.03	0.03	0.11	0.16	0.19
Costa Rica	0.87	0.85	1.53	1.39	1.58	0.23	0.17	0.13	0.14	0.17
Cuba	0.69	0.62	0.16	0.19	0.21	0.00	0.01	0.00	0.00	0.00
Dominica	0.86	2.57	3.16	1.58	1.59	0.00	0.00	0.19	0.15	0.31
Ecuador	0.84	1.05	1.13	1.52	1.05	0.20	0.18	0.37	0.54	0.44
El Salvador	0.38	0.35	1.07	1.15	1.14	0.02	0.03	0.09	0.09	0.10
Guatemala	0.58	0.50	0.78	0.96	1.03	0.18	0.12	0.11	0.15	0.17
Guyana	**0.94**	**0.30**	**0.36**	**0.52**	**0.51**	**0.99**	**0.65**	**4.55**	**4.02**	**3.95**
Haiti	0.12	0.24	0.30	0.42	0.30	0.00	0.00	0.00	0.00	0.00
Honduras	0.86	1.20	1.08	1.55	1.36	1.11	0.53	0.77	0.70	0.27
Jamaica	1.01	1.03	1.14	0.89	0.82	0.03	0.01	0.00	0.00	0.00
Mexico	0.15	0.18	0.40	0.46	0.53	0.00	0.04	0.04	0.04	0.05
Nicaragua	0.35	0.26	0.51	0.68	0.69	0.15	0.07	0.42	0.39	0.35
Panama	0.53	0.98	0.57	0.53	0.63	0.01	0.06	0.06	0.10	0.17

Table II.3 (concluded)

Country	Imports of forestry products					Exports of forestry products				
	1979-1981	1989-1991	1999-2001	2003	2004	1979-1981	1989-1991	1999-2001	2002	2004
Paraguay	0.20	0.31	0.46	0.59	0.79	1.16	0.50	0.56	0.48	0.42
Peru	0.10	0.32	0.31	0.40	0.45	0.02	0.01	0.15	0.16	0.18
Dominican Republic	0.77	0.66	1.01	0.91	0.90	0.00	0.00	0.00	0.00	0.01
Saint Kitts and Nevis	0.00	0.01	0.55	0.53	0.51	0.00	0.00	0.01	0.01	0.01
Saint Lucia	0.00	0.04	1.74	1.73	1.67	0.05	0.00	0.00	0.00	0.00
Saint Vincent and the Grenadines	0.23	0.69	5.57	5.27	1.49	0.00	0.00	0.00	0.00	0.02
Suriname	1.20	0.36	0.24	0.49	0.49	1.27	0.15	0.38	0.29	0.26
Trinidad and Tobago	1.16	0.87	1.10	1.20	1.26	0.03	0.01	0.04	0.01	0.02
Uruguay	**0.21**	**0.19**	**0.47**	**0.36**	**0.32**	**0.06**	**0.09**	**0.41**	**0.74**	**0.66**
Venezuela (Bolivarian Republic of)	0.28	0.25	0.28	0.21	0.33	0.00	0.00	0.04	0.05	0.07
World	**0.30**	**0.41**	**0.44**	**0.46**	**0.52**	**0.30**	**0.41**	**0.44**	**0.46**	**0.52**

Source: Food and Agriculture Organization of the United Nations (FAO), *FAO Statistical Yearbook, 2005-2006*, vol. 1, Rome, 2006.

Forestry is less important economically than agriculture, suggesting that the effects of climate change will be less severe, but there are no estimates available for the economic repercussions of certain systemic changes such as the "savannahization" of the Amazon, to mention one likely scenario. The consequences of having less forest so that deforested areas can be farmed or livestock reared there are not well understood either, although there are expected to be adverse effects in regions where forests are a significant component of local populations' survival strategies. Latin America has undergone a process of rapid deforestation (see table II.4), with rates more than double the global average (FAO, 2007a).[3] It is not clear that climate change leads to more rapid loss of forests, as it could affect agriculture more. If deforestation can be adequately offset and the environment preserved through carbon markets, then climate change and the complex environmental and social interactions that go with it could be favourable to forests.

In fact, the IPCC Fourth Assessment Report (Easterling and others, 2007) concluded, with medium confidence, that climate change could lead to a global increase in wood production as a result of changes in the distribution of woodland and higher growth rates due to CO_2 fertilization. However, it is possible that this increase may result in an expanded supply of wood, with all the consequences this would have for prices. Even greater uncertainty surrounds regional trends.

[3] About 68.7 million hectares of woodland were lost in 1990-2005, equivalent to 4.6 million a year. Of this total, 59 million hectares were in South America and 42.3 million in Brazil (62% of the total). Central America is the subregion most affected, with its forest cover diminishing by 23.3% in the period, followed by Mexico (7.4%) and South America (7.1%). Only in the Caribbean did the forested area increase (by 10.4%).

TABLE II.4
LATIN AMERICA AND THE CARIBBEAN: EXTENT AND VARIATION OF FORESTED AREAS

Subregion	Area (thousands of hectares)			Variation in forested area				
	1990	2000	2005	Annual (thousands of ha) 1990-2000	Annual (thousands of ha) 2000-2005	Annual (percentages) 1990-2000	Annual (percentages) 2000-2005	Cumulative 1990-2005 (percentages)
Caribbean	5 350	5 706	5 974	36	54	0.665	0.939	10.45
Meso-America[a]	96 655	89 377	86 649	-728	-546	-0.753	-0.610	-11.55
Central America	27 639	23 837	22 411	-380	-285	-1.376	-1.196	-23.33
Mexico	69 016	65 540	64 238	-348	-260	-0.504	-0.397	-7.44
South America	890 818	852 796	831 540	-3 802	-4 251	-0.427	-0.499	-7.13
Latin America and the Caribbean (LAC)	992 823	947 879	924 163	-4 494	-4 743	-0.453	-0.500	-7.43
World	4 077 291	3 988 610	3 952 025	-8 868	-7 317	-0.217	-0.183	-3.17
LAC/world (percentages)	0.244	0.238	0.234					

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Food and Agriculture Organization of the United Nations (FAO), *State of the World's Forests, 2007*, Rome, 2007.

[a] The figures for Mexico were included in the North America chapter, but in the present paper they have been included under Meso-America as part of Latin America and the Caribbean.

A number of studies have concluded that South America will be one of the regions where climate change will benefit the forestry sector. Global production of timber is expected to rise by between 29% and 38% by the middle of this century, increasing in South America and declining in North America and the Russian Federation (Sohngen, Mendelsohn and Sedjo, 2001). Another study based on projections for 2040 (Pérez-García and others, 2002) concluded that forestry production in South America would rise by between 10% and 13% (Pérez-García and others, 2002). In general, output is expected to increase by more in the region than in the world as a whole and in other regions, so lower prices would generate greater welfare for both producers and consumers.

Again, some subregions of Latin America are expected to benefit from the relocation of forestry operations and plantations as a result of climate change. According to one study of the subject (Easterling and others, 2007), the shift will be mainly from tropical to subtropical regions, particularly if warming is significant, and in particular to Argentina and southern Brazil.

The same study indicates that there would be changes in the production and supply of other forestry-related environmental goods and services, such as seeds, nuts, berries, hunting, resins and plants used in the pharmaceutical industry, botanical medicine and the cosmetics industry. These changes are expected to be highly diversified and regionalized.

Developments in the forestry sector also depend on other factors such as planted woodland. Output from plantations in the region has risen from practically zero 50 years ago to almost a third of the total now, and is expected to grow to over 40% by 2030 and to 75% by the middle of this century (Easterling and others, 2007). Another non-climatic factor is the development of competitive production of lignocellulosic biofuels. However, the net results of these different initiatives and the demand associated with them are hard to predict.

Higher temperatures and lower humidity would contribute to an increase in forest fires, but the causality is not unequivocal. The IPCC assessment of the forestry sector found evidence for both an increase and a reduction in the number of forest fires in the region. The report notes that, according to some studies, rising temperatures and longer harvesting seasons will increase the risk of fires owing to greater aridity (Easterling and others, 2007).

BOX II.2
LATIN AMERICA AND THE CARIBBEAN: CLIMATE CHANGE IMPACTS THAT COULD GRADUALLY AFFECT FORESTRY

Likelihood	Direct impacts		Indirect impacts
Almost certain	Increased yields in colder environments, decreased yields in warmer ones and increased insect outbreaks	▲	Higher wood production
Fairly certain	Reduced yields in colder regions owing to heat stress	▲	Marginal GDP share of forestry sector
Very likely	Soil erosion and inability to cultivate land owing to lack of water	▲	Risks for people with respiratory diseases and breathing problems
Likely	Increased risk of forest fires	▲	Human migration
Likely	Crop damage, weakening of tree roots	▲▼	Fluctuations in market prices
Likely	Salinization of irrigation water, estuaries and freshwater systems	▲▼	Variations in the geographical distribution of production and in the orientation/value of trade
		▲	Revenues
		▲	Expenditure (production emergencies and appropriate infrastructure)

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Food and Agriculture Organization of the United Nations (FAO), *State of the World's Forests, 2007*, Rome, 2007 and Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: Summary Report. Contributions of Working Groups I, II and III to the Third Assessment Report of the IPCC*, Geneva, 2001.

C. Fisheries

There are more net exporters than net importers of fishery products in the region. As table II.5 shows, the latter include landlocked countries (the Plurinational State of Bolivia and Paraguay) and a number of Caribbean islands (Barbados, Dominica, the Dominican Republic, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia and Saint Vincent and the Grenadines). All continental countries with coasts are net exporters.

TABLE II.5
LATIN AMERICA AND THE CARIBBEAN: IMPORTS AND EXPORTS OF FISHERY PRODUCTS AS A SHARE OF GDP
(Percentages)

Country	Imports of fishery products					Exports of fishery products				
	1979-1981	1989-1991	1999-2001	2002	2004	1979-1981	1989-1991	1999-2001	2003	2004
Antigua and Barbuda	0.50	0.40	0.47	0.73	0.54	0.15	0.07	0.06	0.19	0.09
Argentina	0.01	0.01	0.03	0.01	0.02	0.08	0.18	0.30	0.34	0.28
Bahamas	0.08	0.16	0.27	0.10	0.15	0.37	1.02	1.95	1.84	1.75
Barbados	0.19	0.29	0.45	0.54	0.45	0.01	0.01	0.05	0.03	0.03
Belize	0.18	0.18	0.33	0.26	0.34	1.88	1.58	3.26	1.63	1.17
Bolivia (Plurinational State of)	0.09	0.02	0.07	0.04	0.03	0.00	0.00	0.00	0.00	0.00
Brazil	0.02	0.04	0.05	0.03	0.04	0.04	0.03	0.04	0.07	0.07
Chile	0.01	0.02	0.07	0.10	0.13	1.06	2.31	2.41	2.60	2.86
Colombia	0.15	0.07	0.09	0.09	0.11	0.07	0.19	0.22	0.18	0.17
Costa Rica	0.04	0.14	0.14	0.16	0.17	0.12	0.67	0.84	0.75	0.63
Cuba	0.31	0.10	0.14	0.13	0.17	0.53	0.39	0.32	0.22	0.28
Dominica	0.29	0.56	0.55	0.53	0.61	0.00	0.00	0.00	0.07	0.00
Ecuador	0.00	0.03	0.02	0.17	0.11	1.52	3.70	4.58	4.39	4.02
El Salvador	0.03	0.03	0.06	0.07	0.12	0.21	0.16	0.22	0.24	0.35
Guatemala	0.02	0.04	0.05	0.07	0.08	0.06	0.13	0.15	0.10	0.05
Guyana	0.00	0.30	0.32	0.15	0.20	2.59	5.76	7.21	7.41	8.35
Haiti	0.07	0.11	0.18	0.20	0.23	0.01	0.04	0.09	0.10	0.09
Honduras	0.05	0.04	0.24	0.17	0.23	0.68	1.18	1.01	0.71	1.38
Jamaica	0.37	0.47	0.77	0.56	0.58	0.00	0.06	0.16	0.11	0.10
Mexico	0.01	0.01	0.03	0.04	0.05	0.15	0.10	0.12	0.11	0.10
Nicaragua	0.02	0.07	0.18	0.09	0.08	0.70	0.48	2.11	1.61	2.26
Panama	0.10	0.14	0.12	0.15	0.12	0.95	1.09	2.25	3.31	3.38
Paraguay	0.01	0.01	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.00
Peru	0.01	0.00	0.03	0.04	0.04	0.76	1.24	1.98	1.78	2.28
Dominican Republic	0.25	0.20	0.28	0.27	0.31	0.01	0.00	0.02	0.02	0.01
Saint Kitts and Nevis	0.35	0.37	0.72	0.55	0.64	0.11	0.05	0.06	0.08	0.05
Saint Lucia	0.49	0.61	0.68	0.75	0.79	0.00	0.01	0.00	0.01	0.00
Saint Vincent and the Grenadines	0.35	0.30	0.40	0.40	0.44	0.00	6.09	0.25	0.16	0.11
Suriname	0.24	0.01	0.41	0.37	0.31	0.35	0.16	4.34	4.54	4.91
Trinidad and Tobago	0.15	0.10	0.10	0.12	0.14	0.03	0.04	0.14	0.10	0.09
Uruguay	0.02	0.02	0.07	0.09	0.08	0.34	0.56	0.52	0.61	0.66
Venezuela (Bolivarian Republic of)	0.03	0.00	0.05	0.02	0.05	0.01	0.10	0.12	0.07	0.07
World	0.09	0.15	0.18	0.19	0.21	0.09	0.15	0.18	0.19	0.21

Source: Food and Agriculture Organization of the United Nations (FAO), *FAO Statistical Yearbook, 2005-2006*, vol. 1, Rome, 2006.

In its chapter on food, fibre and forest products, the IPCC (2007a) states that there is high confidence that climate change will have complex localized effects on small-scale and subsistence fishermen. The report identifies three factors that could negatively impact fishery output: (i) rising sea temperatures, (ii) changes in ocean currents and (iii) a rising sea level (Easterling and others, 2007). It is possible that some of these may affect capture fisheries more than aquaculture (FAO, 2003). According to some sources, there are few studies on the consequences of climate change for fishing and more research is needed to reach a clearer understanding of the sector's vulnerability (FAO, 2007a; Stern, 2006).

It is predicted, with high confidence, that some local fish species will become extinct and there will be changes in the regional distribution and productivity of others (such as salmon and sturgeon) as a result of continuous warming, particularly in cold waters. In some cases, however, productivity could rise (Easterling and others, 2007).

Global studies of the subject anticipate a rise in sea temperatures and variations in ocean currents that would reduce the quantity of plankton on the surface and alter their distribution. This would affect the amount of food available for fish and cause mid-latitude species to migrate to colder waters, a phenomenon that has been studied in the North Atlantic (Reid and others, 1998). The bleaching of coral and its destruction due to rising sea temperatures could also cause serious damage to fish nurseries (FAO, 2003).

Estimates made in Peru (Government of Peru, 2001) have revealed that climate change could manifest itself in the marine ecosystem as an ENSO type phenomenon and that the fisheries sector will probably suffer losses in mariculture, particular where shrimp production is concerned. Another possibility is the disappearance of the extensive wetlands along the coast, which would lead to further losses in fish farming.

According to the IPCC studies, under scenario B2 (see box I.2) Peru would be one of the 15 worst-affected countries in the world. The main harm caused by ENSO includes smaller catches of the predominant commercial species, loss of continental and maritime fishing infrastructure and the repercussions on local employment, directly affecting low-income fishermen in the country's north.

FAO (2007a) considers that not all the effects of climate change on the fisheries sector will necessarily be negative at the global level, as the redistribution of fish stocks will mean losses for some countries but gains for others. Fishing fleets are mobile and markets for fish products global, so international trade agreements could have an important role to play in facilitating adaptation. In this context, countries and firms with more resources will be better able to adapt than poorer and more vulnerable countries.

D. Tourism

Although tourism has grown in South America and the Caribbean in recent years, it declined in Central America between 2007 and 2008. According to the data available from the World Tourism Organization (UNWTO), activity in the sector increased by 2% in 2006 and almost 5% in 2007. This trend is expected to tail off in 2008, owing both to extreme weather events and to the constraints on family budgets resulting from the financial shocks at year's end.

In 2005, the tourism sector expanded less strongly in Latin America and the Caribbean than in the rest of the world, where growth averaged 12%. Table II.6 shows the change in visitor numbers between 2005 and 2007, by country. The most dynamic subregion was Central America (11%), while results in Brazil, Uruguay and Mexico were negative. The 3% decline in Mexico is attributed to the severity of the 2005 hurricane season (UNWTO, 2007b).

TABLE II.6
LATIN AMERICA AND THE CARIBBEAN: INTERNATIONAL TOURISM REVENUES AT LEADING TOURIST DESTINATIONS

Main destinations	International tourist arrivals					International tourism revenues		
	Number of people			Percentage change		Millions of dollars		
	2005	2006	2007	2006-2005	2007-2006	2005	2006	2007
Argentina	3 823	4 173	4 562	9.2	9.3	2 729	3 344	4 313
Bahamas	1 608	1 601	1 528	-0.5	-4.6	2 069	2 056	2 187
Brazil	5 358	5 017	5 026	-6.4	0.2	3 861	4 316	4 953
Chile	2 027	2 253	2 507	11.1	11.3	1 109	1 212	1 419
Colombia	933	1 053	1 193	12.9	13.2	1 222	1 554	1 669
Costa Rica	1 679	1 725	1 973	2.7	14.4	1 571	1 732	1 974
Cuba	2 261	2 150	2 119	-4.9	-1.4	2 150	1 969	1 982
Ecuador	860	841	953	-2.2	13.4	486	490	637
El Salvador	1 127	1 279	1 339	13.5	4.7	543	793	847
Guatemala	1 298	1 482	1 448	14.2	-2.3	869	1 013	1 199
Honduras	673	739	831	9.8	12.6	463	488	557
Jamaica	1 479	1 679	1 704	13.5	1.5	1 545	1 870	1 841
Mexico	21 915	21 353	21 424	-2.6	0.3	11 803	12 177	12 901
Nicaragua	712	749	800	5.2	6.8	206	231	255
Panama	702	843	1 103	20.1	30.8	780	960	1 185
Peru	1 486	1 635	1 812	10.0	10.9	1 308	1 577	1 938
Puerto Rico	3 686	3 722	3 687	1.0	-0.9	3 239	3 369	3 414
Dominican Republic	3 691	3 965	3 980	7.4	0.4	3 518	3 917	4 026
Uruguay	1 808	1 749	1 752	-3.2	0.2	594	598	809
Venezuela (Bolivarian Republic of)	706	748	771	5.9	3.0	650	768	817

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Tourism Organization (UNWTO), *UNWTO Tourism Highlights*, 2007.

In the Caribbean, tourism accounts for almost half of all goods and services exports. Although visitor numbers decreased, profits in the sector rose in almost all the countries (ECLAC, 2007c).

The IPCC has stated, with high confidence, that the effects of climate change on the tourism sector will be significantly negative (Wilbanks and others, 2007; Mimura and others, 2007). Higher temperatures in tourists' home countries will reduce the number of visitors,[4] as will water shortages and the increase in tropical diseases (Mimura and others, 2007) in destination countries.

4 According to studies prepared by UNWTO (2003, 2007a), higher temperatures in some areas such as the United States (the main country of origin for tourists going to the Caribbean) could lead travellers to opt for other destinations.

BOX II.3
LATIN AMERICA AND THE CARIBBEAN: CLIMATE CHANGE IMPACTS THAT COULD GRADUALLY AFFECT TOURISM

Likelihood	Direct impacts		Indirect impacts
Almost certain	Changes in the length and quality of tourist seasons as determined by climate	▲	Need to have preparations in place for emergencies
Fairly certain	Likely alteration of a number of extreme weather events as a result of the climate changes expected	▲	Operating costs (insurance, water and electricity back-up systems, evacuation measures)
Very likely	Damage to infrastructure	▲	Travel more expensive because of migration policies
Likely	The climate conditions that attract tourists move towards higher latitudes and altitudes	▲	More disease outbreaks

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Tourism Organization (UNWTO), "Davos Declaration. Climate Change and Tourism: Responding to Global Challenges", 3 October 2007.

It is predicted (Mimura and others, 2007) that the beaches of the Caribbean, one of the area's main attractions, will be affected by marine erosion (see figure II.5). It is also possible that coral reefs there may suffer 75% bleaching, as they would have to withstand a thermal variation of between 0.2° and 0.3°C per decade over the next 30 to 50 years (Wilkinson and Souter, 2008).[5]

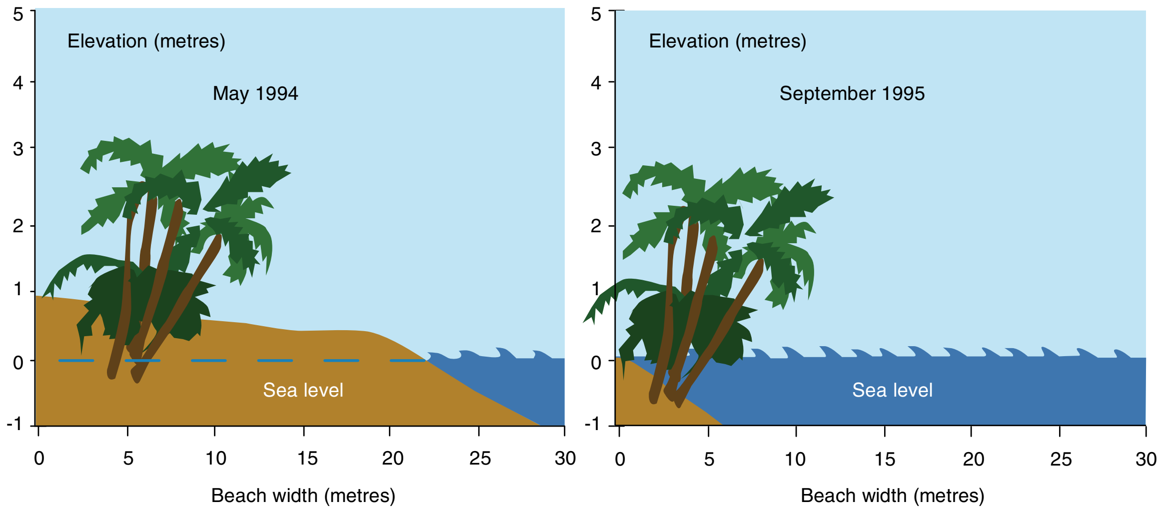
An analysis conducted in Barbados revealed that a 0.5 m rise in sea level would result in the loss of 38% of beaches and 30% of turtles' nests (Fish and others, 2005).

Tourism is vulnerable to cyclones. In 2005, the main Mexican tourist destinations in the Caribbean area were struck by three major hurricanes, Emily, Stan and Wilma, that mainly affected Cancun. The losses caused by Wilma were put at US$ 1,788 million, with over 90% of them concerning the tourism sector (ECLAC, 2005). The World Tourism Organization suggests applying supplementary preparation measures against emergencies and interruptions to commercial activities, and increasing operating expenditure on insurance, water and electricity back-up systems and evacuation methods (UNWTO, 2007a).

Tourism should be less affected in South America than in other regions of the world. According to a study by UNWTO (2003), skiing tourism in the Andes (Chile and Argentina) could actually increase significantly. However, the study did not cover the reduction of glaciers. In the Plurinational State of Bolivia, for example, the surface of the Chacaltaya glacier has shrunk by half since mid-1990, leading to the complete loss of tourism in the area (Government of Bolivia, 2000).

5 The authors of the IPCC report suggest that coral bleaching could be avoided if efforts are made to reduce emissions significantly and preserve local marine resources, since both will be necessary to prevent long-term degradation of coral ecosystems.

FIGURE II.5
DOMINICA: CHANGES TO COCONUT BEACH AFTER THE 1995 HURRICANE SEASON



Source: United Nations Environment Programme (UNEP)/GRID-Arendal, "Changes to Coconut Beach (Dominica) after the 1995 hurricane season" [online] http://maps.grida.no/go/graphic/changes-to-coconut-beach-dominica-after-the-1995-hurricane-season.
Note: This beach changed completely during the period from May 1994 to September 1995 as its sand was washed away by storms and a rising sea level. Coasts became even more vulnerable to surges, as a result of which the sea gained ground and left the area eroded and less attractive to tourists.

E. Industry

The share of value added contributed by the manufacturing sector has declined in the region's countries over the past 15 years. Only in Brazil and some Central American economies has there been a small increase in the relative share of industry.

The average GDP share of industry was 20% in 1990-2005, which reveals the degree of development of the industrial structure in the region's countries. The larger countries (other than Mexico) have an industrialization coefficient of more than 20%, while in medium-sized and small countries (South and Central America) it is in the range of 15% to 20% and in the Caribbean it is less than 15% (ECLAC, 2008a). Composition has an important bearing on the effects of climate change upon manufacturing, which means that a further research effort is required at the regional level.

TABLE II.7
LATIN AMERICA AND THE CARIBBEAN: INDUSTRIALIZATION COEFFICIENT
(Manufacturing value added as a percentage of GDP)

		1990	2002	2005
Large countries	Argentina	24.9	21.3	23.2
	Brazil	22.7	22.0	23.0
	Mexico	20.6	18.4	17.5
Medium-sized countries	Chile	18.1	19.7	18.0
	Colombia	18.6	15.0	14.2
	Peru	19.7	16.1	16.3
	Venezuela (Bolivarian Republic of)	27.1	17.0	17.6
Small countries				
South America	Bolivia (Plurinational State of)	18.2	14.4	13.8
	Ecuador	13.9[a]	13.3	13.3
	Paraguay	18.5	17.1	15.6
	Uruguay	26.5	16.5	21.9
Central America	Costa Rica	21.7	20.6	21.3
	El Salvador	21.8	23.8	22.2
	Honduras	16.3	20.5	20.1
	Nicaragua	16.9	19.3	17.9
	Panama	13.3	8.2	7.5[b]
Caribbean	Antigua and Barbuda	3.2	2.2	1.9
	Barbados	8.0	6.5	6.9[b]
	Belize	12.9	9.2	8.6[b]
	Dominica	6.6	7.1	7.5
	Grenada	6.2	6.4	5.5
	Guyana	5.2	3.4	3.6
	Haiti	14.2	10.0[c]	n.a.
	Jamaica	17.5	13.5	13.1
	Saint Lucia	7.7	4.5	5.1
	Saint Vincent and the Grenadines	8.1	6.3	5.3
	Suriname	11.7	16.3	16.3[b]
	Trinidad and Tobago	6.2	8.0	6.2
Latin America and the Caribbean (weighted average)		**21.9**	**19.0**	**19.4**[b]

Source: Economic Commission for Latin America and the Caribbean (ECLAC). For Ecuador, official figures provided by the Central Bank of Ecuador.
Note: The average for Latin America and the Caribbean includes ECLAC data for Ecuador.
[a] 1993 data.
[b] 2004 data.
[c] 2000 data.

The region's main exports are energy and minerals (Jiménez and Tromben, 2006). The countries can be classified into the following three groups by the average share of products of this type in total exports during the 1980-2005 period.

- The first group contains the Bolivarian Republic of Venezuela, where oil exports account for 79% of the total, and Trinidad and Tobago, where oil and natural gas account for 66% of total exports.

- In the second group are Chile and Ecuador, whose exports of copper (Chile) and oil (Ecuador) averaged over 40% of total annual exports (40.9% in Chile and 45.6% in Ecuador).
- The third group comprises the Plurinational State of Bolivia, Colombia and Mexico, where the share of non-renewables in total exports ranged from 20% to 35%.

According to the IPCC (2007a), the direct effects of climate change on the industrial sector will be seen mainly in energy costs, construction and the integrity of infrastructure (highways, ports, etc.). Changes in energy costs, together with new construction conditions and requirements for buildings and infrastructure, would force the construction sector to submit to new climate-related regulations and standards, quite apart from possible changes in consumer behaviour and preferences.

The effects of climate change on the agricultural, fishing and forestry sectors will indirectly affect agro-industries, such as the food industry (Wilbanks and others, 2007). Industrial activities that depend on water, such as mining, energy industries and sanitary services, could be faced with shortages (see box II.4).

BOX II.4
CLIMATE CHANGE IMPACTS THAT COULD AFFECT INDUSTRY

Sector	Direct impacts	Indirect impacts
Built environment Construction, civil engineering	Energy costs, external fabric of buildings, structural integrity, construction process, service infrastructure	Climate-driven standards and regulations, changing consumer preferences
Infrastructure industries Energy, water, telecommunications, transport	Structural integrity of infrastructures, operations and capacity, control systems	Changing average and peak demand, rising standards of service
Natural resource-intensive industries Pulp and paper, food processing, etc.	Risks to and higher costs of input resources, changing regional pattern of production	Supply chain shifts and disruption, changing lifestyles influencing demand

Source: T.J. Wilbanks and others, “Industry, settlement and society”, *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

Some national communications to the IPCC identified the area most vulnerable to the effects of climate change. In some cases these were industrial or agricultural areas or both, such as the Caribbean area in Colombia (Government of Colombia, 2001).

In Mexico, a study was carried out to assess the vulnerability of industrial zones (Sánchez, 2004). This concluded that the most vulnerable sector was heavy industry, including power generation and the country’s oil sector, since their various industrial processes and geographical locations are sensitive to climate shifts. Hydroelectric and thermoelectric power generation in Chile and Argentina, for example, depends heavily on the availability of water.

Extreme hydrometeorological events could also affect the integrity of the production chain in respect of the supply and transportation of products to markets. This being so, the location of industrial areas will be a crucial factor in determining the risk posed by climate change.

F. Human settlements and infrastructure

The risks to human settlements are from a loss of drinking water sources and an increase in diseases and extreme weather events. The situations of greatest vulnerability will arise in the places where the poorest populations live and in high-risk areas.

According to figures from the World Health Organization (WHO), access to drinking water increased by about 13% in the region on average during the 1990-2004 period. The increase was from 93% to 96% in urban areas and from 60% to 73% in rural areas. Nonetheless, 50.3 million people, over 60% of them in rural areas, still have no drinking water supply (WHO/UNICEF, 2007).

Because of population growth, the cost of supplying drinking water has increased tenfold in the last century. This has particularly affected countries like Mexico and Brazil, which are the largest consumers of water in Latin America and the Caribbean (ECLAC, 2002).

In addition, the volume of water reserves available has diminished because of lower precipitation and the retreat of glaciers in some areas. Water quality has also been affected by factors such as deforestation, urban growth, inappropriate use of resources and poor practices in agriculture (UNEP, 2003).

Some climate scenarios predict that water shortages will be compounded by droughts and flooding in some regions. The number of people affected by this problem in Latin America is expected to range from 12 to 81 million by 2025 and from 79 to 178 million by 2055. The Caribbean countries could have difficulty in meeting their demand for water during periods of low precipitation, particularly under IPCC scenarios A2 and B2, since some islands depend heavily on surface sources (Arnell, 2004) (see table II.8).

TABLE II.8
LATIN AMERICA: NET INCREASE IN POPULATION AFFECTED BY WATER STRESS, 2025 AND 2055
(Millions of people)

Scenario	1995	2025		2055	
		Without climate change[a]	With climate change[b]	Without climate change[a]	With climate change[b]
A1 HadCM3	22.2	35.7	21	54.0	60.0
A2 HadCM3	22.2	55.9	37 to 66	149.3	60.0 to 150.0
B1 HadCM3	22.2	35.7	22	54.0	74.0
B2 Had CM3	22.2	47.3	7 to 77	59.4	62.0

Source: N. Arnell, "Climate change and global water resources: SRES emissions and socio-economic scenarios", *Global Environmental Change*, vol. 14, 2004.

[a] According to Arnell (2004), table 7.

[b] According to Arnell (2004), tables 11 and 12.

Another scenario (Warren and others, 2006)[6] in which the level of water stress was determined[7] on the basis of the rise in temperatures and population growth revealed that the former would affect the water situation of billions of people. This scenario shows the population of South America being most affected by water shortages.

Populations whose water supply depends on thawing ice are likely to be affected during the dry season. This is the situation of millions of people living in the Andean region of the Plurinational State of Bolivia,[8] Colombia,[9] Peru[10] and Chile (Casassa, 2007), where a reduction in glacier levels has already affected some production sectors. Box II.5 summarizes the factors influencing the availability of water.

BOX II.5
EFFECTS OF CLIMATE CHANGE ON WATER RESOURCES

Factors affecting the availability of water	Socio-economic effects
▲ Rapid urban growth	▲ Drinking water supply cuts in many cities
▲ Rising poverty	▲ Large percentages of the urban population lacking access to basic sanitary services
▼ Low investment in drinking water infrastructure	▲ High level of water pollution in the subsoil owing to lack of sewage treatment services
	▲ Lack of urban sewer systems
	▲ Occupation of flood-prone valleys in dry periods
	▲ Serious repercussions at times of flooding

Source: C.E.M. Tucci, "Urban drainage in humid tropics", *Urban Drainage in Specific Climates*, vol. 1, Technical Documents in Hydrology Series, Paris, United Nations Educational, Scientific and Cultural Organization (UNESCO), 2001.

6 The study was based on the results of the hydrological analysis carried out by Arnell (2004) for the 2080s. The findings did not include adaptation effects, as this indicator measures the availability of water and not its utilization.

7 This indicator shows the availability of water but does not reflect potential access to it. According to the United Nations, a country experiences water scarcity or severe water stress if the supply is below 1,100 cubic metres per person per year and absolute scarcity or extreme water stress when supply is below 500 cubic metres per person per year (Stern, 2006).

8 The Zongo glacier has lost 9.4% of its surface area since 1991 and could disappear in 2045-2050, which would create serious problems for agriculture and the sustainability of Andean growing areas. The Chacaltaya glacier could disappear in 2010, having now lost almost half its surface area and two thirds of its volume. This would mean the almost complete loss of tourism and skiing activities in the area (Francou and others, 2003, cited in IPCC, 2007a).

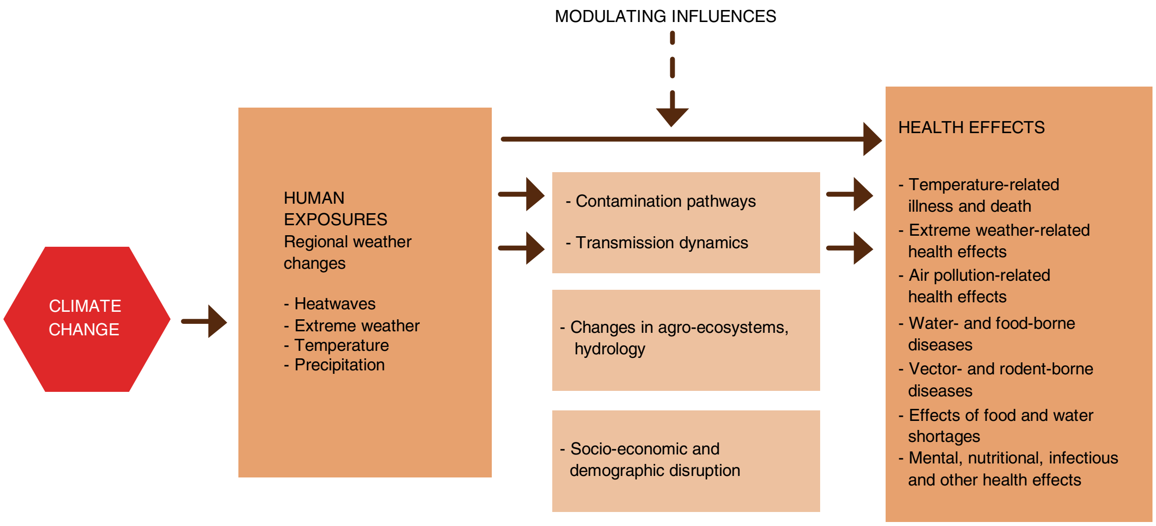
9 The glacier zone of the Santa Isabel volcano has retreated, and this is connected with the recent dynamic of the El Cocuy range (on sedimentary rocks). According to field measurements taken over the last decade (1990-2000), an average of 10 to 15 metres of ice have melted per year, a figure that can change under extreme weather conditions (national communication of Colombia).

10 Between 1972 and 1997, the Broggi glacier lost the equivalent of some 29 million cubic metres of water, or a total surface area of 53 hectares. In 1980-1997, the Uruashraju glacier shrank by 33.4 hectares, implying a loss of glacier mass equivalent to 33.16 million cubic metres of water. From 1980 to date, meanwhile, the average rate of retreat of the Yanamarey glacier has increased to 20.3 metres a year, while the surface area of the Santa Rosa glacier diminished by 25.5 hectares over the 1962-1997 period, with a loss of 59.8 million cubic metres of water; the front retreated by 525 metres in total. In the past 50 years, these four glaciers have lost over 188 million cubic metres of their water reserves, which will affect the water supply in the Santa and Huaraz basins (Government of Peru, 2001).

1. Public health

Where the effects of climate change on health are concerned, the IPCC (2007a) has warned, with high confidence, that there will be a rise in malnutrition rates and in the number of cases of death and sickness resulting from extreme weather events, as well as an increase in the range of diseases associated with the loss of plant cover and water contamination (see diagram II.2). In 2001, the IPCC also observed that ocean warming could lead to contamination of seafood, in turn increasing the frequency of food poisoning.

DIAGRAM II.2
ADVERSE EFFECTS OF CLIMATE CHANGE ON HUMAN HEALTH



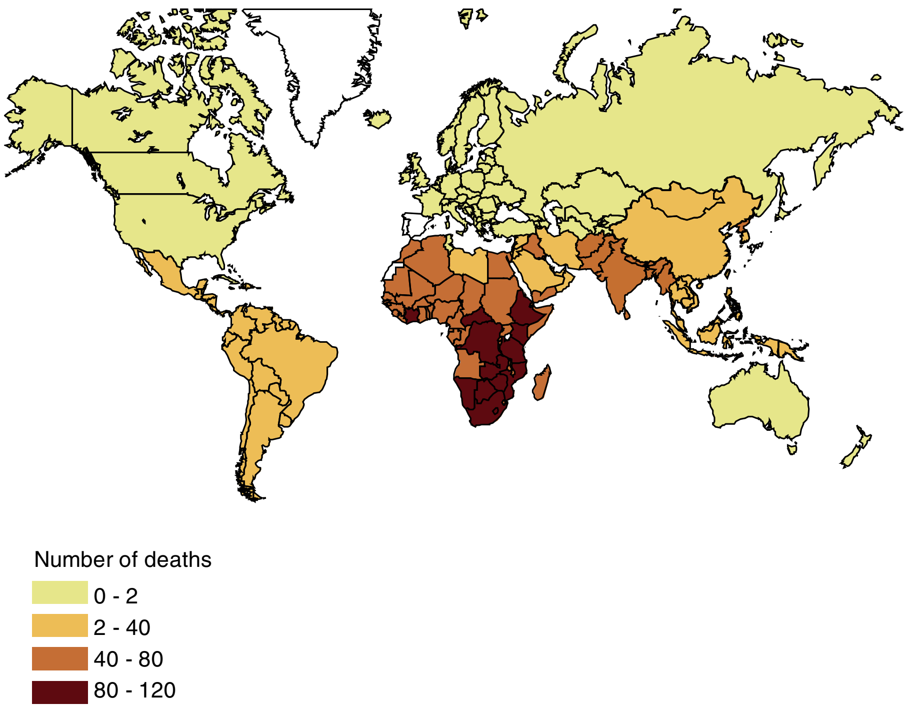
Source: World Health Organization (WHO), *Climate Change and Human Health. Risks and Responses. Summary*, Geneva, 2003.

The scenarios point to a large increase in mortality owing to an upsurge in diseases transmitted by vectors and associated with temperature change, such as malaria, diarrhoea, dengue and malnutrition (Campbell-Lendrum and Corvalán, 2007; McMichael, 2004).

Some comparative studies of different cities (London, São Paulo and New Delhi) have shown that heatwaves could increase mortality levels (Hajat and others, 2005). Another recent study calculated that each degree Celsius rise in temperature resulted in up to 20,000 additional deaths from air pollution and higher CO_2 emissions (Jacobson, 2008).

Some analyses suggest that the risk of malaria exposure and transmission in the region would increase by up to 18% with a temperature rise of up to 1°C (McMichael and others, 2004). As regards dengue, the historical record shows an increase in the number of sufferers and in the areas where this disease has been reported (PAHO, 2007b). Figure II.6 shows the number of cases of disease or premature death associated with climate change in 2000. The figures for Latin America and the Caribbean are the result of three main factors: flooding, malaria and diarrhoea.

FIGURE II.6
ESTIMATED DEATHS ATTRIBUTABLE TO CLIMATE CHANGE IN 2000, BY SUBREGION
(Per million inhabitants)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Health Organization (WHO), *Climate Change and Human Health. Risks and Responses, Summary*, Geneva, 2003.
Note: The borders shown on this map are intended only to illustrate the effects of climate change and do not imply endorsement by the United Nations.

The rise in malaria and dengue cases would have substantial economic effects, given that two thirds of sufferers in the past decade have been people in their most productive years (PAHO, 2007a).

The projections mentioned suggest a need to allocate additional resources to health systems and increase follow-up and control of diseases, and to have an appropriate hospital infrastructure in place to attend to the growing number of emergencies occurring as a result of extreme weather events.

2. The most vulnerable groups

As indicated in the *Social Panorama of Latin America* (ECLAC, 2007d), 36.5% of the region's population were poor in 2006 and 13.4% were extremely poor or indigent. Furthermore, the urban population increased from 69% to 77% of the total between 1987 and 2005 (UNEP, 2007), and by 2030 the share is expected to be 84%.[11]

According to the IPCC (2001), many of the poorest human settlements are located in high-risk areas and 60 of the 77 most densely populated Latin American cities are on the coast. This combination means that a substantial section of the population is exposed to flooding, contamination of groundwater by salt water and constraints on the availability and quality of drinking water, as well as a rising sea level (IPCC, 2007a).

[11] These projections are speculative. For further details, see chapter 7 of the *Fourth Assessment Report* of the IPCC.

This is why extreme weather events often occur in areas that have been previously affected or have not yet been able to recover properly, with cumulative effects that are difficult to overcome. Overpopulation and inadequate basic services favour the appearance of vectors and organisms that transmit disease. Limited preparation and lack of planning (Zapata, 2006) compound the factors mentioned.

As some reports have pointed out, children and women (American Academy of Pediatrics, 2007) are most vulnerable to the effects of climate change, as they have limited access to resources and fewer capabilities and opportunities for participating in decision- and policymaking.

This situation indicates that governments will have to concentrate on poverty reduction, while spending a significant amount of resources on infrastructure and basic service improvements, especially in the poorest areas.

G. Summary

- The anticipated effects of climate change are especially significant in the primary sector, but the time intervals involved make them hard to perceive. Ecosystems change slowly and the losses expected by 2020 are still relatively modest. The productivity curves of agricultural crops as determined by temperature and humidity are similar. The expectation is that a moderate rise in temperature and CO_2 fertilization will initially boost production. According to studies of the economic effects of climate change being conducted in Mexico and Brazil, however, yields would decline in most places if the rise in temperature exceeded 3°C, something that is likely to happen around 2050. In Latin America and the Caribbean, the Brazilian and Argentinean pampas are the only regions where production potential might be expected to increase, while a shift to higher latitudes is to be expected where fisheries and forests are concerned. The effects of climate change will be compounded by the proliferation of pests and diseases. Changes in agricultural productivity will affect food security and prices. The adverse effects (on agriculture, tourism and fisheries more than forestry) are expected to influence the countries' currency generation capacity and thence the trade balance between net exporters and importers of primary sector products.
- The industrial sector will not be unaffected by climate change, mainly owing to shortages of primary sector inputs, higher construction costs and possible damage to infrastructure (highways, ports, etc.).
- Extreme weather events are expected to have severe effects on the poor population, especially in urban areas.
- In the private sector, the impacts will be important when reflected in profits, but even so it will be difficult to separate climate change from the climate variability experienced in the past. Governments too, accustomed as they are to taking sectoral action and externalizing costs by passing them on to future administrations, will find it hard to draw a clear line between climate change and normal variation.
- Given the time horizon of the projections, the need to respond does not seem urgent, while the idea that wealth will be greater in future represents an obstacle to appropriate decision-making.
- Since environmental services are not traded in the market, they have no value and their gradual deterioration is not reflected in the national accounts. Losses are not obvious until they are fully felt, at which point they do have a price. By then, however, it might be too late to react.

III. Adapting to climate change

What is meant by adaptation, according to the Intergovernmental Panel on Climate Change (IPCC), are adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts.[1] This chapter reviews the types of adaptation needed, the challenges facing decision-makers and some suggested measures. As the previous chapter pointed out, the Latin America and Caribbean region is physically and economically vulnerable, with a large primary sector that would be directly affected. This could increase levels of poverty and inequality, threatening sustainable development (Conde-Álvarez and Saldaña-Zorrilla, 2007).

As the analysis in chapters V and VI shows, mitigation measures in the region's countries are having little global and regional impact because their contribution to global emissions is relatively low.[2] However, adaptation will require a considerable effort, and unfortunately adaptation and mitigation measures coincide in only a few cases. For the most part, then, these efforts should be seen as non-synergistic.

BOX III.1
ADAPTING TO CLIMATE CHANGE

Adaptation means adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: Synthesis Report. Summary for Policymakers*, Geneva, 2001.

[1] Articles 2 and 4 (4.1(b,e,f), 4.8 and 4.9) of the United Nations Framework Convention on Climate Change (UNFCCC) recognize the importance of adaptation for coping with climate change.

[2] This does not mean that mitigation measures should be neglected: the sum of these contributions is also important in any global effort to keep the planet's greenhouse gas emissions on a path that allows the average temperature to stabilize.

The adaptation process requires adjustments to reduce vulnerability and enhance the ability to recover from observed and expected climate changes. If these adjustments are to occur, however, they will have to be accompanied by a perception of climate risk and opportunities both in government and among the general population (Adger and others, 2007).

Table III.1 shows how the sustainability of the region's countries could be affected. It does this by considering the obstacles to achieving the Millennium Development Goals (MDGs), and suggests some areas where adaptation is required (UNEP/SEMARNAT, 2006; UNFCCC, 2007c and UNDP, 2007).

TABLE III.1
CLIMATE CHANGE IMPACTS THAT COULD AFFECT ATTAINMENT OF THE MILLENNIUM DEVELOPMENT GOALS

MDG	Potential consequences of climate change [a]
Goal 1: Eradicate extreme poverty and hunger	Climate change is expected to affect the lifestyles of the poorest population in respect of health, water access, housing and infrastructure, for example. Alterations are expected in the style and pace of economic growth as a result of changes in natural systems, infrastructure and labour productivity. It is anticipated that food security will be affected because of a decline in the productivity of staple grains. There are expected to be social strains over the use of resources, potentially reducing earning opportunities and thus leading to migration.
Goal 2: Achieve universal primary education	Loss of ways of life (social, natural, physical, human and financial capital) that could reduce opportunities for full-time education. Natural disasters and drought reduce the time available for children's education as people move away from their home areas and migrate. Malnutrition and disease will reduce school attendance and children's ability to learn in class.
Goal 3: Promote gender equality and empower women	Climate change is expected to exacerbate current gender inequities. The diminution of natural resources and agricultural productivity could increase pressure on women's health and reduce the time available for them to participate in decision-making processes and income-generating activities. Climate disasters have been found to have severe consequences in female-headed households, particularly when women heads of families have fewer opportunities to start afresh.
Goal 4: Reduce under-5 mortality	Possible increases in mortality and disease related to rising temperatures, vector-borne diseases and pressure on water resources, preventing the target for disease containment from being met. Children and pregnant women particularly susceptible to vector-borne diseases.
Goal 5: Improve maternal health	Climate change could reduce the quantity and quality of drinking water, which is essential to health, with shortages potentially exacerbating malnutrition. Natural disasters could jeopardize food security, thereby increasing malnutrition.
Goal 6: Combat HIV/AIDS, malaria and other diseases	Water stress and higher temperatures would increase disease. People suffering from AIDS have more vulnerable living conditions and malnutrition would accelerate the negative effects of the disease.
Goal 7: Ensure environmental sustainability	Climate change will alter the quality and productivity of natural resources and ecosystems: some of these changes could be irreversible, reduce biological diversity and intensify environmental degradation.
Goal 8: Develop a global partnership for development	Climate change is a global issue and the response to it requires international cooperation, especially to help developing countries adapt to the negative repercussions of climate change. International relations need to be strengthened to cope with the anticipated climate effects.

Source: United Nations Framework Convention on Climate Change (UNFCCC), "National Communications from Non-Annex I Parties" [online] http://unfccc.int/national_reports/non-annex_i_natcom/items/2716.php.

[a] Based on national communications from non-Annex I countries and the *Sixth Compilation and Synthesis of Initial National Communications from Parties Not Included in Annex 1 to the Convention*, Note by the Secretariat, Addendum 5, "Climate change impacts, adaptation measures and response strategies".

A. Adaptation measures required

Adaptation is already in progress in Latin America and the Caribbean in the form of isolated measures to deal with and aid recovery from natural disasters, for example, or crop changes and mixing in agriculture, most of these measures being spontaneous or reactive in character (UNDP, 2007; UNFCCC, 2007c).

Recent analyses from an adaptation standpoint (Magrin and others, 2007; Levine and others, 2007; McGray, Hammill and Bradley, 2007) have highlighted existing national and regional projects, including policies to protect natural ecosystems, water resources, coastal zones, agriculture and forestry and human health, that were not designed for adaptation but do contribute to it. There is another compilation of adaptation initiatives in Latin America and the Caribbean, prepared by the World Resources Institute (McGray, Hammill and Bradley, 2007), which is presented in table III.2. These initiatives are helping to increase the recovery capacity of the countries and the region, even though they may not necessarily have been adopted for the purpose of adapting to climate change.

TABLE III.2
LATIN AMERICA AND THE CARIBBEAN: SELECTED EXAMPLES OF ADAPTATION TO CLIMATE CHANGE

Sector	Country	Project	Geographic scale	Type of settlement
Agriculture	Ecuador	Analogue Forestry New World	Community	Rural
	El Salvador	Drought response and mitigation	Subnational	Rural
	El Salvador	Climate change strategy and adaptation measures in rural areas along the central coast of El Salvador	Subnational	Rural
	Guatemala	Climate change studies with emphasis on adaptation	National	Urban and rural
	Multinational (Central America)	Restoration of woodland landscape to increase the resilience of communities in tropical mountain areas.	Multinational	Rural
	Peru	Waru Waru irrigation system	Community	Rural
Disaster risk management	Argentina	Preparation for disasters caused by climate change	National	n.a.
	Brazil	Rio de Janeiro community reforestation project	Subnational	Urban
	Colombia	Phase II: disaster vulnerability reduction project	Subnational	Urban
	Costa Rica	Training for flood preparedness in the community	Community	Rural
	Cuba	Framework for disaster reduction	National	n.a.
	Guatemala	Preparation for disasters caused by climate change	Subnational	Urban
	Nicaragua	Preparation for disasters caused by climate change	National	n.a.
	Nicaragua	Adaptation to climate change through disaster risk management in Waspam, Bonanza, Rosita and Santa Teresa	Community	Rural
	Trinidad and Tobago	Preparation for disasters caused by climate change	National	n.a.
Human health	Cuba	Vaccination programme	National	n.a.

Table III.2 (concluded)

Sector	Country	Project	Geographic scale	Type of settlement
Human health and water	Bolivia (Plurinational State of)	Enhancing adaptation capacity in semiarid and mountainous regions	Subnational	Rural
	Colombia	Comprehensive national adaptation programme	National	Rural
Water	Bolivia (Plurinational State of)	Storage of rainwater in Qhuthañas (small dams)	Subnational	Rural
	Brazil	Improving agricultural productivity with photovoltaic water pumping in Pintadas	Community	Rural
	Colombia	Monitoring and restoration of wetlands	Community	Rural
Coastal areas	Colombia	Enhancing the capacity to adapt to a rising sea level along the Tumaco coast on the Pacific and in Cartagena on the Caribbean coast	National	Urban and rural
	Cuba	Beach restoration technology	National	n.a.
	Guyana	Planning for adaptation to a rising sea level	National	n.a.
	Multinational (Caribbean nations)	Adaptation to climate change	Multinational	n.a.
	Multinational (Dominica, Saint Lucia, Saint Vincent and the Grenadines)	Project to implement adaptation measures in coastal zones	Multinational	n.a.
	Suriname	Sustainable lifestyles in coastal zones	National	Urban and rural
Energy	Argentina	Renewable electricity in remote settlements of Jujuy province	Community	Rural

Source: H. McGray, A. Hammill and R. Bradley, *Weathering the Storm: Options for Framing Adaptation and Development*, Washington, D.C., World Resources Institute, 2007.

The following are sectoral adaptation guidelines emphasized in the literature:

- **Ecosystems**: The Latin America chapter of the IPCC (Magrin and others, 2007) contains suggestions that would help to reduce the degradation of ecosystems, such as the design and implementation of natural resource planning and management policies.
- **Water**: The practices described are found mainly in developed-country municipalities, but developing countries could perhaps adopt them as well. Some options are the desalinization of seawater and increased rainwater storage. Where the demand for water is concerned, the emphasis is on efficient use and recycling, reducing irrigation needs by changing crop cycle dates and irrigation methods, the promotion of indigenous practices of sustainable water use and the expanded use of financial incentives for conservation (Kundzewicz and others, 2007).

- **Agriculture**: Given its exposure, heterogeneity and potential repercussions, the agriculture sector may require decisive joint public- and private-sector action and financing to assist with adaptation within a shorter timescale. The character of agricultural adaptation as a public good, the higher levels of poverty in the countryside and the high chances of intractable externalities arising are strong arguments for implementing public policies in this sector, particularly in places where the positive externalities are most evident. The United Nations Framework Convention on Climate Change (UNFCCC, 2007a) suggests the mixing of grains and livestock, investment in irrigation equipment to improve drainage conditions, the creation of storage infrastructure, control and management of pests and pathogenic diseases and the creation of a system of risk insurance.

- **Extreme events**: The disaster assessments carried out by ECLAC in the region indicate a need to support long-term adaptation to reduce the impact of extreme phenomena, both socioculturally and economically (Zapata, 2006). The sociocultural composition of the region and current methods of dealing with natural disasters mean that the predominant formula is to defray the costs of disasters once they occur, in a context of multiple externalities where the costs of private individuals are transferred to local and national governments and, in many cases, to international cooperation agencies.

- **Health**: The UNFCCC (2007a) considers that the main adaptation requirement where human health is concerned is to improve public health systems, particularly by creating or improving oversight systems that can identify the presence or appearance of new diseases. The World Health Organization (WHO, 2003) proposes a better understanding of the complex causal relationship between climate change and disease transmission patterns, chiefly in three areas: (a) historical follow-up of climate variability and the occurrence or spread of infectious diseases, (b) observation of indicators of new infectious disease effects because of climate change in the long term, and (c) the creation of models for estimating the future burden of infectious diseases.

- **Coastal areas**: In the face of a potentially higher sea level, protection for natural systems such as mangrove swamps and coral reefs can increase their ability to react to climate change. The cost of protecting coastal areas will be much lower than the losses in threatened areas (Nichols and others, 2007) and for this reason three basic adaptation options are suggested for these areas: protection, preparation and withdrawal from areas or uses that could be highly vulnerable.

Taken together, these measures could help to reduce risk in the tourism, fishing, forestry and industrial sectors.

Proposed supplementary cross-cutting measures include recalibrating production conditions to reduce losses of income and well-being, considering microlending programmes for housing, overhauling and reconstructing monitoring and early warning systems, and preparing preferential relocation zones.

Naturally, it is understood that measures will be taken to strengthen environmental management and some of its mechanisms such as river basin management programmes, payment for environmental services and risk management for biosystems and river basins using regional maps of threats, vulnerability and risk. Some new regional (Meso-American, Caribbean, Latin American) risk management and transfer instruments would have to be introduced, such as modified infrastructure investment evaluation mechanisms to make additional adaptation requirements enforceable, something that would be required for secure infrastructure operation.

B. Adaptation challenges

The main challenges include:

- Uncertainty about the science and about causal relationships when it comes to quantifying adaptation resources. In particular, it is difficult to identify additional consequences and thus determine the baseline in most cases, to formulate methodologies for quantifying economic effects, and to estimate total cost, impacts on non-commercial goods (such as ecosystemic services), the distribution of costs between private and public agents and the simultaneity and synergy of changes.
- Location and specificity of the measures required.
- The knowledge available and the capacity for action of the authorities responsible for economic, social and environmental management in the countries, and the creation of national or regional institutions for follow-up and information, these being public goods.
- Resources to finance adaptation activities and programmes (public, private and international cooperation).

Other considerations concern the climate change response measures being adopted by Annex 1 countries in respect of emissions content in international trade, which will be analysed further on.

1. Costs: scientific uncertainty and the difficulty of quantifying resources

The national evaluations to ascertain where and how much investment in adaptation is required and who should provide it began with the preparation of national communications. As a systematic, comprehensive and long-term exercise, however, these evaluations began only in 2007, with reliable information expected to be available by late 2009.[3]

The preparation of climatic and geospatial models with the level of resolution needed to provide a sufficiently detailed picture of changes is still a work in progress in most of Latin America and the Caribbean, the chief exceptions being Brazil, Mexico, Ecuador, Colombia and Chile. Once the direction and scale of change have been identified, an economic assessment can be carried out.

Another difficulty is that manifestations of climate change, even at their most extreme, are no different in essence from climate variability. Where adaptation costs are concerned, differentiating additional costs from total costs may be pointless in most cases, as the costs will still have to be met in their entirety.

Efforts to estimate climate change costs to date have varied between countries and subregions. In 2008, progress was made with the economic impact study in Brazil, financed by the United Kingdom through the World Bank. The Andean Community paid the University of the Pacific to conduct a study of that subregion; the finance and environment ministries and office of the Presidency of the Federal Government of Mexico carried out an estimation project with technical support from the Economics Department of the Autonomous National University of Mexico (UNAM) and financing from the United Kingdom, the Inter-American Development Bank (IDB) and ECLAC. For its part, in 2009 ECLAC initiated the Central American, Caribbean and South American studies with support from Denmark, Germany, Spain, the United Kingdom, the European Union and IDB and funds of its own.

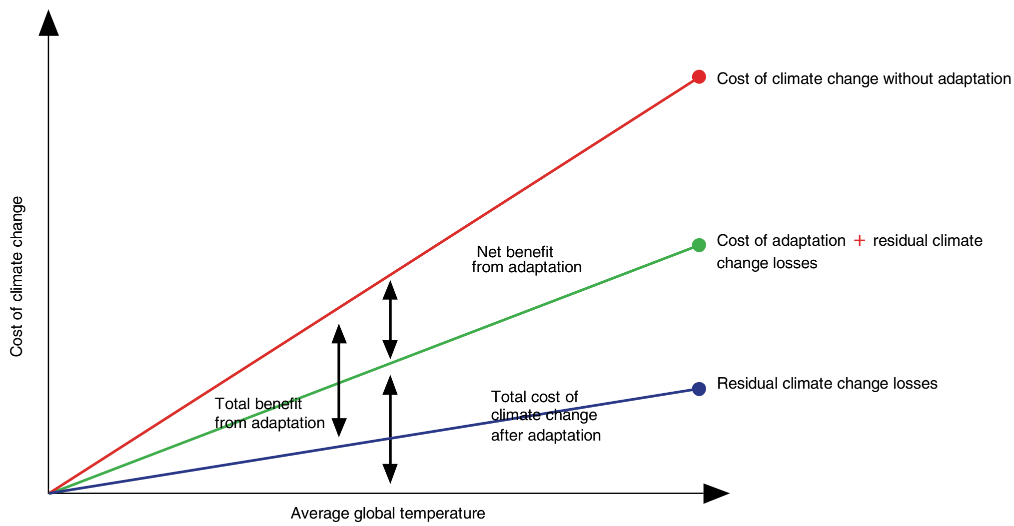
3 Ignoring adaptation costs could be a decision that implicitly allows the groups best placed to exert pressure to shift their costs on to less powerful groups, so that emergencies and the resource transfers they involve play a cost arbitrage role. In some circumstances there may be an incentive not to internalize adaptation.

The small geographical size of some countries, the availability of information or both could place serious constraints on studies of this type, as could other factors relating to individual countries' installed capacity (Smith and others, 2001).

In any event, it would be desirable to have comparable results so that there can be a regional view of the problem and a regional response.

As figure III.1 shows, investment in adaptation measures will allow the countries to lower the cost of future repercussions, even when such measures have a positive cost.

FIGURE III.1
COST OF ADAPTING TO CLIMATE CHANGE [a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Nicholas Stern, *The Economics of Climate Change. The Stern Review*, London, Cambridge University Press, 2006.

[a] Adaptation will reduce the negative consequences of climate change (and enhance the positive effects) but there will usually be some residual damage. Consequently, the gross benefit from adaptation is the damage avoided, and the net benefit will be the damage avoided minus the cost of adaptation. The relationships between rising temperature and different climate change and adaptation costs have been depicted as linear, but the costs of climate change actually accelerate as the temperature rises, while the net benefit from adaptation falls in relation to the cost of climate change (chapter 13, part II of the Stern Review).

The investment flows required for the most vulnerable sectors to adapt have been analysed by the UNFCCC (2007a). The most vulnerable sectors are considered to be agriculture, forestry, fishing, water, health, coastal zones and infrastructure.

This study notes that at present there is a global "adaptation deficit" (Burton, 2004), if the indicator used is the continuous increase in losses from extreme events. It is estimated that investment in the agriculture and forestry sector needs to increase by about US$ 2.9 billion in Latin America and Africa. As regards the construction of additional infrastructure to meet projected drinking water demand in the Latin America region, considering economic growth and climate change in the run-up to 2030, US$ 23 billion of investment would be needed plus US$ 680 million of additional infrastructure investment to protect coastal zones. Most of these resources would have to come from the public sector and be combined with the application of public policies.[4]

Providing drinking water for 121 million people in Latin America as part of the effort to meet the Millennium Development Goals would require investment estimated at US$ 17.7 billion, to which must be added the cost of increasingly prevalent droughts and a substantial improvement in the efficiency of water use in the agricultural sector.[5]

The World Bank did another study on potential global adaptation costs. It put the investment required at between US$ 9 billion and US$ 41 billion a year. Table III.3 shows other estimates of costs (OECD, 2008a) which give an idea of their scale and the need for research in this area.

TABLE III.3
ESTIMATED COSTS OF GLOBAL ADAPTATION TO CLIMATE CHANGE

Analysis	Adaptation cost	Timing	Countries	Sectors and financial flows[a]	Comments on methodology
World Bank	US$ 9 billion to US$ 41 billion a year	Now	Developing countries	Unspecified, assumed to be all sectors deemed "climate sensitive" Financial flows: ODA (40%), FDI (10%) and GDI (2%-10%)	Estimates based on official analyses of flows by OECD and the World Bank "Climate-proof" costs are identified
Stern Review	US$ 4 billion to US$ 37 billion a year	Now	Developing countries	Unspecified, assumed to be all sectors deemed "climate sensitive" Financial flows: ODA (20%), FDI (10%) and GDI (2%-10%)	Updates the data calculated by the World Bank, with some modifications
Oxfam	At least US$ 50 billion a year	Now	Developing countries	Unspecified, assumed to be all sectors deemed "climate sensitive" Financial flows: ODA, FDI and GDI plus the costs of non-governmental organizations	Considers the World Bank study and adds an extrapolation of the costs estimated by national adaptation programmes and non-governmental organization projects
United Nations Development Programme (UNDP)	US$ 86 billion to US$ 109 billion a year	2015	Developing countries	Unspecified, assumed to be all sectors deemed "climate sensitive" Financial flows: ODA, FDI and GDI	Considers the World Bank study and adds in the cost of meeting the goals of programmes to reduce poverty and strengthen disaster response systems

[4] These cost studies did not consider possible indirect economic impacts such as migration, job losses and changing lifestyles.

[5] Water consumption for agricultural use is estimated at 70% of the total in the region (Winpenny, 2003).

Table III.3 (concluded)

Analysis	Adaptation cost	Timing	Countries	Sectors and financial flows[a]	Comments on methodology
United Nations Framework Convention on Climate Change (UNFCCC)	US$ 28 billion to US$ 67 billion a year	2030	Developing countries	Agriculture, forestry and fisheries, water, human health, coastal zones and infrastructure Would require 0.2% to 0.8% of global investment flows, i.e., 0.06% to 0.21% of GDP projected for 2030	Conducts an in-depth analysis of the cost of adapting to climate change in sectors such as water, health and coastal zones. Adaptation costs for agriculture, infrastructure and ecosystems are less detailed. Infrastructure costs are the most abstract
United Nations Framework Convention on Climate Change (UNFCCC)	US$ 44 billion to US$ 166 billion a year	2030	Global	Agriculture, forestry and fisheries, water, human health, coastal zones and infrastructure	Infrastructure adaptation costs are added to the costs for coastal zones and water resources

Source: Organisation for Economic Co-operation and Development (OECD), *Economic Aspects of Adaptation to Climate Change. Costs, Benefits and Policy Instruments*, Paris, 2008.

[a] ODA = official development assistance, FDI = foreign direct investment, GDI = gross domestic investment.

International organizations and the IPCC reports argue that, despite the adaptation work done by governments, more resources need to be invested in strategies, measures and policies to increase the countries' resilience.

The distribution of costs between public and private actors is one of the key elements in the design of adaptation instruments. Settling this clarifies the division of responsibilities between each level of government (national, state, provincial or local), between government and the private sector and between producers and consumers within the private sector.

Generally speaking, it will be the responsibility of the public sector to:

- put the necessary regulations in place (e.g., a compulsory insurance provision for infrastructure operation, a review of the conditions under which environmental or economic emergencies are declared and the regulation of land use);
- generate public goods, such as information for risk abatement;
- design economic incentives.

It will be up to the private sector to:

- absorb additional infrastructure costs;
- invest in a way that reflects the new conditions and increased risks.

A low level of adaptation will mean that private costs (losses) from collapsing output, whether due to gradual changes (longer droughts or higher minimum temperatures) or to extreme events, are transferred to the public finances by way of financial compensation for emergencies or production losses, thus affecting public spending at its different levels: municipal, state, national and international in the case of international cooperation in disaster situations. Similarly, an adaptation deficit will mean losses because of lower economic activity, with all the consequences this has for public revenues. The combination of the two effects will weaken the public finances and, potentially, the economic governance of countries.

This tendency will be heightened when the pressures on the public finances from droughts, flooding and epidemics occur simultaneously. Accordingly, adaptation measures need to prevent extreme events from generating negative synergies with one another.

Conversely, if adaptation initiatives incorporate the additional costs of private actors, for example through insurance, these costs will stay in the private domain. This does not rule out a distributive struggle between producers and consumers or the possibility that a low level of adaptation among private-sector producers might lead to higher prices for consumers.

A low level of adaptation will be reflected, then, in numerous indirect factors and unanticipated resource transfers, such as greater pressure on the public finances at the different levels and instability in goods and services markets. From this standpoint, progress with adaptation constitutes an effort to protect the structure of the public finances and the stability of the private sector and is conducive to macroeconomic stability. One aspect that institutions need to consider is the design of measures to overcome obstacles to adaptation.

2. The location and specificity of the measures required

Climate change and adaptation measures have specific geographical manifestations, as does the relocation of production activities and human settlements. Adaptation to climate change can cause reactions such as worsening environmental degradation of climatic origin, for example when production activities are relocated to environmentally fragile areas.

It has been suggested that the design of measures needs to be informed by a combination of scientific approaches and traditional knowledge as a reciprocal adjustment measure to ensure they are suited to the conditions of each local area, particularly in the agricultural sector (UNFCCC, 2007a). A classification by type, as described in table III.4, has been developed to reflect the location and specific characteristics of adaptation measures.

TABLE III.4
TYPES OF ADAPTATION

By spatial scale	Local, regional, national
By sector	Water resources, agriculture, tourism, public health, etc.
By type of action	Physical, technological, investment, regulatory, market
By actor	National or local government, international donors, private sector, NGOs, local communities and individuals
By climatic zone	Dryland, floodplains, mountains, Arctic, etc.
By baseline income/development level	Least-developed countries, middle-income countries and developed countries

Source: N. Adger and others, "Assessment of adaptation practices, options, constraints and capacity", *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2007.

3. Institutions and national capabilities

The scale of changes expected locally will prompt governments, supported by public- and private-sector research institutions, to prepare national or regional climate change projections, as the availability of models and economic assessments allows to provide an understanding of each country's specific vulnerabilities and the socio-economic costs of climate change. This measurement effort entails a dialogue between the different levels of government and with their peers in other countries and regions so that they can share good outcomes, lessons learned, tools and suitable adaptation policies. Table III.5 shows some components suggested by international organizations.

TABLE III.5
LATIN AMERICA AND THE CARIBBEAN: SOME COMPONENTS SUGGESTED FOR THE FORMULATION AND APPLICATION OF CLIMATE CHANGE ADAPTATION MEASURES

Human Development Report (UNDP, 2007)	UNFCCC (2005)	ECLAC (on the basis of different disaster evaluations)
Information for effective planning: High-quality historical data to forecast repercussions and evaluate risks Climate protection infrastructure: Better infrastructure as part of disaster management, which may be more economical in cost terms Insurance for social risk management and poverty reduction: Strengthening of job creation schemes, cash transfers at times of crisis and insurance-related transfers to cope with climate change Disaster risk management institutions: Public awareness-raising and appropriate institutional organization are a crucial part of countries' institutional capabilities	Methods, models, tools and information: Focused on standardization and increased usage Key sectors and their vulnerability: Coastal zones, fisheries, human settlements, health, ecosystems, desertification and soil degradation, industry and energy Strengthening of capital (human and institutional): By means of workshops for data use, application of methods and models, creation of databases where these do not exist Financial and technical support: Technical and financial resources are crucial for adaptation activities Education, training and public awareness: Promotion of project proposals and financing for adaptation and for assistance to vulnerable sectors Creation of networks and information: Measures to strengthen regionwide technical knowledge-sharing networks	Some sample measures: Insurance in the primary sector and regulations if this is compulsory Introduction of additional requirements for new investments Clear regulations governing the declaration of emergencies

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Development Programme (UNDP), *Human Development Report, 2007-2008*, UNEP, 2007 and United Nations Framework Convention on Climate Change (UNFCCC), *Sixth Compilation and Synthesis of Initial National Communications from Parties Not Included in Annex 1 to the Convention* (UNFCCC/SBI/2005/18/Add.5).

Other studies propose focusing on key areas of development, such as advances in economic and food security and removal of the structural causes of hunger and insecurity, the construction of education and health systems, better urban planning and provision of public services and infrastructure, and improvements in gender equality (Stern, 2006).

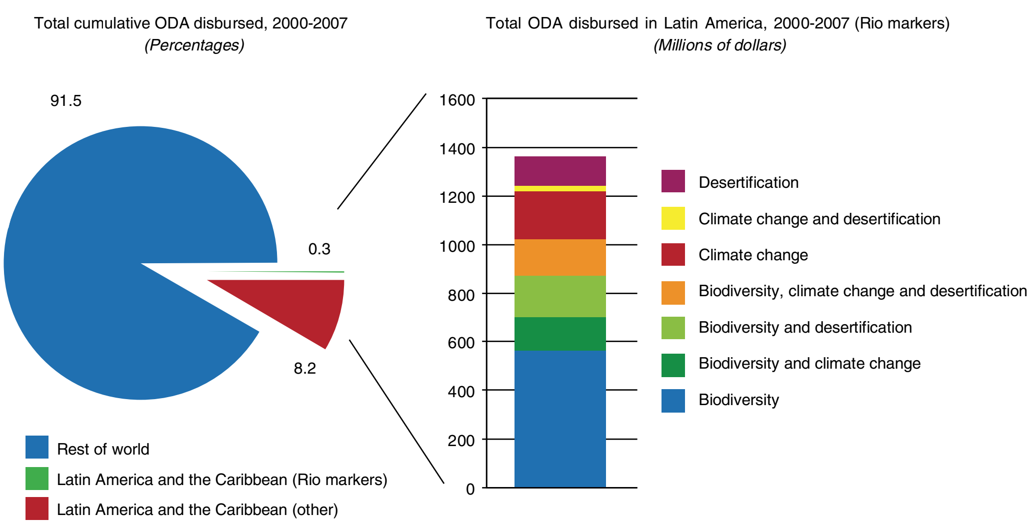
Policy implementation by the region's governments will need to be complemented by international cooperation as mitigation and adaptation come to take on greater prominence in developed-country agendas (UNEP/SEMARNAT, 2006). Much international cooperation has focused primarily on assistance to deal with the effects of natural disasters and far less on developing long-term responses (UNDP, 2007).[6] ECLAC has supported the region's countries with some of these components, such as disaster quantification, training to strengthen human resources and information sharing between countries with a view to standardizing methods and quantifying the economic consequences of climate change.

4. International financing for climate change adaptation

As the global estimates show, the inflow of international resources has not kept up with the financial requirements of adaptation. The funds invested in projects, programmes and technical development cooperation are still a long way from meeting the extra funding target agreed upon by the leaders of the Group of Eight at their 2005 Summit in Gleneagles (United Kingdom).[7]

The percentage of funds received as official development assistance in Latin America and the Caribbean during the 2000-2006 period was less than 9% (US$ 42 billion) of the world total (US$ 512.8 billion). Of this 9%, the funds for the Rio markers, which relate to climate change, desertification and biodiversity and other items, amounted to 0.3%, i.e., US$ 1.362 billion. In this period, the reported total for activities relating to climate change was some US$ 121 million (see figure III.2).

FIGURE III.2
LATIN AMERICA AND THE CARIBBEAN: OFFICIAL DEVELOPMENT ASSISTANCE (ODA), CLIMATE CHANGE ONLY



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organisation for Economic Co-operation and Development (OECD), "OECD StatExtracts" [online database] August 2009.

[6] The German technical cooperation agency (GTZ) runs a large adaptation programme in the Andean countries.
[7] The goal agreed by the countries at the 2005 Summit of the Group of Eight in Gleneagles was to lift official development assistance (ODA) from US$ 80 billion in 2004 to US$ 130 billion in 2010. In 2007, the amount was US$ 104 billion.

The Global Environment Facility (GEF) was given a mandate by UNFCCC to finance climate change adaptation projects through three financing mechanisms:

- The Special Climate Change Fund for all developing countries, to finance technology transfer and economic diversification. This fund contains US$ 65 million, some of which comes from regular official development assistance resources.
- The Least Developed Countries Fund, which has mobilized US$ 165 million to finance the preparation and implementation of national programmes of action for adaptation in the 49 least developed countries.
- The Strategic Priority on Adaptation project, a fund which began operating in 2004 with the focus on adaptation projects to implement measures that would reduce countries' vulnerability. This fund has mobilized US$ 50 million in its pilot phase.

Since its establishment in 1991, the GEF has financed UNFCCC implementation to the extent of US$ 7.4 billion and mobilized another US$ 28 billion of cofinancing across all climate change-related issues. Of the amount allocated, 3% (US$ 280 million) has been applied to climate change adaptation initiatives and the rest to mitigation, national communications and capacity-building.

Latin America and the Caribbean have received US$ 544 million from the GEF for climate change-related activities via organizations such as the World Bank, the Inter-American Development Bank (IDB), UNDP and UNEP, while US$ 2,514 million of GEF cofinancing has been mobilized. About half of these totals has been allocated to capacity-building, national communications and adaptation, while the other half has been earmarked for mitigation and energy efficiency projects.

The World Bank (2007) has used other cooperation funds to finance projects in the region aimed at identifying critical impacts of climate change, such as the retreat of glaciers and bleaching of coral reefs and the projected repercussions on ecosystems and the environmental services these provide. It has also provided funding for mitigation projects involving sanitary landfills, energy efficiency, biomass, rural electrification and cleaner transport. The World Bank was given responsibility for administering the climate investment funds, to which developed countries had committed US$ 6.1 billion as of 2008 for investment and technology transfer with less intensive use of greenhouse gases (World Bank, 2008b).

The Adaptation Fund is a mechanism agreed upon in 1997 as part of the Kyoto Protocol. It was implemented at the thirteenth session of the Conference of the Parties (COP-13), held in Bali in 2007. The fund is financed out of a 2% tax on the value of all certified emission reductions (CERs) traded, with the aim of raising US$ 100 million by 2012 (Stern, 2006).[8] This fund was placed under the administration of the World Bank over the objections of some developing countries.

Among the initiatives supporting adaptation activities is the Ibero-American Network of Climate Change Offices (RIOCC), supported by the regular participation of the region's countries; and the German and French cooperation. The Andean Development Corporation (ADC) has funds available for climate change adaptation, particularly disaster reduction, under its recent Disaster Risk Management Programme (PREVER), which supports projects and activities to manage and reduce El Niño-related risks and vulnerabilities, adapt and reduce vulnerability to climate change, provide disaster relief where necessary and carry out risk prevention from a municipal perspective. The global mechanism of the Convention to Combat Desertification has made progress with research into the economic cost of soil degradation in certain of the region's countries.

8 Taxation of developed countries' market operations is still the subject of intensive negotiations.

C. Summary

- Adaptation to climate change is very important for Latin America and the Caribbean, but research to quantify the economic costs of the impacts expected from it has only just begun. Changes are gradual for the time being, making it difficult to separate climate change from the climate variability experienced in the past. There are undoubtedly barriers to adaptation, including present costs, which are clearer than the uncertain benefits that might perhaps arise in the future, and the way costs are currently shifted on to other sectors and future generations. Early adaptation ought to be the prudent attitude, as it would allow costs to be better spread over time.
- Adaptation may seem untimely or unnecessary from the economic standpoint, however. The idea of a more prosperous future thanks to technological development means that adaptation decisions are postponed, and the need to respond does not seem urgent given the long timescales involved and the gradualness of change. It will not be easy to strike a balance between cost, timeliness, irreversibility, perception and the adjustment of decision-making mechanisms.
- Timely adaptation will allow costs to be properly and gradually managed, preventing them from being externalized or shifted from producers to consumers, from the private sector to the public sector and from current generations to future ones.
- Spontaneous adaptation is already in progress and has proven able to address the changes that have already begun in sectors such as agriculture.
- The implementation of a political framework chosen by the region's governments will need to be supplemented by the action and assistance of international organizations and donors, and this requires the commitment of developed countries to adaptation activities. International, regional and national financing for adaptation is increasing but is not enough to cover the estimated requirements of adaptation to climate change. GEF funds applied to adaptation in the region are estimated at US$ 280 million, while international funds have another US$ 230 million or so to be applied globally. Much greater funding has been allocated to mitigation, and this means that continued efforts are required to encourage contributions both from individual countries and from taxation of carbon market operations among developed countries.
- Adaptation also brings with it some opportunities to pursue more sustainable development, such as better infrastructure, crop variety research and development, the development of environmental service payment systems and better management of river basins, among other things.
- Most adaptation measures are already part of the development toolkit. It is recommended that greater efforts be made to create public goods such as monitoring, the generation of relevant information for early warning systems and the strengthening of instruments for good land use.
- It is important to document change in each country, however slow, because this information will be needed to overcome resistance to the increasing financial demands of what will be a slow, long-term process.
- The adaptation mechanisms that could be most effective include compulsory insurance for the creation and secure operation of infrastructure such as ports, highways, transport and telecommunications.

IV. Adapting to international responses: international trade and competitiveness

The debate about the relationship between international trade and climate change is being led by countries with emissions reduction commitments and has its origins in their concern about a possible loss of competitiveness in their export sectors if these have to compete with other exporters that have lower production costs and have not accepted climate obligations. This concern has brought new issues on to the trade agenda, such as carbon footprints, carbon leakage, life cycle assessment in the trade chain and responsibilities for global carbon accounting.[1] Besides these new issues, some longer-standing topics have moved up the trade agenda, examples being liberalization of environmental goods and services and the need for technology transfer to developing countries, but now with a greater emphasis on greenhouse gas emissions reduction technologies (World Bank, 2008a).

A. Competitiveness

Countries that have accepted emissions reduction commitments to address climate change are fearful of putting their energy-intensive industries at a disadvantage to competitors. The emissions reduction commitments of Annex I countries have caused attention to turn to measures such as carbon taxes, tradable emission rights (with upper limits) and technical barriers that include energy efficiency requirements.

Application of these measures in countries with emissions reduction commitments has led to changes in relative prices and in the differentiated and growing costs of emitting carbon, and thence to adjustments in production and consumption and new business opportunities, but also fears about a possible loss of competitiveness vis-à-vis the exports of countries that have not committed themselves to reducing emissions.

The key variables for sectoral competitiveness include the energy intensity of the production process,[2] the scope for passing on higher costs to the final consumer price,[3] the availability of

1 It has also brought pressure on developing countries to accept comparable commitments.
2 In a sector such as aluminium, for example, energy accounts for some 30% of total production costs.
3 This depends on the availability of substitutes, either in the domestic market or from external markets, which means that transport costs are critical.

technological options and opportunities for reducing emissions and the ability to dominate innovation processes and stay at the technology frontier to meet international demand for new products. However, it is very likely that the competitiveness of emissions-intensive production processes will be increasingly affected as the rising price of emitting carbon is transferred to operating costs.

In this new scenario, firms will be forced to move up the value chain and stop competing on the basis of low energy costs, doing so instead on the basis of new products and processes. At the same time, climate imperatives will progressively generate new opportunities to pursue competitive business advantages in low-carbon processes and products.

In any event, what is currently being discussed in trade forums is the existence of an uneven playing field for trade, where the exports of countries with different climate obligations and production costs are competing. This concern principally relates to major exporters such as the United States of America, China and India.[4]

1. The carbon footprint

One of the central issues in the competitiveness debate is the carbon embodied in internationally traded goods, what is known as the ‘carbon footprint’ or ‘virtual carbon’. From the life cycle perspective, internalizing the climate costs of carbon emitted in the production and transportation of traded goods and services is one of the options for allocating emissions mitigation costs by applying measures to those responsible, be they consumers or producers. Measures currently under discussion aim to penalize producers, for example, by applying a virtual carbon tariff to products in the market or equivalent measures.

Determining where the responsibility for reducing the carbon footprint lies is not straightforward, however. While the international regime lays emissions at the door of those who generate carbon in the production and transportation of goods and services, it is obviously for the benefit of consumers that these goods and services are produced and traded internationally. The responsibility for emissions generated in the course of trade could just as well be assigned to consumers, on the grounds that they are the prime cause of the carbon footprint.[5] Carbon accounting based on consumption would affect lifestyles more severely, and some countries that have succeeded in mitigating emissions from production may not have had the same success as regards consumption, and may therefore have a growing responsibility.

This argument has become more prominent because of the role played by China and India in international trade and their growing contribution to global emissions from production, which are mainly the result of demand from the developed countries that consume goods. An example of the opposite situation is provided by developed countries where consumption of carbon is increasing but not its production. The Kyoto Protocol focuses on commitments to reduce the emissions produced by each country and does not take account of the carbon embodied in imported goods, or consumption in general. Yet a more comprehensive view of the problem would require an approach encompassing both aspects.

A study prepared by the Norwegian University of Science and Technology (Peters and Hertwich, 2007) puts the CO_2 content of world trade at some 21.5% of global emissions. The study reveals that Annex I countries export 18.9% and import 24.5% of their domestic CO_2 emissions, meaning that they are net importers. To put it another way, they produce less carbon than they consume. Focusing on production alone does not fully reflect their global responsibility. Conversely, non-Annex I countries export 25.3% of their emissions and import 17.2%, which makes them net exporters of emissions. From this same standpoint, they are being held responsible for the CO_2 they

4 We should not forget, however, that the growth and competitiveness of the developed countries in the past was based on the ability to generate environmental externalities that reached the limits of sustainability.

5 The idea of holding consumers accountable for emissions has a precedent in offsets to mitigate emissions from air travel.

produce when in fact they are consuming less. Economically speaking, in the absence of a mechanism for internalizing the environmental impact of CO_2, countries that are net carbon exporters are generating a positive externality for consumers-importers because the environmental impact is not being internalized.

Table IV.1 provides some estimates of carbon content in international trade that were obtained for the study to illustrate the situation of some developed countries and four countries in the region.

TABLE IV.1
SELECTED COUNTRIES: EMISSIONS EMBODIED IN TRADE, 2001

	CO_2 production	CO_2 consumption	Exports	Imports
	(Millions of tons)		(Percentages)	
United States	6 006.9	6 445.8	8.3	15.6
Japan	1 291.0	1 488.8	14.5	29.8
Germany	892.2	1 032.1	25.3	41.0
Spain	305.7	336.7	26.4	36.6
Sweden	59.7	83.4	34.1	73.7
All Annex I countries	14 616.7	15 438.9	18.9	24.5
All non-Annex I countries	10 138.9	9 316.7	25.3	17.2
China	3 289.2	2 703.7	24.4	6.6
India	1 024.8	953.9	13.1	6.2
Mexico	389.9	407.5	19.4	23.9
Brazil	321.0	318.5	19.7	18.9
Venezuela (Bolivarian Republic of)	155.8	124.0	29.3	8.9
Argentina	120.4	118.4	18.4	16.7

Source: G. Peters and E. Hertwich, *CO_2 Embodied in International Trade with Implications for Global Climate Policy*, Norwegian University of Science and Technology , 2007.

The data in table IV.1 show that developed countries tend to be net importers of CO_2 emissions. The same is true of Mexico, which confirms that the country is fairly well insulated from growing climate requirements in international trade, reflecting an export structure in which medium- and high-technology products such as maquila goods predominate, a subject that will be touched on in the next section.

From a microeconomic standpoint, product and service life cycle assessment has been developed to improve global accounting of carbon embodied in production and some consumption and to better internalize carbon costs in trade, including international trade. This means including in the carbon footprint not only emissions at the production stage but also those at the stages of transportation, consumption and final disposal of the product or service, throughout the production chain.

This proposal could trigger major debates about equity (as it blurs the principle of common but differentiated responsibilities between countries by treating goods alike regardless of origin), and there are methodological difficulties involved in calculating carbon emissions. This is because today's globally organized production is characterized by increasing fragmentation (geographical, sectoral and functional) into different links that together form a country's global production chain, which adds complexity to the calculation of different countries' responsibilities. Further on, we discuss some progress made with the quantification of carbon footprints.

a) Some unilateral responses based on the carbon footprint

Some early unilateral trade initiatives by developed countries to create trade restrictions based on production processes and carbon content have moved climate change up the international trade agenda. Such measures would not only revive the old conflict at the World Trade Organization (WTO) over production processes and methods, with all the resistance this has aroused in developing countries, but would also open the way internationally for the creation of unnegotiated mechanisms and the application of trade barriers, on top of multilateral agreements. This is the case with initiatives such as carbon labelling in France from 2011 and the Markey-Waxman bill, or Clean Energy and Security Act of 2009, in the United States, which would seek to protect carbon-intensive domestic industries and commodity producers by forcing United States exporters and importers in certain sectors to purchase emission allowances in the United States to offset emissions embodied in imports.[6] A similar goal is aimed at by the Bingaman-Specter initiative, which targets the five main countries of origin for imports, including Brazil and Mexico. Both projects propose the adoption of internal limits in the United States and the application of border measures for certain imports from countries that have not adopted comparable policies. Other proposed restrictions would apply to specific countries and sectors, such as Chinese steel.

We shall now present the most important initiatives relating to carbon footprints and, indirectly, to international trade. It is very likely that these initiatives will gather strength and that developing countries —those of Latin America and the Caribbean in particular— will need to be prepared if they are to avoid a potential loss of export markets due to the appearance of competitors better equipped to cope with these requirements.

b) Progress with carbon footprint accounting

Concern about emissions, competitiveness and the carbon footprint has led different organizations to propose accounting and reporting models for the effects of greenhouse gases on products and services. The most important methodologies are backed by governments and seek to facilitate national standard-setting. Others aim to reduce emissions in production processes, while some are intended only to provide customers and governments with higher-quality environmental information. Countries such as France, Germany, Japan, the United Kingdom and the United States have made enormous progress in developing and applying methodologies for calculating carbon footprints so that this information can be included on labelling as an extra input in decision-making. They also believe that this type of accounting allows firms to work with their suppliers to reduce emissions.

Methodologies are of three types:

- General guidelines: ISO norms constituting reference standards for calculating CO_2 (ISO standard 14040 on Environmental Management – Life Cycle Assessment; BS ISO standard 14064-1:2006 on Greenhouse Gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals).
- Specific guides: PAS 2050, Bilan Carbone® or GHG Protocol for accounting, calculation and monitoring of greenhouse gases.
- Calculation tools for specific activities such as transportation or consumer behaviour.

In the short run, some of these initiatives are expected to give rise to obligations regarding carbon footprint information for consumers (in France and New Zealand, for example). In other cases, firms themselves will require suppliers in their production chains to report on their carbon footprint (such as Wal-Mart and Tesco). Table IV.2 presents some major national initiatives.

[6] Such as iron, steel, aluminium and cement.

TABLE IV.2
SOME CARBON FOOTPRINT MEASURING AND REPORTING INITIATIVES

Country	Initiative	Date	Website	Information
France	Bilan Carbone	Since 2002	French Government website (in French)	Government support for trials of carbon labels (some 3,000 products labelled in 2009)
France	Grenelle Environnement process	Since 2007	French Government website (in French)	Government environmental agenda (in support of Bilan Carbone)
Germany	Product Carbon Footprint (PCF) pilot product	Since 2008	PCF website	Pilot project run by a business consortium trialling carbon footprinting of products and services (10 firms, 15 labels in phase 1 in 2008)
Japan	Ministry of Economy, Trade and Industry (METI) guidelines on product carbon footprinting	Since 2009	METI website	National government guidelines for product carbon footprint calculations and carbon labels (including product category rule specifications)
New Zealand	New Zealand Greenhouse Gas Footprinting Strategy	Since 2007	MAF NZ website	National strategy for calculating and reducing carbon footprints
New Zealand	Pastoral GHG Research Consortium	Since 2004	Pastoral GHG Research Consortium website	National academic and commercial consortium supporting measurement and reduction of carbon footprints (mitigation for pasturing activities)
United Kingdom	PAS 2050	Since 2008	Carbon Trust website	Government-supported guidelines for product carbon footprinting (used in the United Kingdom and elsewhere)
United Kingdom	Tesco	Since 2007	Tesco website	Leading supermarket trials carbon labels, based on PAS 2050 methods (about 100 products)
United States	Clean Energy and Security Act	Since 2009 (pending Senate ratification)	Website of the Committee on Energy and Commerce	Section 274 of legislation requires EPA to trial voluntary product carbon disclosure system
United States	Wal-Mart Sustainability Initiative	Since 2007	Wal-Mart website	Leading company trials carbon footprints of products from 40 suppliers

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Learn about Carbon [online] http://www.learnaboutcarbon.net/qa/which-initiatives-are-driving-development-product-carbon-footprints.

The initiative that is furthest advanced as regards its effects on economic activity is that of France, which will be compulsory from 1 January 2011. The main characteristics of the different methods are presented below.

(i) Germany: Product Carbon Footprint (PCF) pilot product[7]

The goal of the Product Carbon Footprint (PCF) pilot project in Germany is to prepare a product carbon footprinting standard, using the United Kingdom PAS 2050 as a reference. The project was started in April 2008 by a group of academics and non-governmental and business organizations working with firms in different sectors, such as food, retailing, chemicals, telecommunications, packaging and consumer goods. The process is similar to the PAS 2050 preparation process. In January 2009, the promoters and partners of the PCF project presented the first results of the pilot for 15 products in Berlin. The results of the second phase were announced at the PCF world summit in September 2009.

7 See [online] http://www.pcf-projekt.de/main/news/.

(ii) United States: 2009 Clean Energy and Security Act

The United States Clean Energy and Security Act, known as Markey-Waxman bill H.R. 2454, is a law aimed at making the country's economy cleaner in its energy use while lowering its impact on global warming. The idea behind the bill is to increase production on the basis of renewable energies, increase energy efficiency and reduce greenhouse gas emissions. Section 274 of the bill provides that the Environmental Protection Agency (EPA) is to design a voluntary carbon disclosure programme and evaluate its effectiveness.[8] Access to financial support measures and application of the standards deriving from the law require a major emissions measurement effort in the electricity, oil and transport industries, among others. Where trade is concerned, the bill provides for the implementation of a government compensation scheme for industries that are energy-intensive and produce commodities for the international market. Should this compensation be insufficient to maintain the competitiveness of these activities (measured by their capacity to produce and create jobs), the Executive is empowered to apply border measures that will oblige exporters to the United States and importers in the country to buy and hold international emissions reduction certificates to offset the virtual carbon or carbon footprint of the products imported, with the exception of countries considered by the United States to be among the least developed and those responsible for less than 0.5% of global emissions (section 416 of the bill).

The EPA has also created the Climate Leaders programme, a partnership between industry and the State whose purpose is to help companies design greenhouse gas emissions reduction strategies by completing a corporate-wide inventory of their greenhouse gas emissions based on a quality management system, setting aggressive reduction goals and annually reporting their progress to EPA. Participants in the programme include firms such as Boeing, Kodak, IBM, Pfizer and 3M. As of July 2009, a total of 284 companies were recognized by EPA as climate leaders.

(iii) Spain

In Spain, the Organic Business Association of Andalusia (EPEA) is currently implementing a project in conjunction with the Regional Government of Andalusia to create a carbon footprinting system for the agricultural produce of that community. The information will be included on food labelling.

(iv) France: Bilan Carbone®

Bilan Carbone® is a methodology and tool created and distributed by the French Environment and Energy Management Agency (ADEME) in 2002 and is now in its sixth version. It is an accounting method for direct and indirect greenhouse gas emissions associated with the activities of businesses and other administrative bodies and associations. Emissions are classified by source in an Excel spreadsheet which calculates the emissions associated with each activity in a process (Padilla and Galio, 2007). This tool was developed to quickly convert production activity data (such as energy consumption, number of lorries, distance travelled and tons of steel purchased, among others) into emissions, using emission factors.

(v) France: Grenelle Environnement process

From 1 January 2011, it will be compulsory in France for products to carry labelling with information on their carbon content and the estimated environmental impact of their assembly. This is a result of the Grenelle Environnement process that began in 2007 with a commitment by the French President to make sustainable development a central priority. This process provided the country with specific legislation to give consumers access to information, which is supposed to be transparent, objective and complete, on a product's carbon footprint, excluding consumption, and the environmental impact of its packaging. Acting through the Ministry of Environment, the French

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[8] See [online] http://energycommerce.house.gov/Press_111/20090720/hr2454_sectionsummary.pdf and http://markey.house.gov/index.php?option=content&task=view&id=3583&Itemid=125.

Government has created databases on emissions by product family or emission factors for each product family.[9]

One of the measures proposed as part of the Grenelle Environnement process was the introduction of a carbon tax (*contribution climat-énergie*) in the 2010 national budget, as has already been done in other European countries. A charge per metric ton will be levied on CO_2 emitters with a view to reducing consumption of fossil energy and encouraging membership of emissions trading schemes.

(vi) Japan: Ministry of Economy, Trade and Industry (METI) guidelines on product carbon footprinting[10]

In March 2009, the Ministry of Economy, Trade and Industry of Japan (METI) published guidelines on voluntary carbon footprint labelling for certain products, developed by experts with input from some public consultations. These guidelines include product category rules to avoid inconsistencies when similar products are evaluated. The system measures CO_2 emissions over the whole life cycle of the product or service, from purchasing of the raw material to disposal or recycling, and the results are shown on a specially designed label. The Ministry will use the guidelines and product category rules as a pilot project, the Carbon Footprint Calculation and Labelling Pilot Programme. This project covers 30 firms, which will introduce the system into the market. These guidelines will be compiled in the form of technical specifications and will be recognized by the Japanese Industrial Standards Committee. Labelled products include foods and drinks. The initiative is based on the British model adopted by Tesco and other firms while the local scheme awaits official approval. These guidelines are one response to the reduction commitment adopted by Japan under the Kyoto Protocol (a cut of 6% from the 1990 emission level by 2012). The Ministry of Agriculture, Forestry and Fisheries, the Ministry of the Environment, the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Health, Labour and Welfare are also participants.

(vii) New Zealand: New Zealand Greenhouse Gas Footprinting Strategy[11]

This initiative was organized in 2007 by the Ministry of Agriculture and Forestry (MAF), with the involvement of the primary sector, in response to growing pressure from importers for more information on the greenhouse gas intensity of primary products. The goal is to measure and reduce the emissions of firms that produce from the land in order to increase their competitiveness in the international market. This means settling upon an agreed, internationally recognized methodology for calculating and reporting product carbon footprints.

(viii) United Kingdom: the PAS 2050 standard

In 2005, Carbon Trust, with the collaboration of the Department for Environment, Food and Rural Affairs and of British Standards (BSI), began to design a methodology to allow firms to measure and identify opportunities for reducing emissions in their production chains. In March 2007, with new research and the participation of different stakeholders, Carbon Trust launched a voluntary initiative to measure, reduce and report on greenhouse gas emissions in the life cycle of products. The initiative sought to encourage firms to reduce emissions right along the production chain on the basis of reliable, consistent and transparent information on these emissions, by helping them to adopt abatement measures appropriate to their needs or capabilities. The information is summarized in three framework documents released in October 2008:

- A standardized method for assessing the life cycle greenhouse gas emissions of goods and services (PAS 2050). This document sets out how greenhouse gas emissions are to be measured over the life cycle of a product.

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9 Manufacturers may use specific emission factors as long as they can demonstrate their soundness to the French Government.

10 See [online] http://www.japanfs.org/en/pages/029056.html.

11 See [online] www.maf.govt.nz/climatechange/slm/ghg-strategy/.

- A framework for reducing the emissions associated with a product. This establishes the conditions that have to be met to establish the credibility of claimed reductions in greenhouse gases, measured using PAS 2050.
- A code of good practice for reporting on the emissions associated with products.

Also created was the Carbon Reduction Commitment, a mandatory scheme for all companies whose electricity consumption exceeded 500,000 pounds sterling in 2008, which is to come into force in April 2010. It is estimated that some 5,000 organizations will be part of this commitment, including public-sector firms, banks, hotels and schools, which will have to register and disclose their energy consumption and the associated carbon footprint.

Tesco was a British pioneer in carbon footprinting and product labelling to allow consumers to make informed buying choices. According to Tesco executives, this initiative, which has been taken as a model in other countries, was undertaken in response to customer demand for information of this type.

(ix) Initiatives in Latin America and the Caribbean

The issue is only just beginning to receive recognition in Latin America and few countries have begun to engage with specific initiatives to carbon footprint export products as a preventive strategy. Existing measures are a response to the new demands of export markets or transnational buyers. Most interest has been created by projects associated with the Clean Development Mechanism (CDM) that require carbon footprinting.

In Chile and Peru, some firms in different sectors have begun to carry out voluntary carbon footprint accounting throughout their production chains and this has led them to modify management systems and invest in cleaner machinery, processes and technologies.

BOX IV.1
THE CARBON FOOTPRINT OF THE CHILEAN AGRICULTURAL SECTOR

In 2008, as part of its climate change programme, the Ministry of Agriculture measured the carbon footprint of the forestry sector. A number of firms (Masisa, Mininco, Bosques Cautín and Demaihue) supported the project with a view to making their activities carbon-neutral. In 2009, Fundación Chile, in alliance with international specialists, measured the carbon footprint of the Arauco group for forestry products. This initiative was backed by an independent United States consultancy, Aecom Environment.

In the 2008-2009 application round of the “Agricultural export products carbon footprinting studies” programme, the Agricultural Innovation Foundation (FIA) approved a project for the La Cruz Agricultural Research Institute (INIA) covering fruit, vegetables and cereals, including packaging and transportation to the destination country. To complement this, the Association of Chilean Exporters conducted a number of studies to measure the carbon footprint of apples, dessert grapes and blackberries, in collaboration with ProChile and the Ministry of Agriculture, through FIA. Universidad Santo Tomás is working with Gesex, an export firm, to study the carbon footprint of grapes and apples in the Metropolitan Region and the VI Region.

Among winemakers, in June 2007, Ventisquero carbon footprinted its wine transportation operations to the United Kingdom and was awarded a certificate by Climate Care, a British private-sector organization that charges per ton of CO_2 emitted. In 2008, Cono Sur, Santa Carolina, Casablanca and Tarapacá neutralized the carbon footprint of emissions from sea transportation of the wines they exported. Concha y Toro carbon footprinted its production processes and activities, including transport, when this was required by its customer Wal-Mart.

The British Chilean Chamber of Commerce officially launched a competition for carbon measurement and control by its member firms. This initiative has already been joined by some member firms such as Shell, Xstrata Copper, HSBC, Unilever, PricewaterhouseCoopers, RBS and Seawind, and the plan is to roll it out nationwide in 2010.

Source: Economic Commission for Latin America and the Caribbean (ECLAC).

Other restrictions stem from concerns that are of long standing in the trading system but are now affecting important products in the context of climate change, examples being the antidumping duties imposed by the European Union on fluorescent light bulbs from China and the tariffs applied to sugar cane bioethanol from Brazil.[12]

The WTO entry of oil exporting countries will undoubtedly entail structural changes in energy trading and use. It could lead to an eventual reduction in strategic control over prices and output in the industry and to changes in the WTO approach to environmental issues and in global climate action.[13] Again, as energy is brought under WTO disciplines and energy sources are increasingly differentiated by their levels of carbon emissions (fossil energy in comparison with clean and renewable energies, for example), the conflict over production processes and methods that has aroused such resistance in developing countries is likely to be renewed.

2. Carbon leakage

A second important issue, closely tied to fears about a loss of competitiveness, is carbon leakage. This is the possibility that industrial activities may be relocated in response to restrictions on greenhouse gas emissions in the countries covered by Annex B of the Kyoto Protocol, with energy- and carbon-intensive industries moving production to developing countries that are not subject to similar constraints on their greenhouse gas emissions, thereby reducing industrial emissions in one part of the world only to increase them in another.

The relocation of industries would be a real threat to the attainment of climate goals, as long as these are based on production. One example illustrating this fear is the carbon content of audio and video equipment exported by China to the United States, totalling 27.4 million metric tons of CO_2 ($MtCO_2$) in 2003. The same equipment produced in the United States would have had a content of 21.4 $MtCO_2$, almost 25% less. This difference in carbon content is the result of relatively high carbon use for electricity generation in the production process and less efficient technologies in China. The extra carbon emissions embodied in the trade of China with the United States over the 1997-2003 period are put at a total of 720 $MtCO_2$, which is about 17% more than the total CO_2 emissions of Canada in 2003 (Bin and Harris, 2007, pp. 3-5) and roughly matches the total annual emissions of Mexico.

It could also be argued, however, that United States consumers were transferring to China the emissions they needed to maintain their consumption level.

A study of carbon leakage in the steel sector indicates that a tax of US$ 25 per metric ton of CO_2 applied in Europe and Japan would have led to leakage of 50% by 2020, falling to 35% if the tax were only US$ 12 per metric ton of CO_2 (Gielen and Moriguchi, 2002).

In any event, what is dominating the debate in the developed countries is concern about the weakening of global emissions reduction measures and the economic and social repercussions of relocating industry away from the developed countries, with their commitment to reducing emissions.

B. Technology transfer opportunities

The aim of international climate policy is to make carbon emissions-intensive technologies less competitive in the developed countries (Annex I countries), particularly as operating costs increasingly reflect a rising carbon price, and to favour the rapid spread of clean technologies, which are essential to climate mitigation efforts.

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[12] The United States applies a tariff of US$ 0.41 a gallon to imports of Brazilian ethanol.

[13] For example, there would be a ban on practices such as "dual pricing", commonly applied to energy to promote domestic industrialization, and competition policy rules could limit the scope for producers to use international agreements to protect themselves against falling prices.

More technology transfer is also important to improve the energy and environmental performance of developing countries. Technology transfer has not taken place on a global scale, however, whether because of pricing issues, intellectual property protection or anticompetitive practices. One question that arises is whether WTO rules could be hindering the rapid spread of technology (Roffe and Santa Cruz, 2007), particularly emissions reduction technology, which would indicate that trade negotiators should consider introducing certain climate-related amendments into the WTO Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement and the relevant provisions of regional free trade agreements, with flexibility, for example, in mandatory licensing or in authorizing generic copying or reverse engineering against payment of royalties to the patent holder.[14] This would represent a challenge but also an opportunity, bearing in mind how difficult it has been to introduce flexibilities in the past, most obviously in the area of public health.[15]

Again, it has been shown (Holm Olsen, 2005) that clean development mechanism projects in developing countries have not been as successful as expected in changing investment patterns in the sectors with the greatest climate change impact, such as power generation, transport and industrial energy use projects. Investment rules in the sphere of trade were likewise not designed to promote climate-friendly investments in countries.

It may be necessary to develop a low-carbon investment regime in pursuit of the dual objective of rapidly spreading key emissions reduction technologies while at the same time boosting the competitiveness of sectors that are dynamic in international trade.

C. Adaptation of foreign direct investment (FDI) and the competitiveness of industries with high carbon emissions

As was mentioned in the previous section, a number of studies have focused on geographical divergence in CO_2 production and consumption as a result of international trade, highlighting the elevated carbon content that trade represents for many countries or groups of countries. The CO_2 content of trade is very closely linked to a country's export specialization. The exports of countries with fewer environmentally sensitive industries will have a lower CO_2 emissions content at the production stage.[16]

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14 The basis of intellectual property is that its owners have a legal right to deny third parties the use of a good or service on a particular territory. The internationalization and harmonization of intellectual property protection stemmed from the internationalization and liberalization of trade in goods and services and the need for goods protected in a particular territory to retain that privilege when exported to another territory. Although the purpose of strengthening multilateral disciplines relating to the protection of intellectual property rights has been to encourage the emergence of new technologies in markets, the need to strike a balance between the rapid spread of patented technologies and protection for them in the context of climate concerns could require the introduction of flexibilities into the WTO TRIPS Agreement, much as happened with the 2001 agreement on public health-related aspects of intellectual property rights.

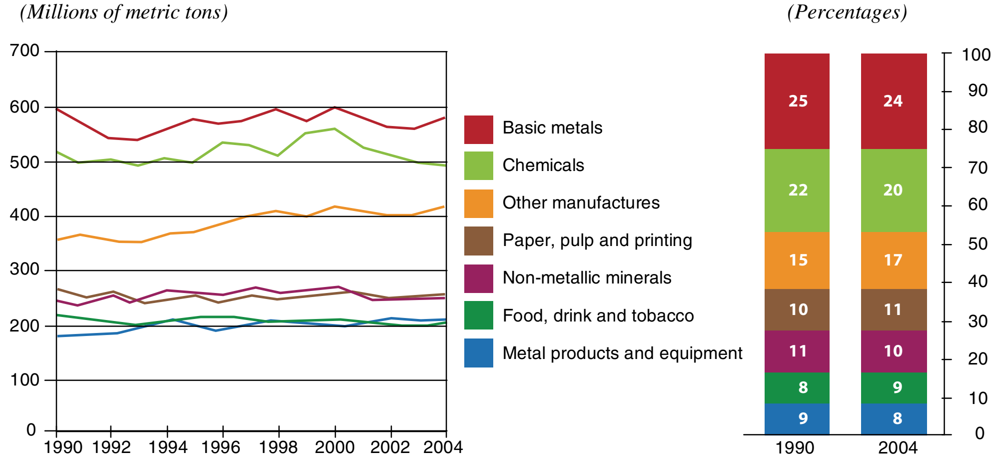
15 At the time, the 2001 Declaration on the TRIPS Agreement and Public Health was considered a real milestone in the history of the international trading system and the agreement was ultimately a clear manifestation of political will on the part of the countries. It basically reiterates the flexibilities of the TRIPS Agreement regarding the compatibility between protection for health or any public interest measure and protection for intellectual property. It thus recognizes that the TRIPS Agreement "does not and should not prevent Members from taking measures to protect public health (…) the Agreement can and should be interpreted and implemented in a manner supportive of WTO members' right to protect public health and, in particular, to promote access to medicines for all".

16 This group includes iron and steel, non-ferrous metals, industrial chemicals, pulp and paper and non-metallic minerals, which are not only highly polluting industries but are almost always very energy- and capital-intensive, are responsible for the most emissions into the different environments per unit of output, employ relatively few people and are not dynamic components of world trade (only 10% of them are in the group of industries that are dynamic in world trade). The location of environmentally sensitive industries' production is explained by developments in the relative prices of energy, capital and natural resources and, in future, the carbon price.

The following chart illustrates International Energy Agency (IEA/OECD, 2007b) estimates for CO_2 content in certain developed-country manufacturing subsectors, with the highest emission levels being found in mining.

Again, the destination sectors for investment, its characteristics in terms of emissions intensity and its role in technology transfer are vital considerations in the effort to move towards less contaminating, less carbon-intensive and more knowledge-based production systems so that development patterns can be made more sustainable and less damaging to the climate of the recipient country.

FIGURE IV.1
CO_2 EMISSIONS BY MANUFACTURING SUBSECTOR



Source: International Energy Agency/Organisation for Economic Co-operation and Development (IEA/OECD), *Energy Use in the New Millennium. Trends in IEA countries*, Paris, 2007.

In addition to the sectoral effects of foreign direct investment (FDI), markets have been opening up to the outside world. The relative price changes and reallocation of resources that have resulted from this are influencing the industrial specializations and export profiles of the Latin American and Caribbean countries, essentially because of three effects:

- The scale effect: economic activities will expand if trade and investment grow, and if the nature of these activities remains unchanged then total pollution and energy use will grow as well.
- The composition effect: as economies open up, countries tend to redistribute their resources to reflect their comparative advantages, thus tending to specialize in sectors that may have a greater or lesser climate impact. In many of the region's countries, this has provided a stimulus to investment, production and exports in polluting energy- and capital-intensive industries.
- The technology effect: this refers to changes that may occur in production processes depending on whether or not new technologies are incorporated into them. It is strongly linked to pollution and to energy and carbon emissions intensity per unit of output.

These effects are important for sectoral climate change adaptation options in the region. The quality of investment, the target sectors and its role in technology transfer will determine the environmental impact of the countries' involvement in the international economy.

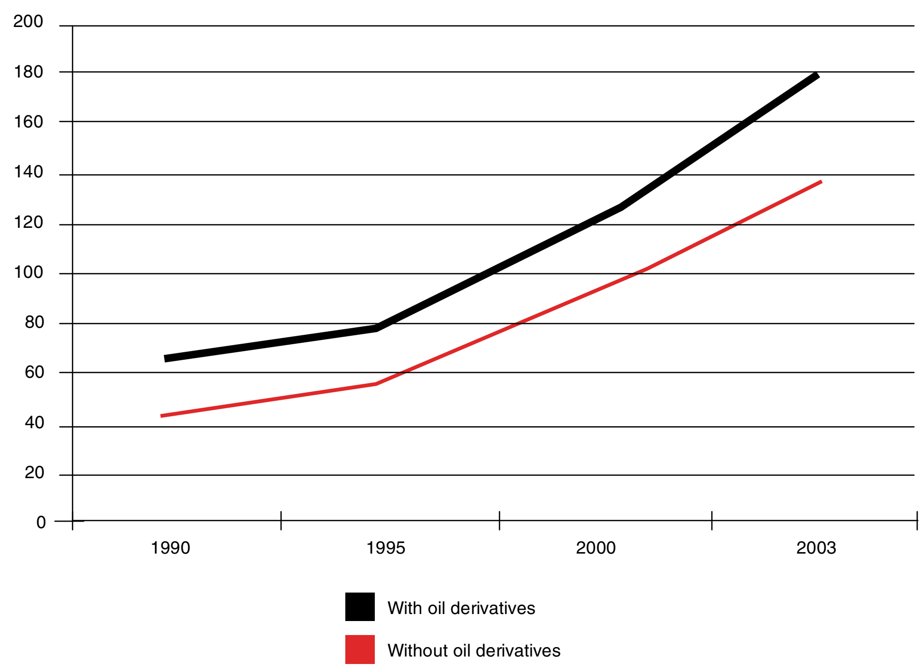
While it is difficult to form a precise idea of the environmental and climatic consequences of foreign direct investment (FDI) in the countries of Latin America and the Caribbean, the data on incoming FDI indicate that it has played a crucial role in the selection of large-scale projects involving the extraction of natural resources for export. We also know (Romo, 2007) that, particularly in South America, FDI has been a determining factor in the growing competitiveness of environmentally sensitive industries, which in turn has increased the opportunity cost of leaving natural resources unexploited and thus placed greater pressure on them.

What has finally been taking shape in the region, and South America in particular, is an export structure (in many countries a competitive one) based on highly polluting energy- and capital-intensive industries. Although regional exports have grown enormously over the past decade, the reallocation of resources that has taken place in most of the region's countries has often boosted investment, output and exports in environmentally sensitive industries, while most of the world's advanced economies are adopting trade patterns in which the role of such industries is clearly diminishing as they consolidate less carbon emissions-intensive export patterns with a higher technology content (ECLAC, 2008a).

This environmentally sensitive export pattern is also making it harder for the region to move towards a low carbon economy and respond to growing climate demands in its export markets.

As figure IV.2 illustrates, the volume exported by industries of this type trebled in the countries of Latin America and the Caribbean during the period from 1990 to 2003, with most of these exports going to industrialized-country markets.

FIGURE IV.2
LATIN AMERICA AND THE CARIBBEAN: VOLUME EXPORTED BY ENVIRONMENTALLY SENSITIVE INDUSTRIES TO THE REST OF THE WORLD
(Millions of tons)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of the Foreign Trade Data Bank for Latin America and the Caribbean (BADECEL).

An analysis of individual export profiles reveals great heterogeneity in the region's countries, however, with large variations in the share of total exports contributed by environmentally sensitive industries. In other words, some of the region's countries are more vulnerable to potential restrictions than others (see table IV.3).

TABLE IV.3
LATIN AMERICA AND THE CARIBBEAN (SELECTED COUNTRIES): SHARE OF ENVIRONMENTALLY SENSITIVE INDUSTRIES IN THE EXPORT TOTAL, 2003-2004
(Percentages)

Jamaica	63.0
Trinidad and Tobago	55.0
Chile	45.4
Barbados	38.0
Venezuela (Bolivarian Republic of)	36.1
El Salvador	25.2
Colombia	19.0
Argentina	18.0
Guatemala	13.6
Uruguay	10.5
Bolivia (Plurinational State of)	10.2
Mexico	7.9

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of the Foreign Trade Data Bank for Latin America and the Caribbean (BADECEL).

Although the contribution of environmentally sensitive industries to the export total is an important piece of information, it does not tell us whether a country is competitive in that product group. This is established by calculating the revealed comparative advantage (RCA) index, where a score greater than one means a country is internationally competitive.[17]

Figure IV.3 shows the 2004 RCA index values for environmentally sensitive industries presented by Latin America and the Caribbean in five markets: Latin America and the Caribbean, developing Asia,[18] Western Europe,[19] North America[20] and the industrialized countries.[21] The calculation was performed both with and without Mexico, as the country's importance in regional trade could skew the results for the whole region. The findings show that the region, excluding

[17] The revealed comparative advantage (RCA) index is calculated as $RCAij = (Xji/Xjt)/(Xit/Xtw)$, where *j* is a product or industry (SITC, Rev. 1), *i* a country, *w* the world and *t* the total. It measures changes in a country's share of exports for product *j* in world exports of that product *j*, comparing this with changes in the country's total exports as a share of total world exports, i.e., weighting the result by the country's size. If $RCA>1$, the country has a comparative advantage in the product, i.e., its share of the world market for that product is greater than its share of world exports overall. If $RCA<1$, it has no comparative advantage in that product.

[18] The developing Asia market includes: China, Cyprus, Hong Kong Special Administrative Region, India, Indonesia, Jordan, Macao Special Administrative Region, Malaysia, Nepal, Oman, Pakistan, Philippines, Qatar, Republic of Korea, Saudi Arabia, Singapore, Syria, Thailand and Turkey.

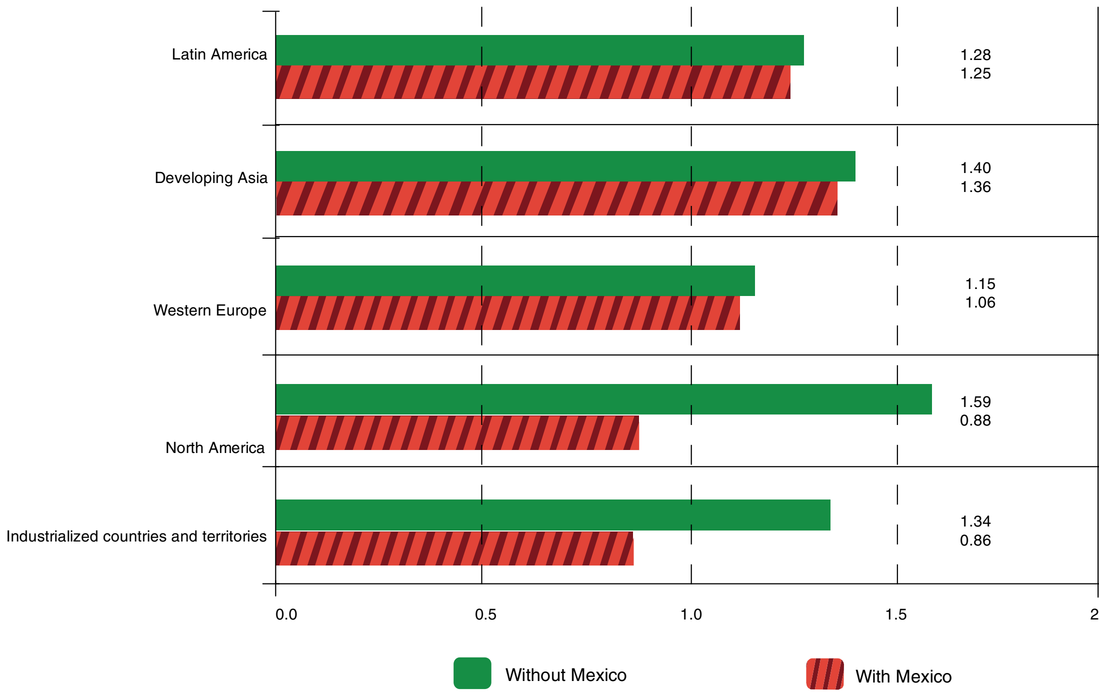
[19] The Western Europe market includes: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Guadeloupe, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Martinique, Monaco, the Netherlands, Norway, Portugal, Réunion, Spain, Sweden, Switzerland and the United Kingdom.

[20] The North America market includes: Canada and the United States.

[21] The industrialized countries and territories market includes: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Guadeloupe, Iceland, Ireland, Israel, Italy, Japan, Liechtenstein, Luxembourg, Martinique, Monaco, the Netherlands, New Zealand, Norway, Portugal, Réunion, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Mexico, is highly competitive in developed-country markets, where this group of industries could face growing climate demands in a not too distant future.

FIGURE IV.3
REVEALED COMPARATIVE ADVANTAGE INDEX FOR ENVIRONMENTALLY SENSITIVE INDUSTRIES IN FIVE IMPORT MARKETS
2004



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of TradeCAN 2006 Edition software.

In terms of orientation towards environmentally sensitive or higher-technology industries, the findings on export competitiveness and specialization likewise reveal a high degree of heterogeneity between countries, making it misleading to generalize about the climate vulnerability of the export profile of the region as a whole (Romo, 2007):

- Chile and Trinidad and Tobago and, to a lesser extent, Peru and the Bolivarian Republic of Venezuela have the largest share of environmentally sensitive industries in their export profiles, making them more vulnerable to the new climate demands.
- Costa Rica and Mexico present higher-technology export profiles and are less vulnerable.
- The situation in the rest of the countries varies: some, such as Argentina and Brazil, have more balanced profiles, with environmentally sensitive industries operating alongside medium- and high-technology ones.

Foreign direct investment has played a fundamental role in shaping the different export profiles. Mexico has attracted investment into medium- and high-technology sectors, which has helped create a cleaner export pattern. In other cases, such as Chile, Peru and the Bolivarian Republic of Venezuela, the impact of FDI has helped to consolidate a more polluting export pattern (see table IV.4).

TABLE IV.4
LATIN AMERICA AND THE CARIBBEAN (SELECTED COUNTRIES): FOREIGN DIRECT INVESTMENT (FDI) IN ENVIRONMENTALLY SENSITIVE INDUSTRIES
(Millions of dollars and percentages of total FDI)

	1996	1997	1998	1999	2000	2001	2002
Brazil	606	1 032	741	2 132	2 117	3 820	2 520
	6.3	**5.9**	**2.8**	**6.8**	**6.3**	**18.1**	**13.5**
Bolivia (Plurinational State of)	73.1	325.8	500.1	407.2	410.1	442.6	519.4
	17.1	**38.1**	**48.7**	**40.3**	**49.2**	**53.1**	**49.7**
Chile	1 586.5	2 074.2	2 855.9	1 611.8	414.6	1 549.3	2 110.8
	32.8	**39.7**	**47.8**	**17.7**	**13.8**	**31.9**	**63.5**
Ecuador	302	555.3	753.6	602.9	680.4	1 119.9	1.062.6
	60.4	**76.7**	**86.6**	**93.0**	**94.5**	**84.2**	**83.3**
Trinidad and Tobago	322.9	949.9	587.5	451.9			
	90.6	**95.0**	**80.3**	**70.3**			
Venezuela (Bolivarian Republic of)	1 087	3 164	1 731	2 045	1 354	2 204	541
	49.8	**57.2**	**38.5**	**62.2**	**30.3**	**63.9**	**39.5**
Mexico	1 635.2	1 054.7	1 267	1 580.1	1 925.8	510.8	
	16.4	**7.3**	**10.3**	**12.3**	**12.5**	**2.0**	
Peru	131.9	88.8	140.9	281	34.9		
	11.3	**8.5**	**17.7**	**20.1**	**2.4**		

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information provided by the United Nations Conference on Trade and Development (UNCTAD).

Creating an export structure that is more attuned to sustainable development aspirations and less vulnerable to climate demands means channelling investment towards more dynamic production sectors that combine technological innovation with value added. This would also reduce the environmental impact and carbon intensity of national economies. To return to the case of Mexico, the country's exceptional export pattern, dominated as it is by medium- and high-technology products, could not have come about without foreign direct investment in the electronics sector and automobile industry. A high-carbon export profile implies that countries are emitting carbon as part of their production activities to satisfy consumers in the developed countries, who are the main buyers. This is why, as mentioned earlier, it is so important for there to be a debate about the equitable distribution of mitigation costs, which must include consumers, and about the way climate costs are shifted to developing countries. From the standpoint of this analysis, the region is essentially a producer of emissions, except for Mexico, which is also a consumer.

D. Summary

Adaptation includes adjusting to changes caused by the way developed countries respond to their mitigation needs in areas such as trade and investment. Trade may be restricted on the basis of the carbon content of goods and services, including transport.

Developing countries will need to allow for the fact that the competitiveness of products based on production processes requiring high levels of emissions will be affected as the rising price of emitting carbon feeds through to their operating costs. Protection for exports should include better production processes and a gradual, coordinated improvement in energy efficiency rules for inputs (electric motors, for example) and tradable products (white goods).

Foreign investment may consolidate specialization and competitiveness in higher-emissions sectors, either because it results from policies to relocate production away from countries committed to restricting carbon emissions or because the predominant concern is to exploit natural resources and generate rent. This investment pattern may have consequences for the possible future costs of moving towards cleaner production patterns in the region's countries. It is recommended that investment authorization and infrastructure tendering or construction processes should incorporate carbon intensity as a factor in both construction and operation. It would also be advisable to develop methods of transportation for international trade that were less emissions-intensive.

In a context of new trade restrictions based on carbon content, carbon accounting at the different stages of the life cycle (production, transportation and consumption) takes on particular importance. Hitherto, carbon accounting has been applied to producers and not consumers. Other than Mexico, the region's countries are net producers of carbon, i.e., they emit carbon to cater to consumption beyond the region. Consequently, the distinction between carbon production and consumption is an important one for the region. It would also be advisable to create institutional mechanisms for identifying virtual carbon content in international trade (labelling) in future, in case more stringent requirements should be imposed or pursued.[22]

[22] International trade includes both imports and exports.

V. Latin America and the Caribbean in the global energy context

Any regulatory changes in world energy consumption made by industrialized countries to mitigate their CO_2 emissions are bound to impact on the climate, and changes in energy companies' strategies can affect world energy markets and the dynamic of relative prices. This, in turn, would have macroeconomic and fiscal effects, depending on the energy mix of importing countries, and negative repercussions for exporting countries.

The speedier development and marketing of new technologies that alter demand for fuels and the relative share of the different generation sources will also modify prices and compel countries to take steps to absorb technological change more effectively.

Lower unit costs for new energy technologies could intensify the changes in investment in gas, oil, coal, nuclear energy and renewable energy planned by Latin American and Caribbean countries to meet demand and guarantee supplies.[1]

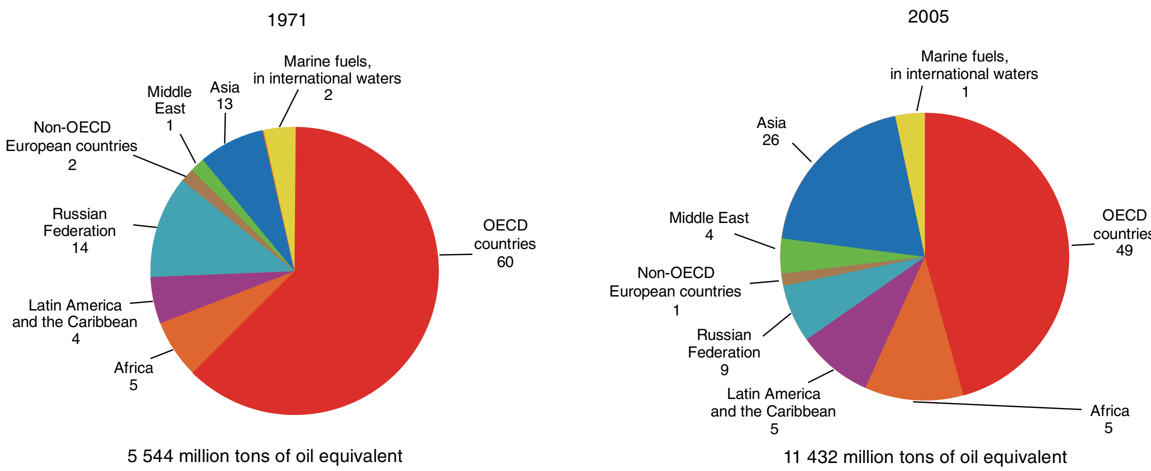
It is therefore imperative to take into account the world energy situation and the scenarios of industrialized countries regarding the world's energy future and the way in which the Latin American and Caribbean region fits into these scenarios. This chapter aims to gain a better understanding of these issues and it is based on the study *Energía y Cambio Climático: oportunidades para una política energética integrada en América Latina y el Caribe* (Acquatella, 2008), which was produced as an input to this project document.

1 For instance, a country may rule out a comparatively inexpensive investment in fuel oil in favour of more expensive gas-powered generation. However, compared with a shift from fuel oil to natural gas in an OECD country, it could become economically unviable if gas prices were to rise and fuel oil prices were to fall, as this would leave the developing country with a costly investment and a higher operating cost, and it would be required to convert back to fuel oil.

A. Latin America and the Caribbean in world primary energy supply

Between 1971 and 2005, the increase in Latin America's share of world primary energy production (4%-5%) was the lowest of all the developing regions and comparable only with that of Africa. In contrast, Asia's share —including China— increased from 13% to 26%, and that of the Middle East rose from 1% to 4%. Even though the countries of the Organisation for Economic Co-operation and Development (OECD) continued to be the world's biggest energy producers during the same period, their share dropped from 60% to 49%. The trend was similar in the former Soviet Union countries, with their share shrinking from 14% to 9%. The developing world is increasing its share, whereas that of Latin America and the Caribbean has all but come to a standstill in relative terms, even though its supply more than doubled in absolute terms between 1971 and 2005, as figure V.1 shows.

FIGURE V.1
TOTAL PRIMARY ENERGY SUPPLY, BY REGION
(Percentages)

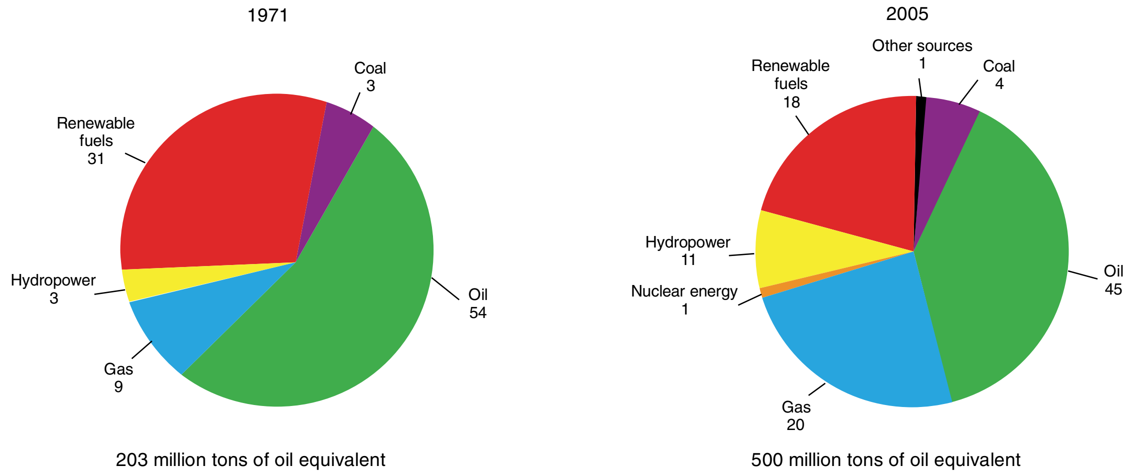


Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *Energy Balances of non-OECD Countries 2004-2005*, Paris, 2007.

1. Composition of energy supply

Up to 2005, oil was still the most important fuel in Latin America's primary energy supply, with a 45% share. The share of natural gas grew from 9% in 1971 to 20% in 2005, whereas that of coal —which has been rising in recent years— represented 4% of supply. Hydropower generation tripled from 3% to 11% between 1971 and 2005. The share of renewable fuels (fuelwood) fell from 31% to 18% during the same period, reflecting the urbanization process and people's increased purchasing power, whereas nuclear energy levelled off, representing only 1% of the region's primary energy supply (see figure V.2) (Acquatella, 2008).

FIGURE V.2
LATIN AMERICA AND THE CARIBBEAN: FOSSIL FUELS AS A SHARE OF TOTAL ENERGY SUPPLY
(Percentages)



Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *Energy Balances of non-OECD Countries 2004-2005*, Paris, 2007.

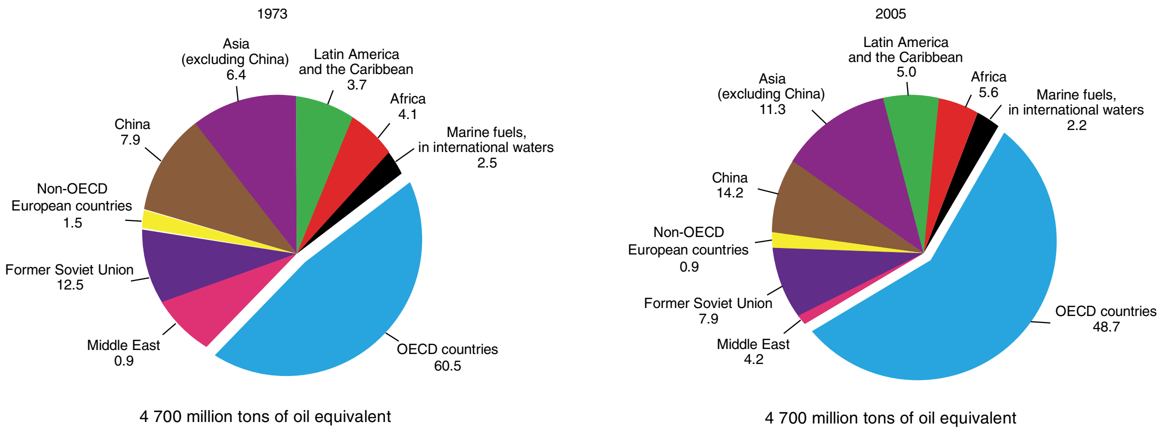
In 2005, fossil fuels represented roughly 69% of the region's energy supply, having risen from 66% in 1971, in step with the world trend. The reference scenario of the International Energy Agency (IEA) forecasts a continuation of this trend in the coming years, since the gas and coal industries are still growing relatively faster than the other energy sources in primary energy supply.

B. Latin America and the Caribbean in world energy consumption

Between 1971 and 2005, the world's final energy consumption grew at an average rate of 2.2%, with the highest demand from the transport, industrial and residential sectors (27%, 27% and 25% respectively in 2005). Up to 2005, most of the coal produced (78%) was for the industrial sector and 60% of oil products were for the transport sector, whereas natural gas consumption was divided between the industrial sector (35%) and the residential sector (33%).

During the period from 1973 to 2005, Latin America's share in final primary energy consumption grew from 3.7% to 5.0% of the world total. Figure V.3 compares the trend in the region's share of final primary energy consumption to that of other regions of the world. It shows that the OECD countries are the heaviest energy consumers, with a little under half of the world total (49%). Owing to stronger growth in energy consumption in developing regions, their share continued to fall (from 60.5% in 1973 to the current 49%). In the developing world, the highest growth in consumption occurred in China (from 8% in 1973 to 14.2% in 2005), the rest of Asia (from 6.4% in 1973 to 11.3% in 2005) and the Middle East (from 0.9% in 1973 to 4.2% in 2005).

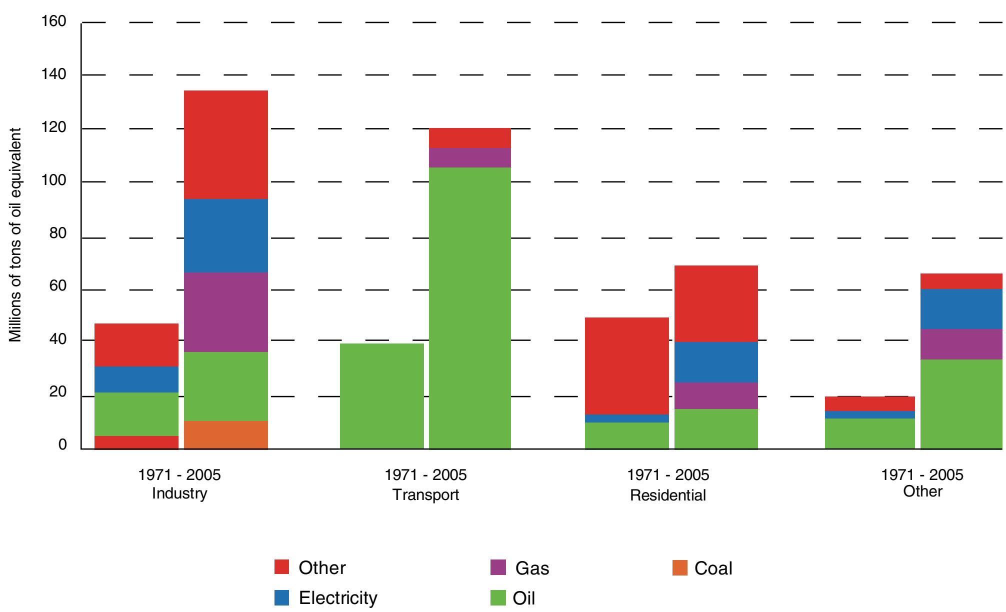
FIGURE V.3
FINAL PRIMARY ENERGY CONSUMPTION, BY REGION
(Percentages)



Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *Key World Energy Statistics, 2007*, Paris, 2007.

Figure V.4 shows the composition of final energy consumption in Latin America by sector during the period from 1971 to 2005, during which time both the industrial and transport sectors tripled their final energy consumption. With regard to increased demand by type of fuel, the transport sector was responsible for most of the oil consumption growth during this period. The rise in the industrial sector's energy consumption was based on a greater diversification of sources, with the highest growth occurring in electricity and natural gas consumption during the period.

FIGURE V.4
LATIN AMERICA AND THE CARIBBEAN: TOTAL FUEL CONSUMPTION, BY SECTOR
(Millions of tons of oil equivalent)



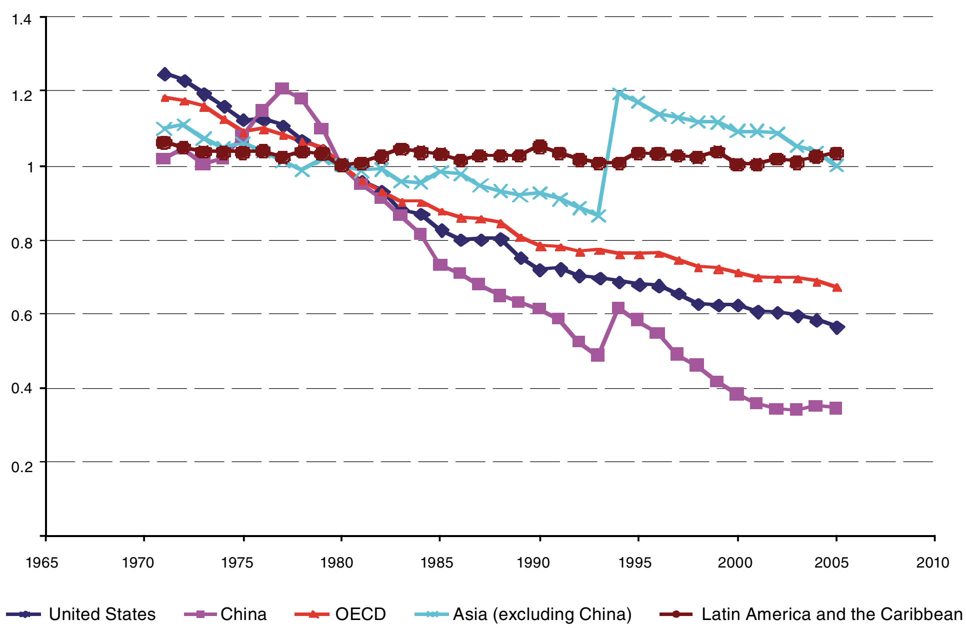
Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *Energy Balances of non-OECD Countries 2004-2005*, Paris, 2007.

C. Energy intensity in Latin America and the Caribbean[2]

The trend in energy intensity (the ratio between energy consumption and gross domestic product (GDP) in Latin America and the Caribbean during the period from 1980 to 2005 stagnated in comparison with the advances made in other regions. Figure V.5 shows that the region's indicator remained at practically the same levels as in 1980. However, in the world average, the European Union, which is known for its energy efficiency policies, and even the United States —with laxer energy efficiency policies— show a large reduction in this indicator during the past 25 years.

Latin America's stagnant energy intensity is very likely related to the weakness of, or lack of priority given to, energy efficiency policies in the countries of the region, which have an economic structure in which primary industry and the exploitation of natural resources play a larger role than the world average, and with the highest energy consumption in the transport sector, where efficiency has improved in relative terms.

FIGURE V.5
TREND IN ENERGY INTENSITY, 1970-2005 [a]
(Index 1980=1)



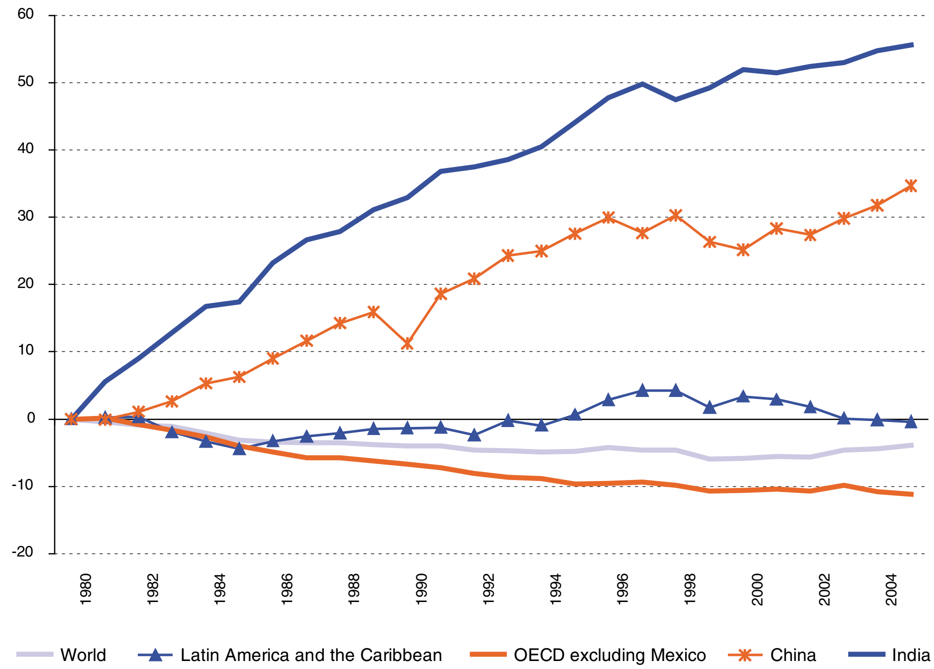
Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *Energy Balances of non-OECD Countries 2004-2005*, Paris, 2007 and Hugo Altomonte and others, "América Latina y el Caribe frente a la coyuntura energética internacional", *Project documents*, No. 220 (LC/W.220), Santiago, Chile, Economic Commission for Latin America and the Caribbean (ECLAC), 2008, section 1.4.1, pp. 30-32.

[a] Energy intensity is the ratio between total primary energy supply (TPES) and gross domestic product (GDP).

The carbon intensity of energy use in the region is also stationary, which points to opportunities for improving the technologies used and for meeting mitigation needs (see chapter VI). This stagnation is partly the result of the regulatory framework in the electricity sectors, which promotes highly carbon-intensive fast-return investments and energy security (see figure V.6).

[2] This section is based on Altomonte and others (2008), sections 1.4.1 and 1.4.2.

FIGURE V.6
CARBON INTENSITY OF ENERGY USE, 1980-2005
(Index 1980 = 100)



Source: World Resource Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 5.0", Washington, D.C., 2009.

D. The region in the International Energy Agency mitigation scenario between 2005 and 2030[3]

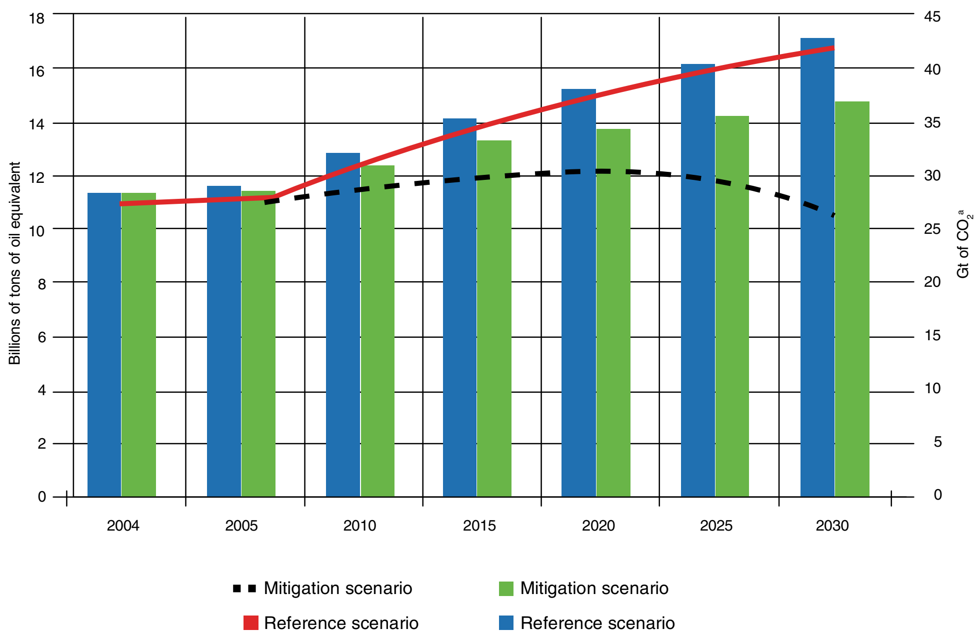
Of the climate change scenarios developed by IEA at the request of the Group of Eight (G8) summit, as part of the Gleneagles Plan of Action,[4] the "Beyond the Alternative Policy Scenario"(BAPS) for reducing CO_2 emissions is the one that best accommodates the assumption of stabilizing the Earth's average temperature to within a "prudent range" (IEA/OECD, 2006). This means stabilizing CO_2 concentrations in the atmosphere in the lower end of the range —450-500 parts per million— and ensuring that emissions in 2030 do not exceed 2005 levels.

[3] This section is partially based on Acquatella (2008), chapter 4.

[4] The Group of Eight Summit, held in Gleneagles (United Kingdom) in July 2005 —in which the Russian Federation, Brazil, China, India, Mexico and South Africa participated— centred on development strategies for mitigating climate change and guaranteeing clean energy and sustainable development.

This stabilization trajectory calls for sweeping technological, regulatory and institutional changes, as well as the mobilization of resources to modify prevailing trends in energy use and production. This is a bold mitigation scenario, with major energy efficiency improvements (15%), an increased share of renewable and nuclear sources, and faster deployment of new clean energy technologies to reduce emissions.[5] Figure V.7 illustrates the trajectory of energy supply and emissions in the mitigation scenario compared with the reference scenario in the region up to 2030.

FIGURE V.7
ENERGY SUPPLY AND GREENHOUSE GAS EMISSIONS UNDER THE REFERENCE AND MITIGATION SCENARIOS



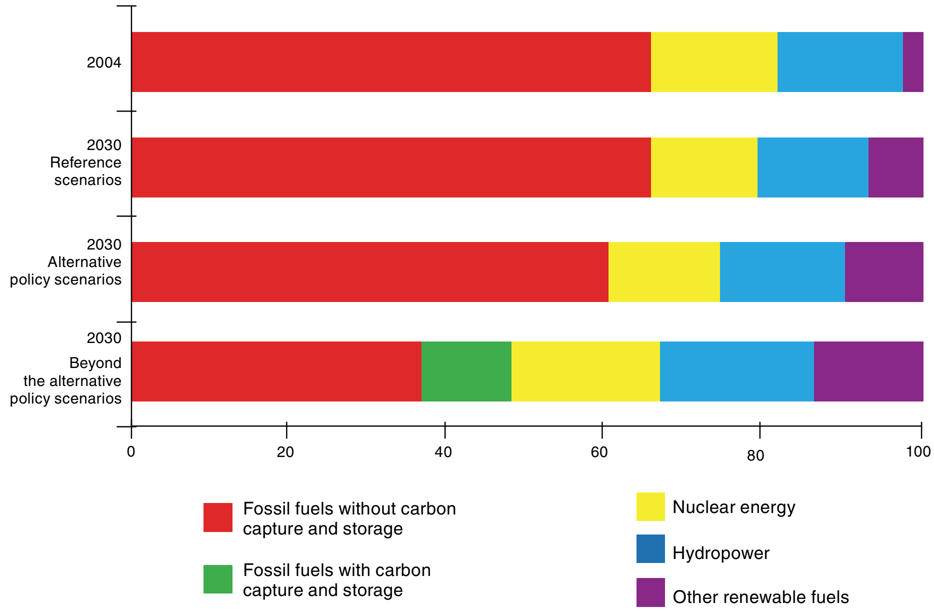
Source: United Nations Framework Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.

[a] Gigatons of carbon dioxide.

As figure V.8 shows, the energy-supply mix would be radically different from the reference scenario in 2030. Under the mitigation scenario, while coal remains the largest source of electricity, its share in power generation shrinks from 40% in 2004 to 26% in 2030, natural-gas-fired generation becomes the second largest source, with a projected 21% share in the region in 2030, and electricity generation from renewable energy, hydropower and nuclear energy grows, each representing approximately 17% of the total in 2030 (IEA/OECD, 2006 and 2007c).

[5] The Beyond the Alternative Policy Scenario does not include the need for increased electricity access (energy access) in developing countries. According to estimates by the International Energy Agency, 1.4 billion people would remain without access to electricity in 2030, and an investment of approximately US$ 25 billion per year (in addition to the beyond the alternative policy scenario) would be required to achieve full access to electricity in 2030.

FIGURE V.8
FUEL MIX IN POWER GENERATION UNDER DIFFERENT SCENARIOS
(Percentages)



Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *World Energy Outlook, 2007,* Paris, 2007.

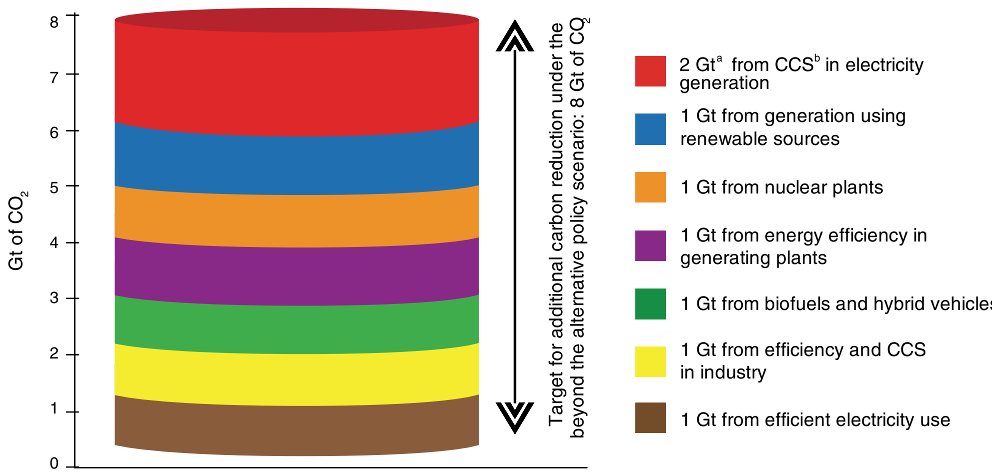
The policies and measures under consideration,[6] which IEA refers to as the alternative policy scenario, seek to decouple energy consumption growth from greenhouse gas emissions. Energy efficiency policies would be responsible for almost 80% of the avoided emissions, whereas the remainder would come from policies to promote switching of fuels or energy sources.

The contribution to avoided emissions can be broken down as follows: 36% from efficiency improvements in cars and trucks; 30% from more efficient electricity use in a wide range of applications, including lighting, air conditioning, household appliances and industrial motors; and 13% from more efficient energy production. Renewable energies and biofuels would account for 12% of the avoided emissions, while the remaining 10% would come from the use of nuclear energy.

In addition to these existing or announced policies, which IEA refers to as reference scenarios, IEA suggests seven areas of opportunity that could be exploited to ensure that emission levels in 2030 are the same as in 2005. Figure V.9 illustrates these seven means for achieving this goal, with their respective carbon reduction potential.

6 Around 1,400 have been formulated up to now.

FIGURE V.9
ADDITIONAL REDUCTIONS IN CO_2 EMISSIONS UNDER THE BEYOND THE ALTERNATIVE POLICY SCENARIO COMPARED WITH THE ALTERNATIVE POLICY SCENARIO
(Gigatons of CO_2)



Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *World Energy Outlook, 2006*, Paris, 2006.
[a] Gt: gigaton.
[b] CCS: carbon capture and storage.

- **Additional reduction in electricity demand**. The average efficiency in electricity use could be 50% greater than under the policies and measures announced to date. Two thirds of this additional reduction would come chiefly from more efficient electricity use in the residential and commercial sector, while the remainder would come mainly from more efficient industrial motors.

- **Measures in the industrial sector**. The suggested measures consist of increasing efficiency in fossil fuel use by 7% above that achieved with the measures announced to date. This would avoid half a gigaton of CO_2 emissions, and a further half gigaton could be cut by equipping industrial boilers and furnaces with small-scale carbon capture and storage (CCS) technology.

- **Cleaner and more efficient vehicles**. It is suggested to increase the share of hybrid vehicles in the region's light vehicle fleet to 60% by 2030, instead of the 18% that would be achieved with existing policies and measures, and to promote hybrid light vehicles that can be recharged from the electricity grid and biofuel use in road transport.

- **Increase in generation efficiency**. It is recommended to retire 30% of inefficient coal-fired power generating plants in addition to existing and announced measures, and to replace them with plants with 48% average efficiency, such as hydrogen power plants, which are more efficient than those considered under existing policies (with an average efficiency of 46%).

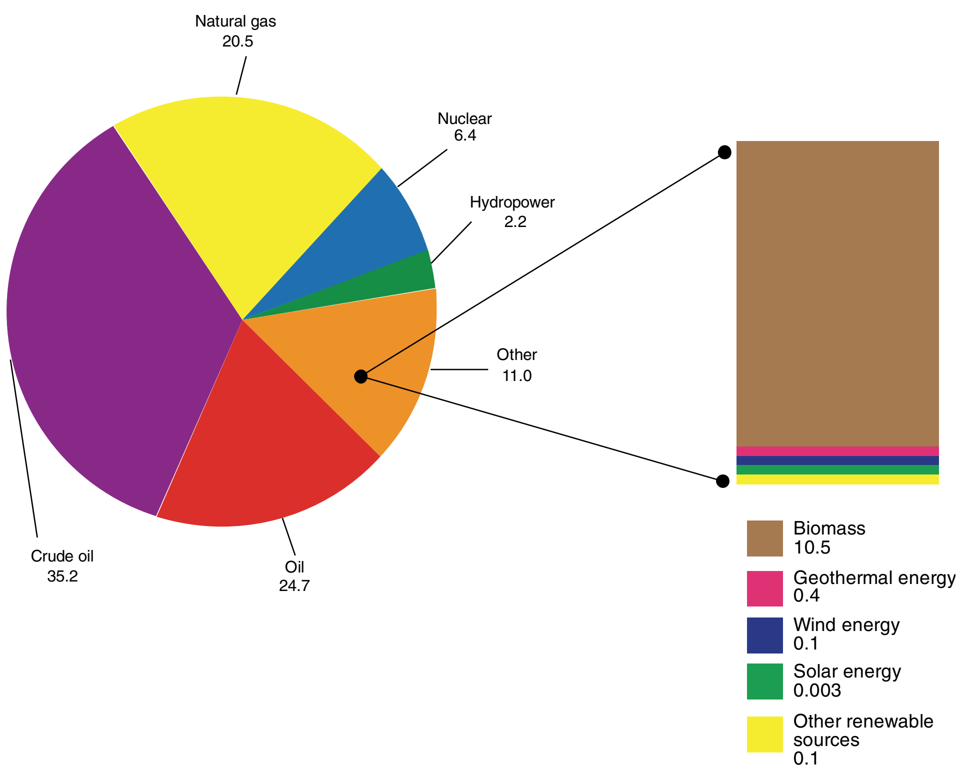
- **Increase in nuclear power plants**. These would replace coal-fired electric power plants, with 27% more efficiency than projected under existing and announced policies and measures (58% more than in the reference scenario).

- **Increase in renewable energy-based generation**. The scenario proposes that in 2030 the base share of electricity generation from renewable sources should be 32%, which is 5% more than under existing and announced policies and measures (or 10% more than in the reference scenario).
- **Introduction of carbon capture and storage technology in electricity generation**. Under the scenario, around 70% of new coal-fired plants and 35% of new natural gas-fired plants need to be equipped with carbon capture and storage technology.

No single policy could encompass all the different aspects that need to be considered when developing and deploying the required new technologies and technology replacements. Significant obstacles will also have to be overcome, such as political inertia, opposition from some quarters, and lack of information and understanding of the effectiveness of the opportunities that are opening up and their positive impact on economic development.

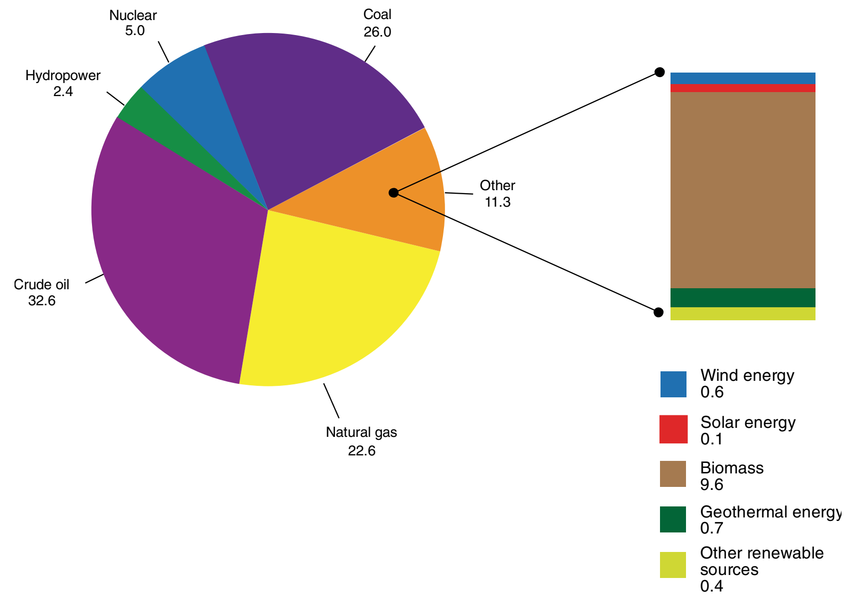
Figures V.10, V.11 and V.12 illustrate the changes required in the global primary energy mix between now and 2030.

FIGURE V.10
GLOBAL PRIMARY ENERGY MIX, 2004
(Percentages)



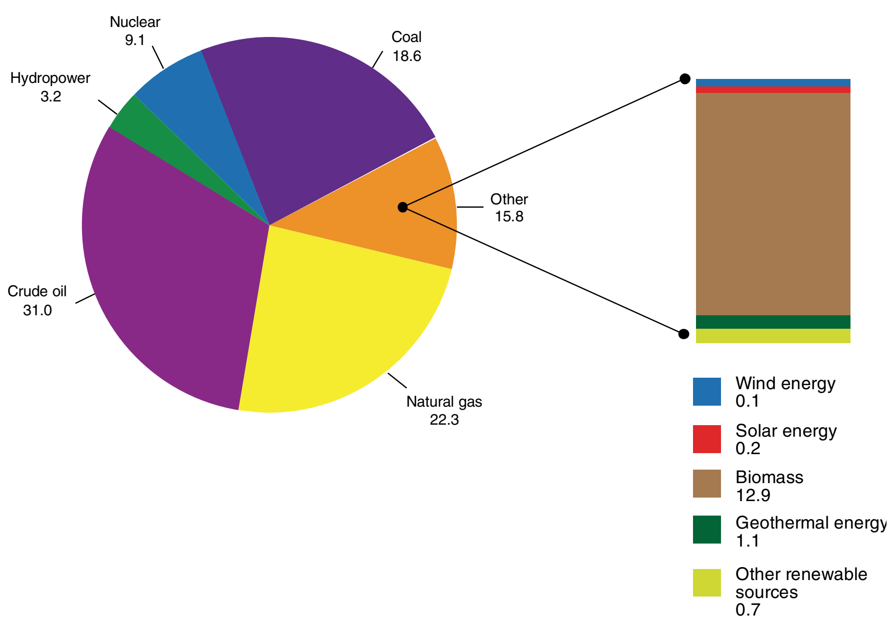
Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *World Energy Outlook, 2006*, Paris, 2006.

FIGURE V.11
GLOBAL PRIMARY ENERGY MIX UNDER THE REFERENCE SCENARIO, 2030
(Percentages)



Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *World Energy Outlook, 2006*, Paris, 2006.

FIGURE V.12
GLOBAL PRIMARY ENERGY MIX UNDER THE MITIGATION SCENARIO, 2030
(Percentages)



Source: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), *World Energy Outlook, 2006*, Paris, 2006.

Below is an analysis of some of the possible repercussions of implementing these scenarios in the Latin American and Caribbean region.

1. Estimated cost of additional efficiency measures[7]

(a) Construction sector

For Latin American and Caribbean countries, or any other developing economies, to harness these opportunities, they must set strict efficiency standards for equipment approaching the level of efficiency currently attained in OECD countries.

Under the IEA scenario, such measures would achieve a worldwide reduction of 554 megatons of CO_2, of which the Latin American and Caribbean region would contribute 4%. These 22 megatons would mean a reduction of around 10% compared with the projected tonnages for the region in 2030 under the reference scenario.

The Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC, 2007a) estimates that the cost for the construction sector would be around US$ 50.8 billion more than under the reference scenario (US$ 11.191 billion). Table V.1 shows the amount of additional investment required in the region.

TABLE V.1
LATIN AMERICA AND THE CARIBBEAN: ADDITIONAL INVESTMENT FLOWS NEEDED IN THE CONSTRUCTION SECTOR IN 2030
(Millions of dollars)

	Latin America and the Caribbean	Brazil	Mexico	Rest of Latin America and the Caribbean
Additional investment	2 000	400	900	700

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Framework Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.

(b) Industrial sector

The industrial sector, with the exception of petroleum refining, is responsible for around 27% of the world's energy consumption, 19% of energy-related CO_2 emissions and 7% of non-CO_2 greenhouse gas emissions (EPA, 2006).

Under the mitigation scenario, the largest contribution to fuel use reductions in the industrial sector comes from developing countries, as a result of technology changes associated with fuel switching and improvements in process heat and boiler efficiencies. Added to this is the use of high-efficiency engines in OECD countries. The largest global industrial energy savings result from increased efficiency in the iron and steel, chemicals and non-metallic minerals industries.

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[7] Based on Acquatella (2008), section 4.4.

In addition, the installation of small-scale carbon capture and storage technology in industrial boilers and furnaces would cut emissions by a further half gigaton, which would require regulations or installation subsidies. This would occur mainly in OECD countries, India and China, and this technology would start to be introduced later in Latin America and the Caribbean.

Achieving the projected emission reductions in the industrial sector will require aggressive policies for increasing energy efficiency. Such policies would need to include mandatory energy efficiency standards, emissions regulations, a pricing policy and related instruments to reduce the cost of capital for more efficient equipment, emissions trading systems for industrial sources and, in non-Annex I countries, intensive use of the clean development mechanism (CDM). Furthermore, regulations and/or incentives for the adoption of carbon capture and storage technology would be required.

These measures could achieve a reduction in CO_2 emissions in the Latin American and Caribbean region of as much as 298 megatons more than under the reference scenario by 2030. This is equivalent to a reduction of roughly 24%, which in turn represents 7.5% of the potential 3,974 megaton reduction that could be achieved worldwide in the industrial sector in 2030 under the IEA scenario.

The industrial sector's additional investment under the mitigation scenario is estimated to be around 1.5% more than that required under the reference scenario (UNFCCC, 2007a). Table V.2 shows the amount of additional investment required in the region.

TABLE V.2
LATIN AMERICA AND THE CARIBBEAN: ADDITIONAL INVESTMENT FLOWS NEEDED IN THE INDUSTRIAL SECTOR IN 2030
(Millions of US dollars)

	Latin America and the Caribbean	Brazil	Mexico	Rest of Latin America and the Caribbean
Additional investment	1 851	614	649	588

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.

The Latin America and Caribbean industrial sector would require a further US$ 1.851 billion in 2030, with US$ 295 million needed for carbon capture and storage technology, most of which would be implemented in Brazil (more than 67%), followed by Mexico (with around 5.5%).

(c) Transport sector

The transport sector accounts for around 25% of the world's final energy consumption, 58% of world oil consumption, 14% of global greenhouse gas emissions and 20% of CO_2 emissions.

As already mentioned, the IEA mitigation scenario relies on a significant increase in the share of hybrid vehicles in world vehicle ownership. Meeting the market penetration target of 60% in 2030 would cut 2 gigatons from the sector's estimated 8.7 gigatons of CO_2 under the reference scenario.

Table V.3 shows the amount of estimated additional investment needed in the region's transport sector under the mitigation scenario, based on the calculations of the UNFCCC Secretariat (2007a).

TABLE V.3
LATIN AMERICA AND THE CARIBBEAN: ADDITIONAL INVESTMENT FLOWS NEEDED IN THE TRANSPORT SECTOR IN 2030
(Millions of dollars)

	Latin America and the Caribbean	Brazil	Mexico	Rest of Latin America and the Caribbean
Additional investment	9 000	4 200	2 400	2 400

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.

The worldwide additional investment needed up to 2030 is estimated to be around US$ 87.9 billion, of which US$ 78.7 billion would be for hybrid vehicles and efficiency improvements in vehicles, and US$ 9.2 billion for biofuels. While the additional investment required in Latin America and the Caribbean represents only 10% of the world total, it would be the region with the highest additional investment in the biofuels sector in 2030, to the tune of US$ 2 billion. This would be nearly 22% of the total worldwide additional investment needed in the transport sector and would be concentrated in Brazil.

2. Carbon capture and storage technology in electricity generation

The worldwide introduction of carbon capture and storage technology in the electricity sector would enable CO_2 emissions to be cut by 2 gigatons in 2030, a target that would be achieved by equipping 70% of the new coal-fired installed capacity and 35% of the new gas-fired installed capacity with carbon capture and storage technology.

To achieve this, it is necessary to promote speedier maturing of this technology, with research and development investment from industrialized countries, incentives for large-scale demonstration projects, financial guarantees, international cooperation for the installation of carbon capture and storage technology in developing countries, emission standards in new plants and some sort of price signal for CO_2 emissions, by means of taxes, or systems of tradable carbon emission rights.

3. Nuclear power

Under the mitigation scenario, worldwide nuclear generation capacity would need to be expanded by a further 245 gigawatts (GW) in addition to the amount projected under the reference scenario (58.6%), to replace coal-fired electric power plants. This will require a reduction in the cost of capital for the construction of facilities and for minimizing waste disposal risks to increase public acceptance.

Under the mitigation scenario, non-Annex I countries are projected to quadruple their investment in nuclear sources, from US$ 3 billion to US$ 14 billion, while Annex I countries will need to increase their investment from US$ 12 billion to US$ 26 billion in the region by 2030.

Furthermore, the alternative scenario projects growth in nuclear-powered generation in Latin America and the Caribbean of 4 million to 12 million tons of oil equivalent between 2005 and 2030. This would represent an increase of 3% to 5% in total generation in 2030, or a 4.0% average annual growth rate during that period, which exceeds the projected world average of 1.6% nuclear-powered electricity generation during the same period.

4. Renewable sources in electricity generation

The potential exists to reduce an additional 1 gigaton of CO_2 emissions worldwide by increasing installed capacity for hydropower generation and by using other renewable sources. This investment would increase the share of renewable sources in total power generation to 32%, compared with the projected 22% under the reference scenario.

For this to happen it would be necessary to adopt such measures as customs and excise incentives, minimum requirements for generation from renewable sources, measures to reduce the cost of capital and technology standards to speed up cost reductions for these technologies.

5. Additional investment to supply energy under the mitigation scenario

Table V.4 analyses the estimated annual investment required in energy infrastructure up to 2030 under the reference scenario, compared with a mitigation scenario the energy supply characteristics of which have been analysed in this section.

TABLE V.4
LATIN AMERICA AND THE CARIBBEAN: INVESTMENT REQUIRED FOR ENERGY SUPPLY, 2030
(Billions of US dollars)

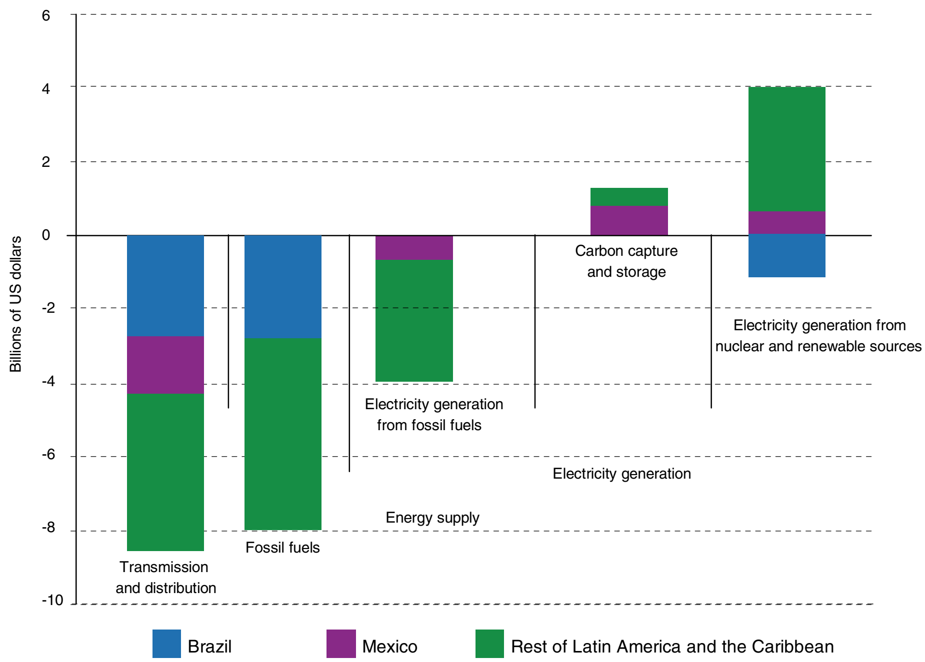
	Latin America and the Caribbean			Brazil			Mexico			Rest of Latin America and the Caribbean		
	R [a]	M [b]	Additional investment (Percentages)	R [a]	M [b]	Additional investment (Percentages)	R [a]	M [b]	Additional investment (Percentages)	R [a]	M [b]	Additional investment (Percentages)
Transmission and distribution	23.4	14. 8	-36.8	4.6	1.9	-58.7	6.1	4.5	-26.2	12.7	8.4	-33.9
Generation	15. 6	16. 2	3.8	4.4	3.4	-22.7	2.6	3.5	34.6	8.6	9.3	8.1
Supply of coal, oil and gas	25. 1	17. 3	-31.1	7.1	4.5	-36.6				18	12.8	-28.9
Total	64. 1	48. 3	-24.6	16.1	9.8	-39.1	8.7	8	-8.0	39.3	30.5	-22.4

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.
[a] Under the reference scenario of the International Energy Agency.
[b] Under the mitigation scenario of the International Energy Agency.

According to these estimates, there would be a reduction of around 24% in additional infrastructure investment required in 2030 to produce and import fossil fuel and to meet growth in energy demand in the region. This means that efficiency improvements would save some US$ 7.8 billion per year in net investment by 2030 by reducing hydrocarbon imports, and around US$ 8.6 billion per year in transmission and distribution infrastructure.

Figure V.13 also illustrates this trend in expected additional investment in the region, and shows that Brazil's performance differs within the overall potential investment savings, as the model estimates that Brazil can make further savings with generation from renewable and nuclear energy compared with the reference scenario. In Mexico and the rest of Latin America, additional net investment is expected to be available for expanding capacity in these sectors.

FIGURE V.13
ADDITIONAL ANNUAL INVESTMENT REQUIRED UNDER THE MITIGATION AND REFERENCE SCENARIOS, 2030
(Billions of dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.

6. Total additional investment required under the mitigation scenario

To conclude this section, table V.5 compares the additional investment required in energy supply by sector in Latin America and the Caribbean with that of other regions of the world, based on stabilizing global greenhouse gas emissions in the lower end of the range of 450-500 parts per million, and ensuring that CO_2 emissions in 2030 do not exceed 2005 levels.

TABLE V.5
INVESTMENT NEEDED TO IMPLEMENT THE MITIGATION SCENARIO, 2030
(Billions of dollars)

	Supply	Industry	Transport	Construction	Total
OECD	-17.9	13.4	44.6	33.3	73.4
Transition economies	-9.1	2.2	5.3	2.5	0.9
Asia	-9	16.3	20.5	9	36.8
Latin America and the Caribbean	-15.9	1.9	9	2	-3.0
Africa	-6.7	0.9	3.9	2.8	0.9
Middle East	-7.7	1.0	4.3	1.3	-1.1
World total	-66.3	35.7	87.9	50.8	108.1

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Convention on Climate Change (UNFCCC), *Investment and Financial Flows to Address Climate Change*, October 2007.

According to these estimates, the Latin American and Caribbean region —unlike the rest of the world, except the Middle East— would save on resources by implementing measures to achieve the IEA mitigation scenario. Some of the factors that explain the region’s distinctive situation are discussed below.

Owing to the characteristics of its energy sector, the Latin American and Caribbean region plays a very different role in each area of the carbon emissions mitigation scenario than the OECD countries—or even developing Asian countries. As described earlier, the region’s share in the global energy mix (approximately 4%) is secondary, meaning that it does not play such a crucial role in the global effort to reduce energy-sector emissions as the United States, Europe, China, India and others.

Moreover, it is a region that imports energy technology —with the exception of Brazil’s bioethanol technology— which places it in a position to absorb new power generation technologies or technology solutions for its greenhouse gas emissions, such as carbon capture and storage technology, as provided for in the mitigation scenario.

In addition, the penetration and dissemination of zero or near-zero emission transport technologies (including hybrid vehicles and fuel cells) is expected to occur first in countries with a higher per capita income than in Latin America and the Caribbean.

Consequently, the opportunities for Latin America and the Caribbean to contribute to the mitigation scenario are concentrated in efficiency improvements in energy use across all sectors (electricity generation, transport, industry, construction and other sectors). These opportunities have already been identified in the energy policy programmes of Latin American and Caribbean countries for some years now.

The ability to harness these efficiency benefits relies on strong political will and on governments’ ability to implement them. Furthermore, as discussed earlier, additional investment flows will be required in the construction, industrial and transport sectors, amounting to around US$ 5.2 billion in Brazil, US$ 3.95 billion in Mexico and US$ 3.69 billion in the other Latin American and Caribbean countries, over and above the reference scenario.

These efficiency improvements would make it possible to meet the region’s projected growth in energy demand by 2030 and to save on investment for expanding the energy supply (transmission and distribution infrastructure, avoided importation of hydrocarbons and avoided electricity generation from fossil fuels), to the total of some US$ 6.3 billion in Brazil, US$ 700 million in Mexico and US$ 8.8 billion in the other countries of the region.

In net terms, the savings in investment for expanding the energy supply are estimated to outstrip the additional investment flows needed to improve generating efficiency.

Despite the importance of models in attempting to understand the repercussions and assess the costs of different strategies for reducing greenhouse gas emissions and, in general, for exploring alternative policies and forming ideas of how the economy might respond to different regulations, they cannot predict future events, nor can they produce precise projections of the consequences of specific policies. This should be borne in mind when making use of the findings described above.

E. Summary

- The supply and consumption of fossil fuels in Latin America and the Caribbean are increasing in both absolute and relative terms. This trend is expected to worsen in the future at the expense of the share of renewable energies in the energy mix. Under the International Energy Agency scenarios, major opportunities exist in the region for improving energy efficiency, bringing economic benefits to virtually the entire region, especially in the industrial sector, where there is great potential for mitigation for a relatively minor investment.
- As fuel and technology prices fall, investment and financial flows into clean energies and energy efficiency are expected to increase. This is illustrated by the new financial mechanisms and investment funds recently established by multilateral and regional banks, such as the World Bank's Clean Energy for Development Investment Framework and Climate Investment Funds (CIF), the Inter-American Development Bank's Sustainable Energy and Climate Change Initiative (SECCI) and the Asia-Pacific Partnership on Clean Development and Climate promoted by the United States.
- The International Energy Agency model shows that the additional investment required under the mitigation scenario would be less than the projected imports and infrastructure savings under the reference scenario. In other words the additional effort would result in a net gain.
- Based on these findings, the region would benefit both economically and environmentally if it were to promote more efficient energy use and production and a more diversified energy mix.

VI. Greenhouse gas[1] emissions and mitigation measures

This chapter looks at the state of play regarding greenhouse gas (GHG) emissions and their main sources in Latin America and the Caribbean, and summarizes the mitigation standards and tools applied in some of the countries of the region.[2] It also examines the region's involvement in the carbon market and what the prospects might be in this regard.

A. Total greenhouse gas emissions

Global emissions of greenhouse gases amounted to 43.5 gigatons of carbon dioxide equivalent ($GtCO_2e$) in 2000 (including changes in land use), of which Latin America and the Caribbean produced 5.1 $GtCO_2e$, or 11.8%.[3] In 1990, the region was responsible for 13.4% of global emissions, with 5.5 $GtCO_2e$, but the estimate by IPCC Working Group I of 2004 placed the figure at 10.3% of the world total. As shown in figure VI.1, the level of GHG emissions produced by the Latin American and Caribbean region is relatively low and has fallen in absolute terms. Although emissions other than from land-use change rose in 1990-2000, the net result was a decrease in emissions owing to the behaviour of those relating to changes in land use.

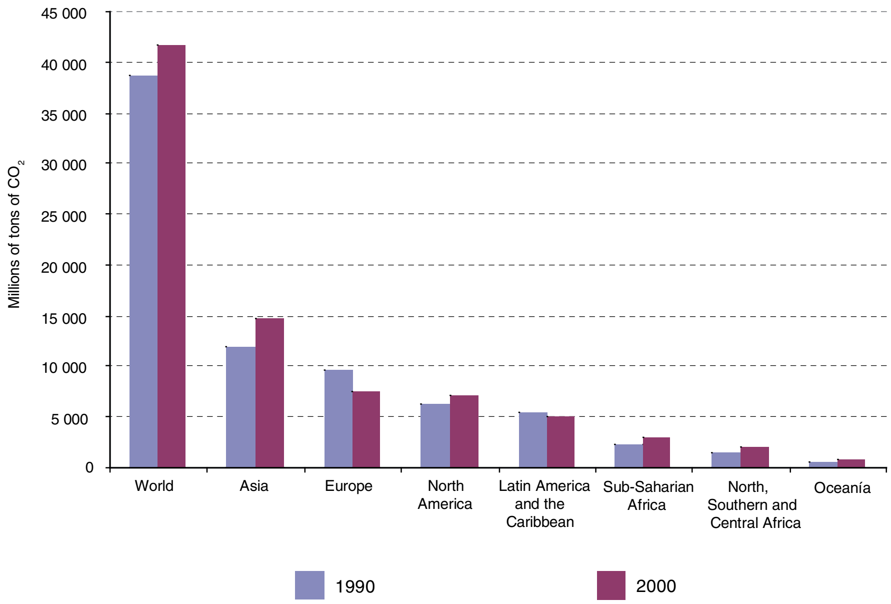
The region's largest GHG emitters are Brazil, Mexico, the Bolivarian Republic of Venezuela, Argentina and Colombia, which together account for over 70% of the regional total (see figures VI.2 and VI.3).

1 The greenhouse gases covered by the Kyoto Protocol are: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons and sulfur hexafluoride (SF6).

2 The main reference document used was *Climate Change 2007 - Mitigation on Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC*, which examines options for mitigating GHG emissions at the global level.

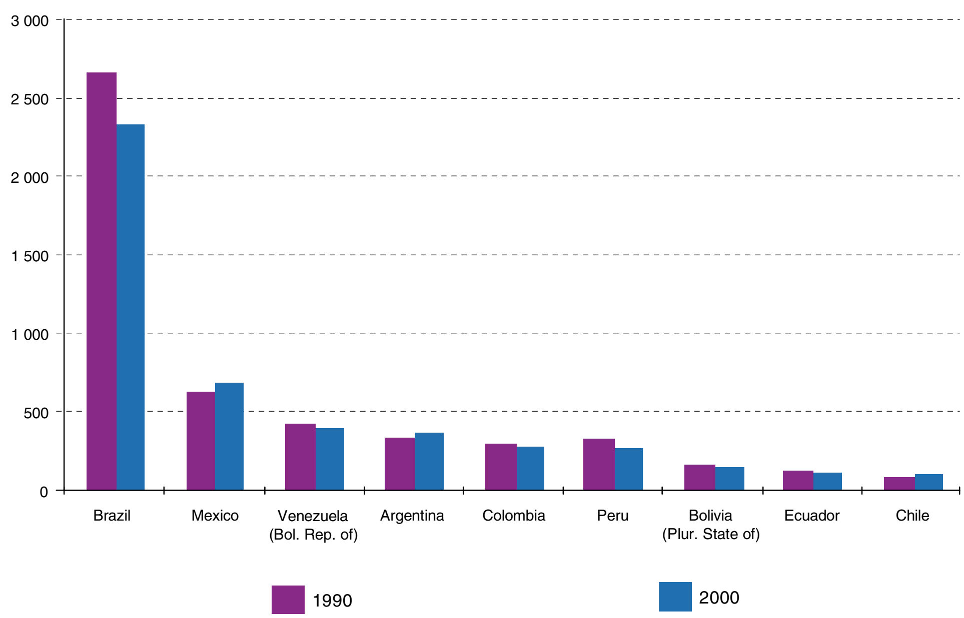
3 Figure obtained from WRI (2008).

FIGURE VI.1
WORLD DISTRIBUTION OF GREENHOUSE GAS EMISSIONS [a]
(Millions of tons of CO_2)



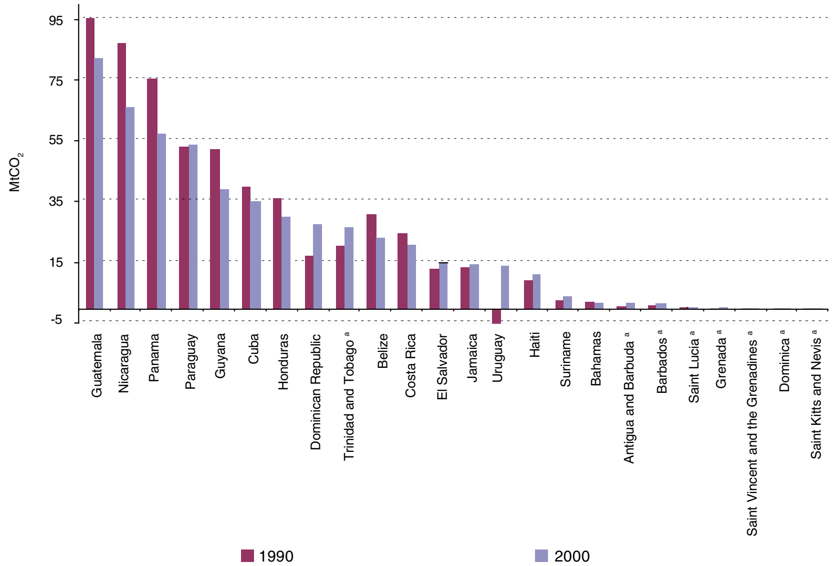
Source: World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT), Version 5.0", Washington, D.C., 2008.
[a] Includes emissions caused by land-use changes.

FIGURE VI.2
LATIN AMERICA: LARGEST EMITTERS OF GREENHOUSE GASES, 1990-2000
(Millions of tons of CO_2)



Source: World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT), Version 5.0", Washington, D.C., 2008.

FIGURE VI.3
LATIN AMERICA AND THE CARIBBEAN: GREENHOUSE GAS EMITTERS,[a] 1990-2000
(Millions of tons of CO_2)



Source: World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT), Version 5.0", Washington, D.C., 2008.

[a] Does not include Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Ecuador, the Plurinational State of Bolivia, Mexico or Peru.

[b] The source does not include data on land-use changes in these countries.

Per capita greenhouse gas (GHG) emissions. In 2000, the World Resources Institute (WRI) found that total GHG emissions in Latin America and the Caribbean stood at 9.9 tons of CO_2 equivalent (tCO_2e) per capita, down from 12.6 tCO_2e in 1990. The global average for 2000 was 7.2 tCO_2e. In the region, emissions excluding land-use changes amounted to 4.9 tCO_2e in 1990 and 5.4 tCO_2e in 2000. The 2000 global average for land-use change emissions was 5.9 tCO_2e. Emissions from land-use change have decreased, by contrast with a steady rise in those from the energy sector.

TABLE VI.1
GREENHOUSE GAS EMISSIONS, 1990-2000

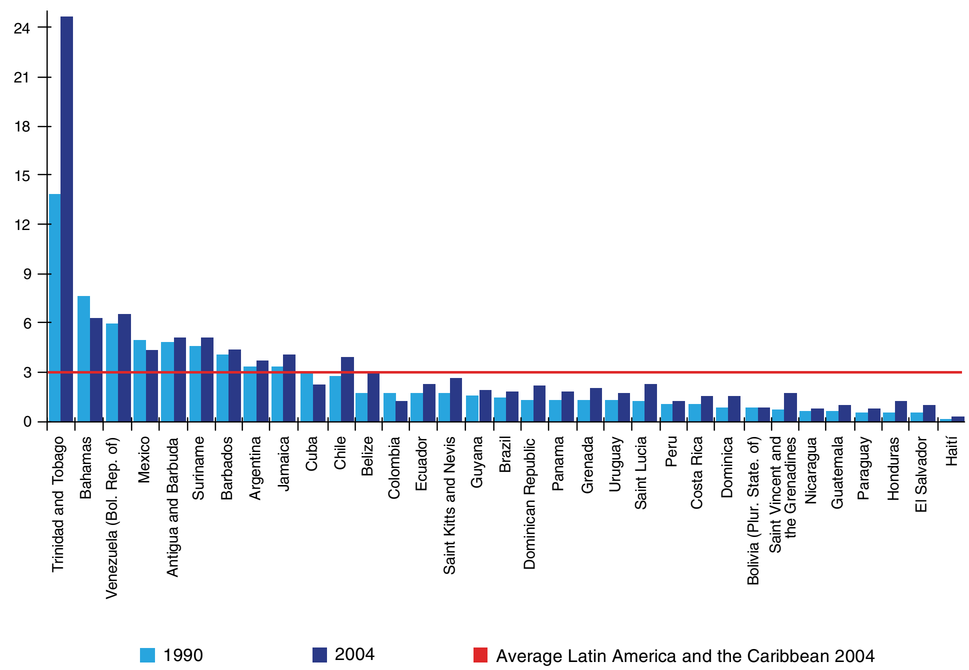
Annual GHG emissions [a]		1990		2000	
		World	Latin America and the Caribbean	World	Latin America and the Caribbean
Emissions not including land-use change	Total $MtCO_2e$ [a]	33 295.60	2 152.10	35 865.20	2 766.90
	(Percentage of world total)	100.00	6.46	100.00	7.71
	TCO_2e per capita	6.3	4.9	5.9	5.4
Emissions including land-use change	Total $MtCO_2e$	41 213.70	5 511.70	43 483.90	5 124.10
	(Percentage of world total)	100.00	13.37	100.00	11.78
	TCO_2e per capita	7.8	12.6	7.2	9.9

Source: World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT), Version 5.0", Washington, D.C., 2008.

[a] GHG emissions and reductions are measured in tons of carbon dioxide equivalent (tCO_2e) and in millions of tons of carbon dioxide equivalent ($MtCO_2e$).

Per capita emissions of CO_2.[4] The United Nations Statistical Division reported emissions of 3.1 tCO_2 per capita in Latin America and the Caribbean in 2004 (see figure VI.4), compared with 2.4 tCO_2 per capita in 1990.[5] This 2004 amount is smaller than the average per capita amount for both Annex 1 countries (9.5 tCO_2) and the world overall (5.4 tCO_2) that year (United Nations, 2008).

FIGURE VI.4
LATIN AMERICA AND THE CARIBBEAN: CO_2 EMISSIONS PER CAPITA, 1990 AND 2004
(Tons of CO_2)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations, "Millennium Development Goals indicators" [online database] http://mdgs.un.org/unsd/mdg/Search.aspx?q=emissions, 2008.

In terms of the intensity of CO_2 emissions, figure VI.5 shows that in Latin America and the Caribbean emissions have decreased per unit of energy consumed, at least up to 2004, when this indicator edged up slightly, pointing to an improvement in the region's energy technology. Per capita CO_2 emissions began to stabilize as of 2000, with a rise in 2004 which could be associated with an increase in emissions per unit of energy. It should be noted that the rate of CO_2 emissions per welfare unit has faster than the carbon intensity of energy has decreased. These indicators suggest that the region is moving in the right direction, albeit very slowly.

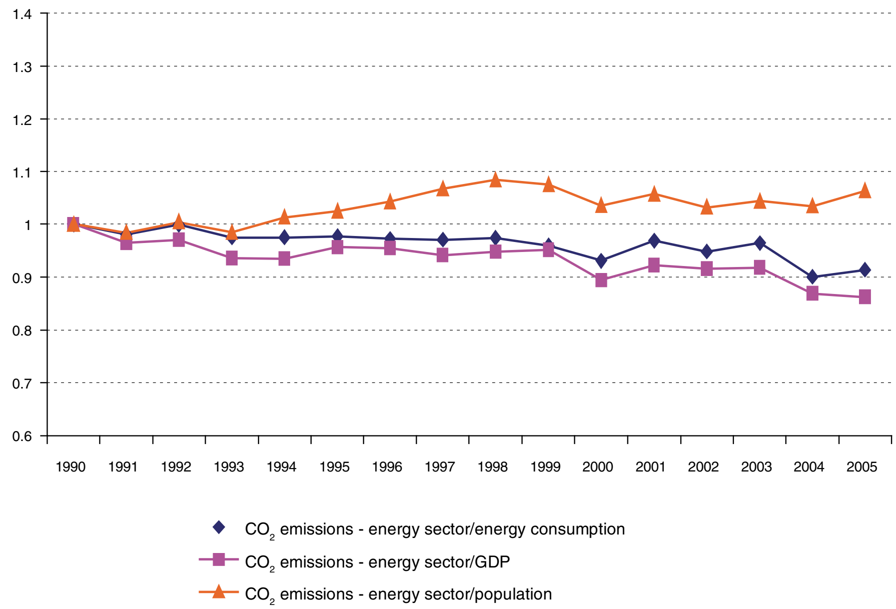
The figures for 2004 produced by WRI, which exclude changes in land use, stood at 1,400 tCO_2.[6] This was 40% higher than the 984 tCO_2 recorded in 1990 (see figure VI.6). The Institute's figure for per capita emissions that year, not including land-use changes, was 4.3 tCO_2.

[4] The indicator used in the seventh Millennium Development Goal —ensure environmental sustainability— is CO_2 emissions (total, per capita and per $1 GDP (PPP)).

[5] A number of countries with larger emissions, including the Bolivarian Republic of Venezuela and Argentina, show a decrease.

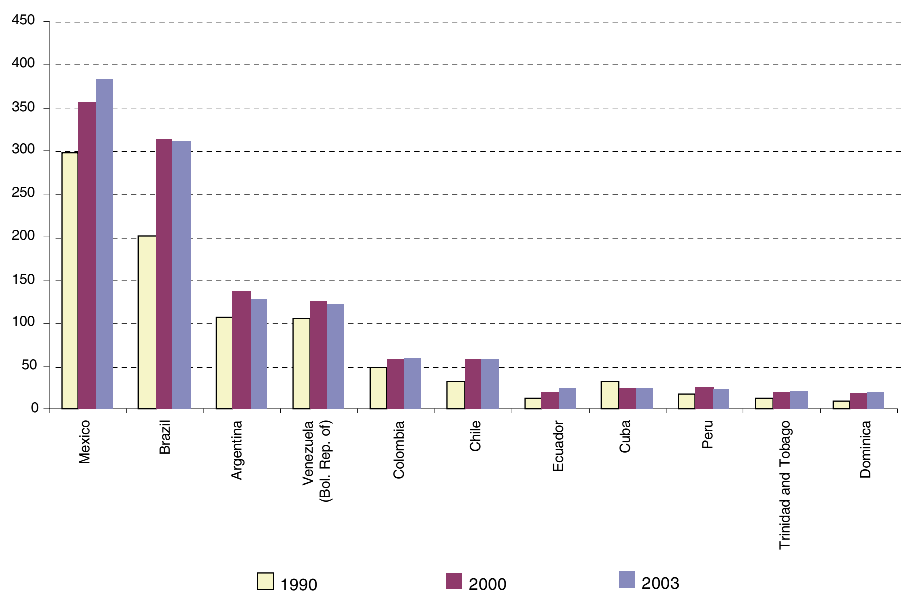
[6] Calculated on the basis of data from WRI (2008).

FIGURE VI.5
LATIN AMERICA AND THE CARIBBEAN: RELATIVE INTENSITIES OF CO_2 EMISSIONS
(Index: 1990=1)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices, Latin American and Caribbean Demographic Centre (CELADE) - Population Division of ECLAC for population data and Latin American Energy Organization (OLADE) for energy consumption data.

FIGURE VI.6
LATIN AMERICA AND THE CARIBBEAN: LARGEST CO_2 EMITTERS, NOT INCLUDING LAND-USE CHANGES
(Millions of tons of CO_2)



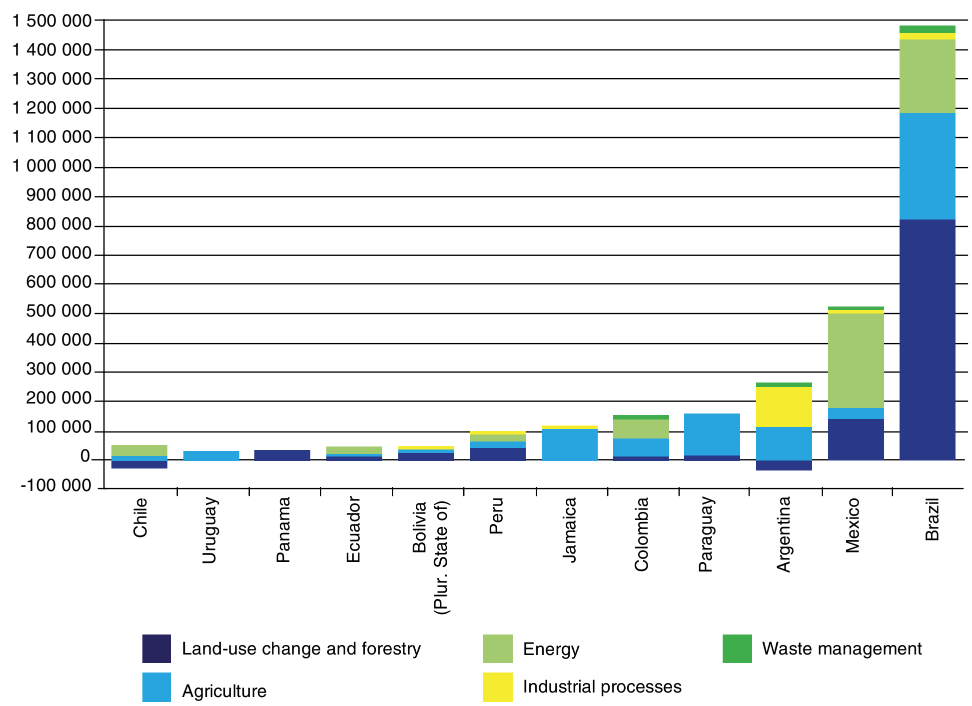
Source: World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT), Version 5.0", Washington, D.C., 2008.

B. Sources of greenhouse gas emission

As shown in figure VI.7, the GHG emissions in Latin America and the Caribbean reported in the first communications submitted under the United Nations Framework Convention on Climate Change (UNFCCC) came mainly from three sectors: agriculture, which generated 32% of emissions from livestock and silviculture; land use, land-use change and forestry (LULUCF), which accounted for 31%, owing mainly to the expansion of the agricultural frontier; and the energy sector, with 31% of emissions, contributed principally by transport. Waste and industrial processes contribute much smaller proportions, of 2.9% and 2.3%, respectively (UNFCCC, 2005).

The agriculture category includes methane emissions from enteric fermentation, which are significant in countries with major livestock industries, such as Argentina and Brazil and, to a lesser extent, Colombia, Mexico and the Bolivarian Republic of Venezuela. Fugitive emissions from petroleum activities are considerable in Bolivarian Republic of Venezuela, Mexico and Trinidad and Tobago.

FIGURE VI.7
LATIN AMERICA AND THE CARIBBEAN (SELECTED COUNTRIES): LARGEST GHG EMITTERS BY SOURCE, AS REPORTED IN FIRST NATIONAL COMMUNICATIONS
(Gigatons of CO_2e)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Framework Convention on Climate Change (UNFCCC), *Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention* (FCCC/SBI/2005/18/Add.5), October 2005.

C. Mitigation

Given that the region has not undertaken compulsory reduction commitments, mitigation reflects efficiency gains in production processes, the absorption of better technologies, sales of emissions reductions, the reduction of local environmental externalities, the anticipation of future emissions restrictions or trade. A number of countries have drawn on national studies to work out the marginal cost curves of different mitigation options,[7] some of which produce economic gain while other carry a high cost per unit of reduction. Examples in the first category are the reorganization of public transport and energy efficiency measures (see box VI.1).

BOX VI.1
EXAMPLES OF POTENTIAL MITIGATION OPTIONS IN THE REGION

Argentina

In 2008, the Bariloche Foundation prepared a study for Argentina and found that many of them would carry negative mitigation costs. The study concluded that specific public policies would be needed to overcome the barriers to the respective measures. In terms of cost, the most attractive options for Argentina appear to lie in the energy sector and in waste management.

Colombia

The study was conduced in 2008 by Universidad de los Andes, which assessed five mitigation operations and their reduction potential for a 20-year implementation period. The findings showed that, by emissions reduction potential, the most significant measure would be to switch coal furnaces over to natural gas in the industrial sector, which would produce reductions of up to 73.3 million tons of CO_2e. With regard to the transport sector, the study found that increasing passenger occupation of private vehicles would generate a reduction of 62.4 million tons of CO_2e and using biofuels could reduce as much as 38 million tons of CO_2e. Another measure offering great potential would be to increase the efficiency of industrial boilers, giving a reduction of 44.6 million tons of CO_2e.

With regard to the costs per ton reduced, major savings would be generated by reducing the oversupply of buses. Conversely, considerable cost —US$ 67.58 per ton of CO_2e— would be involved in incorporating hybrid boilers.

Brazil

The findings of the studies in Brazil showed that the evolution of GHG emissions will depend largely on public policies, principally with regard to the reduction of deforestation in the Amazon. They also found that energy sector expansion would benefit from the construction of renewable energy sources to replace coal-fired plants.

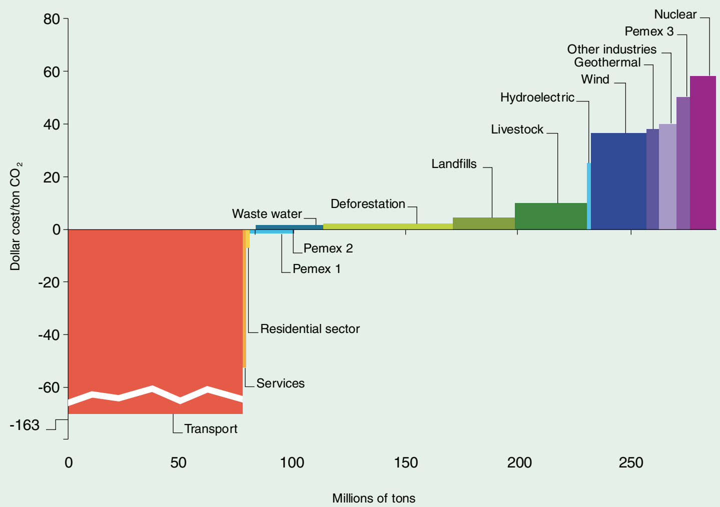
Mexico

A recently published study on the economy of climate change in Mexico (Galindo, 2009) showed that the economic assessment of mitigation costs is highly complex and uncertain, since the calculations depend on the speed and scope of internationally agreed strategies and instruments; the availability of technology, its costs and forms of diffusion; changes in the production structure and its relation with energy consumption; substitution options; marginal cost curves; demand elasticities; and the price per ton of CO_2. The figure below summarizes the findings of different estimates of reduction cost curves.

[7] See the curves for Argentina, Brazil, Colombia, Chile and Peru on the webpage of the high-level seminar on climate change in Latin America: impact, mitigation possibilities and financing, held at the headquarters of the Economic Commission for Latin America and the Caribbean (ECLAC) on 15 and 16 October 2008 [online] http: //www. cepal. org/cgi-bin/getProd. asp? xml=/dmaah/noticias/noticias/6/34276/P34276. xml&xsl=/dmaah/tpl/p1f. xsl&base=/dmaah/tpl/top-bottom. xsl. These studies were financed by Endesa.

Box VI.1 (concluded)

Marginal cost curve for emissions reduction in Mexico up to 2020



Source: G. Quadri, "El cambio climático en México y el potencial de reducción de emisiones por sectores", *La economía del cambio climático en México*, L.M. Galindo (coord.), Mexico City, Secretariat of the Environment and Natural Resources (SEMARNAT), 2009.

1. Energy supply

Taking into account the scenarios and alternatives discussed in chapter V, mitigation in the energy sector means seizing energy efficiency opportunities in the sector itself, creating price signals and promoting the development of alternative technologies. One interesting proposal in the region is the imposition of a carbon tax at the assessment stage of power generation infrastructure investments, which is been considered by the legislature of Brazil.[8] Another is the valuation of power generation externalities proposed by the Government of Mexico with a view to applying related economic instruments. The payments system in the electricity sector is a powerful incentive to keep generation carbon-dependent, because it favours reliable and profitable sources regardless of their environmental merits. This mechanism must be reviewed or offset by promoting the diversification and de-carbonization of the electricity generation matrix. Petróleos Mexicanos (PEMEX) is piloting an interesting experiment with a system of emissions reduction trading among its facilities in Mexico, which has been adopted formally in the Special Programme on Climate Change (SEMARNAT, 2009).

2. Transport sector

The Latin American and Caribbean economies have followed the pattern of mobility prevalent elsewhere, in which there has been a shift from rail and maritime transport towards road transport, which is more emissions-intensive. And, as in the rest of the world, aviation is also on the rise (OECD, 2008b, p. 341 and OECD/SERMANAT/ITF, 2008). The region's rapid and growing urbanization has created a huge demand for mobility, which is fuelling an expanding private vehicle fleet and displacing public transport modalities that produce fewer emissions per passenger. Accordingly, the rising numbers of private vehicles have pushed up pollutants emissions and worsened urban congestion.

[8] See Centre for Integrated Studies on Climate Change and the Environment (Centro Clima) of Brazil, 2008, and the forthcoming study prepared by that organization for Endesa España, 2008.

The IPCC report (2007d) indicates that, worldwide, 95% of transport energy is derived from fossil fuels, mainly diesel and gasoline. CO_2 emissions from the different modes of transport are proportional to the energy they use. As shown in table VI.2, the highest demand for energy comes from light-duty vehicles, heavy-duty freight vehicles and aviation.

TABLE VI.2
WORLDWIDE ENERGY USE FOR TRANSPORT, BY TYPE, 2000

Mode	Energy use (Exajoules)	Percentage
Light-duty vehicles	34.2	44.5
Two wheelers	1.2	1.6
Heavy-duty freight vehicles	12.48	16.2
Medium trucks	6.77	8.8
Buses	4.76	6.2
Trains	1.19	1.5
Aviation	8.95	11.6
Shipping	7.32	9.5
Total	76.87	100.0

Source: World Business Council for Sustainable Development (WBCSD), “IEA/SMP model documentation and reference case projection” [online] http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf, 2004.

Some governments in Latin America and the Caribbean are making efforts to mitigate the rise in emissions from this sector by improving public transport and opening the market to hybrid automobiles. They are also promoting biofuels, although here the focus is more on the benefits for the agricultural sector and the related market instruments have yet to be successfully implemented.

Notable ventures have been undertaken to improve and promote urban public transport in Bogotá (Transmilenio), Curitiba, Mexico, City (Metrobús), Guatemala City, Quito and Santiago (Transantiago), but much remains to be done to address the expansion of the private vehicle fleet and upgrade public transport.

In this respect, the number of light vehicles in the Latin American and Caribbean region could rise significantly. The comparison in figure VI.8 shows that the vehicle fleet of 2000 could double by 2030 and triple by 2050.

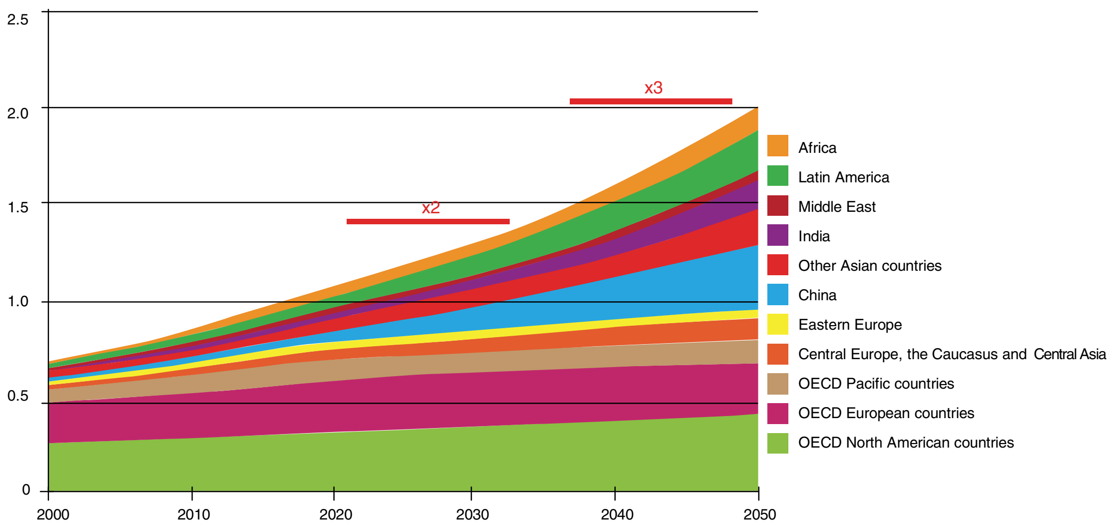
Fuel-saving efficiency measures have produced net benefits per vehicle, but the increase in fleet size far outweighs those gains (and this is equally true for air, road and maritime transport). Furthermore, decisions on numbers, types and sizes of vehicles are made by consumers. Shifting those preferences in order to produce a significant reduction in emissions will take a combination of control and market instruments, such as policies that improve public transport to encourage people to choose it over private transport, at the same time as increasing the costs of the latter option.

Biofuels could play a role, albeit a limited one, in reducing GHG emissions in the transport sector, depending on the way it is produced. One such is the sugar cane biofuel used in Brazil, which has performed well in terms of emissions (BNDES, 2008).

Projections for the uptake of biofuels as additives or replacements for gasoline or diesel suggest that biofuel use will increase to around 3% of overall energy demand by 2030. The possibility of raising this figure to 5% or 10% will depend on the extent of vehicle efficiency improvements and the success of cellulosic conversion technologies for biofuel production, as well as future oil and carbon prices (IPCC, 2007d).

Mitigation options for transport also include changing from private to public transport modes, from road to rail and from land to maritime, planning for land use and increasing the use of non-motorized forms of transport.

FIGURE VI.8
GROWTH IN NUMBERS OF LIGHT-DUTY VEHICLES, BY REGION
(Billions)



Source: World Business Council for Sustainable Development (WBCSD), "IEA/SMP model documentation and reference case projection" [online] http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf, 2004.

The mitigation of CO_2 emissions in the aviation sector in the medium term depends on increasing fuel consumption efficiency though improvements in design technology for aircraft and engines and better air traffic operation and management. These gains may only partially offset the increase in emissions from this sector, however.

Reducing GHG emissions will be a great challenge for the region's transport sector, since —despite the many mitigation options— the sector will grow rapidly across all modalities.

3. Residential and commercial sector

In the Latin American and Caribbean region, residential sector emissions are produced mainly by electricity consumption, as discussed in chapter V, and the most promising measures for reducing them relate to the energy efficiency of domestic appliances and thermal efficiency. The use of improved traditional building materials —such as stabilized adobe, compressed earth blocks, guadua bamboo and timber— for structural work would make a significant contribution to mitigation efforts, since these materials capture CO_2 instead of emitting it.

One major barrier to efficiency gains as regards electrical appliances is the lack of regional coordination on standards and labelling issues. Such coordination would make it possible to protect the environment and competitiveness at the same time.

IPCC has examined a variety of mitigation alternatives (Levine and others, 2007), taking into account the economic and climatic conditions that influence the viability of measures in this sector. The variables considered here were technology maturity, cost-effectiveness and the impact of the measure. The most promising measures for developing countries —economically viable under specific conditions, cheap, effective and readily implemented— are those associated with solar-powered water heating, thermal insulation, heat exchange and use of renewable technologies in supermarkets.[9]

[9] Switching incandescent light bulbs for energy-efficient alternatives has been proven to be effective.

4. Industrial sector

The economic potential of the industrial sector lies primarily in industries that are large-scale energy consumers (IPCC, 2007d), and the upgrading of those facilities could produce significant emissions reductions. The existing mitigation alternatives are not being fully put to use in either the industrialized or the developing countries, however.

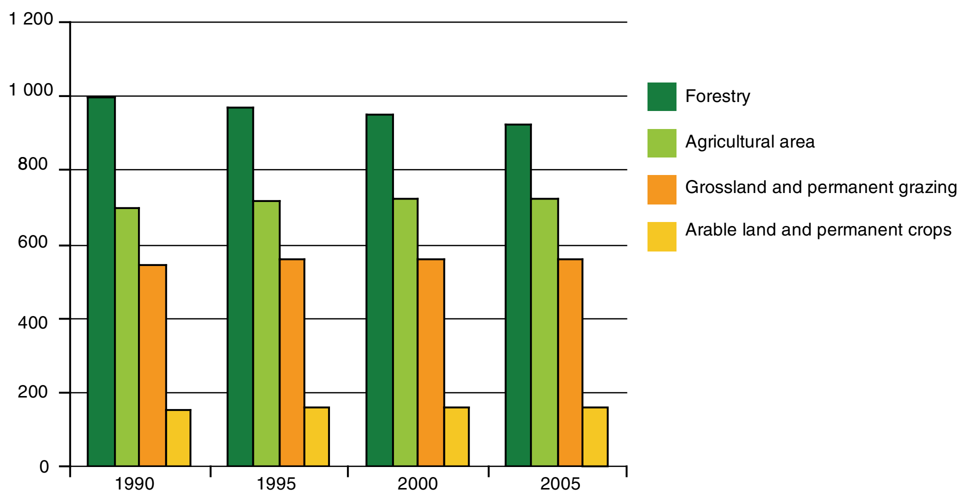
The main barriers to the full use of available mitigation options are: low capital goods replacement rates, lack of financial and technical resources, and the limited capabilities of firms —especially SMEs— to access and absorb technological information. Geographical disparities in prices for labour and land are another important factor, because they disperse value chains and increase the need for movement and transport, which leads to heightened CO_2 emissions.

The development of bioethanol offers interesting opportunities for the production of plastics, and could reduce the use of petroleum and other traditional industrial inputs such as steel and oil-based plastics in the automobile industry. The use of bioethanol and biodiesel in the chemical and refining industries could thus pave the way for sequestering carbon into biomaterials, insofar the bioplastic and wood employed in car manufacturing and in transport, for example, would act as a carbon sink and biofuels would help to neutralize the atmospheric impact of running vehicles. The industry would thus be moving beyond efficiency and become a lead player in the sinking of carbon.

5. Agricultural sector

Land-use change, including the conversion of forest to agricultural and grazing land, along with the normal functioning of agriculture, has brought about an increase in GHG emissions (CO_2 and N_2O).

FIGURE VI.9
LATIN AMERICA AND THE CARIBBEAN: LAND USE CHANGES
(Millions of hectares)



Source: Food and Agriculture Organization of the United Nations (FAO), *State of the World's Forests, 2007*, Rome, 2007.

Although there are no universally applicable mitigation practices, IPCC (2007d) suggests three types of mitigation mechanisms that may be useful in agriculture. The first is to reduce emissions through more efficient management of the carbon and nitrogen flows in agricultural ecosystems. Some examples of such measures are shown in table VI.3.

The second mechanism is sequestration of CO_2 in agro-forestry systems. The third proposes to displace fossil fuel emissions in agricultural processes by using biomass or residues as fuel.

TABLE VI.3
MEASURES PROPOSED FOR MITIGATION OF GREENHOUSE GAS EMISSIONS IN AGRICULTURAL ECOSYSTEMS

Measure	Examples	Mitigative effects [a]			Net mitigation[b] (confidence)	
		CO_2 [c]	CH_4 [d]	N_2O [e]	Agreement	Evidence
Cropland management	Agronomy	+		+/-	***	**
	Nutrient management	+		+	***	**
	Residue management	+		+/-	**	**
	Water management (irrigation and drainage)	+/-		+	*	*
	Rice management	+/-	+	+/-	**	**
	Agro-forestry	+		+	***	*
	Set-aside, land-use change	+	+		***	***
Grazing land management, pasture improvement	Grazing intensity	+/-	+/-	+/-	*	*
	Increased productivity (e.g., fertilization)	+		+/	**	**
	Nutrient management	+		+/	**	**
	Fire management	+	+	+/	*	*
	Species introduction (including legumes)	+		+/	*	**
Management of organic soils	Avoidance of wetlands drainage	+	-	+/-	**	**
Restoration of degraded lands	Erosion control, and organic and nutrient amendments	+		+/-	***	**
Livestock management	Improved feeding practices		+	+	***	***
	Specific agents and dietary additives		+		**	***
	Longer-term structural and management changes and animal breeding		+	+	**	*
Manure and biosolid management	Improved storage and handling		+	+/-	***	**
	Anaerobic digestion		+	+/-	***	*
	More efficient use as nutrient source	+		+	***	**
Bioenergy	Energy crops, solid, liquid, biogas, residues	+	+/-	+/-	***	**

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007 - Mitigation on Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC*, Cambridge University Press, 2007.
Note: A plus sign (+) denotes reduced emissions (positive mitigative effect) and a minus sign (-) denotes increased emissions (negative mitigative effect). +/- denotes an uncertain or variable response.
[a] The mitigative effects on climate change are the apparent effects of reducing emissions of individual gases.
[b] Net mitigation is an estimate of scientific confidence that the proposed practice can reduce net emissions at the site of adoption. This is a qualitative estimate of the confidence in the proposed practice for reducing net emissions of greenhouse gases, expressed as CO_2e. Agreement refers to the relative degree of consensus in the literature (the more asterisks, the greater the agreement) and evidence refers to the relative amount of data in support of the proposed effect (the more asterisks, the more evidence).
[c] CO_2 – carbon dioxide.
[d] CH_4 – methane.
[e] N_2O – nitrous oxide.

In agriculture, mitigation efforts face additional difficulties associated with the provisions of international agreements. For example, agricultural land in Latin America and the Caribbean offers mitigation potential through carbon sequestering, but its exclusion from the clean development mechanism (CDM) stands in the way of the widespread adoption of climate-friendly practices such as zero tillage (IPCC, 2007d).

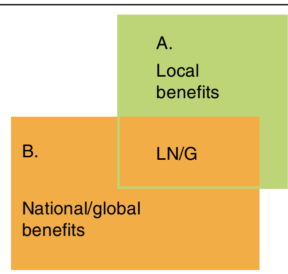
6. Forestry

The region has undergone major deforestation to provide land for activities that offer larger profits than maintaining forests, and this has contributed significantly to the CO_2 emissions of a number of countries, including Brazil, Mexico and Peru. Payment for the global environmental service provided by forests as carbon sinks is thought to act as an economic incentive to leave them standing. This is the principle behind the launch of initiatives such as the World Bank's Forest Carbon Partnership Facility (2007). The application of these incentives can run into institutional and numeric difficulties, however.

Other measures aimed at mitigation include non-consumptive use of forests for activities such as ecotourism and, in a very few countries (since they accrue only local benefits), the payment of local environmental services for water cycle maintenance. Mitigation in any one sector comes down to a delicate balance between local and global well-being.

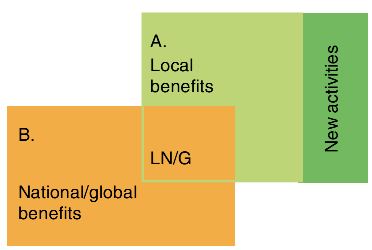
The rationale behind payment for environmental services in the interests of forestry conservation is shown in schematic fashion in diagram VI.1.

DIAGRAM VI.1
THE ECONOMIC INCENTIVES OF FOREST CONSERVATION

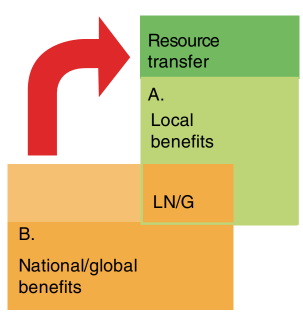


The sum of the benefits provided by a forest is represented by the sum of those in areas A andB. Decisions taken at the local level consider only the benefits of area A, however. If an alternative activity (such as agriculture), which means clearing the forest, offers greater benefits than A, the rational decision from the local point of view is to shift to the new activity. In global terms, this usually causes a net loss of well-being, if the benefits association with the new activity are smaller than those of A +B.

CHANGE IN ECONOMIC INCENTIVES



One way of changing the economic incentives offered to local users of forests is to increase the local benefits associated with conservation and sustainable use (benefits are increased in the area "new activities"). This improves the competitiveness of forest conservation as opposed to other alternatives that require deforestation. The new activities may arise from better knowledge of forest resources (through bioprospection, for example) or involve ecotourism, sustainable timber industry, and so forth.



Another way to change pro-deforestation incentives is to transfer a share of the national or global benefits to local users. Here the benefits are increased in the area "resource transfer". This is the rationale behind transfer mechanisms such as payment for environmental services in Costa Rica and in other countries where the State pays the owners of forests to keep them standing. Transfers also occur at the international level through private resource transfers (CDM) or multilateral transfers such as those from the Global Environment Facility (GEF). Another example is the Noel Kemptff Climate Action Project in Bolivia, which pays compensation for reduction of GHG emissions associated with avoided deforestation. This type of scheme requires a clear system of property rights.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of J.A. Dixon and S. Pagiola, *Local Costs, Global Benefits: Valuing Biodiversity in Developing Countries*, Washington, D.C., Environment Department, World Bank, 2000.

Among the international market mechanisms, the reduction of emissions from deforestation and forest degradation (REDD) is thought to be among the least costly forms of mitigation (though research and project data are still needed to confirm this). This has led, within the international negotiations, to the consideration of quantitative restrictions on the use of this instrument, instead of more imaginative alternatives.

One of the main obstacles, the monitoring of deforestation, has become less of an issue thanks to the lower costs and greater precision of estimates generated using satellite images. What is more, Brazil, which is a strong player in this area, has expressed a willingness to share images and know-how with other countries in the region.

7. Waste management

In Latin America and the Caribbean, waste residues produce much smaller emissions than the agriculture and energy sectors. Yet waste management is one of the more serious challenges faced by local governments today.

IPCC (2007d) sets forth a number of technological alternatives, including landfill, incineration, biotreatment and composting. Inert atmosphere pyrolysis of waste materials and the enrichment of residues have potential for producing fuel inputs, but these methods are not yet developed in Latin America and the Caribbean.

Table VI.4 outlines some of the technologies identified by IPCC, by sector.

D. The clean development mechanism (CDM)[10]

The Kyoto Protocol to the United Nations Framework Convention on Climate Change, adopted in 1997, provided for an international market for GHG emissions reduction, with a view to reducing the cost of compliance for the industrialized countries (Annex I to the Convention and Annex B to the Protocol).[11]

a) The Protocol established three mechanisms, which allow reductions to occur in countries where the marginal cost per ton of emissions reduced is lower: emissions trading between industrialized (Annex I) countries allows the transfer of emissions permits deducted from the national allotment equivalent to reduction commitments under the Kyoto Protocol. Annex I countries which have reduced their emissions further than agreed under the Kyoto Protocol can trade this surplus with other Annex I countries which have not met their reduction commitments. The units traded under this mechanism are known as assigned amount units (AAUs).

b) Joint Implementation (JI) is a mechanism whereby a country acquires emissions reduction units by investing in an emissions reduction project in another Annex I country. It thus enables the transfer among Annex I countries of emissions reduction credits which are deducted from the reduction commitment of the investing country. The units traded under this mechanism are known as Emission Reduction Units (ERUs).

c) The clean development mechanism involves transactions between developing and industrialized countries. It allows Annex I countries to meet part their total reduction commitment under the Kyoto Protocol by purchasing certified emissions reductions (CERs) generated through voluntary projects in non-Annex I (developing) countries.

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10 This section is based on Acquatella (2008), sections 2.4, 2.5 and 2.6 and figures updated to 2009.

11 A classic premise of regulation theory is that the total cost of compliance with a particular target (in this case the overall emissions reductions committed under the Kyoto Protocol) will be lowered by allowing regulated agents (Annex I countries) greater flexibility in attaining that target by making non-uniform reductions until the marginal costs of reduction are equalled among all agents, and this is achieved by allowing agents to meet part of their individual commitments by trading accrued surpluses or deficits in the market. This is the general principle behind a system of tradable permits and flexibility mechanisms such as that discussed here.

TABLE VI.4
SUMMARY OF MITIGATION TECHNOLOGIES AND PRACTICES, BY SECTOR [a]

Sector	Key mitigation technologies and practices currently commercially available	Key mitigation technologies and practices projected to be commercialized before 2030
Energy supply	Improved supply and distribution efficiency: fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of carbon capture and storage (CCS), such as storage of CO_2 removed from natural gas.	CCS for gas, biomass and coal-fired electricity generation facilities; advanced nuclear power; advanced renewable energy, including tidal and wave energy, concentrated solar energy and solar photovoltaic (PV) energy.
Transport	More fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorized transport (cycling and walking); land-use and transport planning.	Second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.
Construction	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves and insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids; recovery and recycling of fluorinated gases.	Integrated design of commercial buildings, including such technologies as intelligent meters that provide feedback and control; solar PV integrated in buildings, autogeneration.
Industry	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO_2 gas emissions; and a wide array of process-specific technologies.	Advanced energy efficiency; CCS for cement, ammonia and iron manufacture; inert electrodes for aluminium production.
Agriculture	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency.	Improvements of crop yields.
Forests and forestry	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use.	Tree species improvement to increase biomass productivity and carbon sequestration; improved remote sensing technologies for analysis of vegetation and soil carbon sequestration potential and mapping land-use change.
Waste management	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimization.	Biocovers and biofilters to optimize CH_4 oxidation.

Source: Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007 - Mitigation on Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC*, Cambridge University Press, 2007.

[a] Sectors and technologies are not listed in any particular order or according to any special criteria. Non-technological practices, such as lifestyle changes, which are cross-cutting, are not included in this table.

Under the conditions attached to CDM, it must be demonstrated that a proposed project will reduce GHG emissions more than would have occurred in its absence (below the established baseline), would not have gone ahead without the economic incentive offered under CDM, and will assist the non-Annex I host country in achieving sustainable development.

The region can make use of CDM to introduce cleaner and less internally damaging production and consumption methods that both cut CO_2 emissions and reduce local pollutants.

The level of development of the CDM market at the global level is one of the greatest achievements of the Kyoto Protocol, but it is still insufficient. As of September 2009, the number of CDM projects worldwide (including those rejected) was 5,316.[12] Of those, 2,605 (49%) were at the validation stage,[13] 234 (4%) were in registration and 1,792 (34%) were registered, which was equivalent to an estimated reduction of over 2.7 $GtCO_2e$ by 2012.

This volume of emissions reductions is equivalent to 77% of all emissions produced in 2005 by the European Union countries (3.5 $GtCO_2e$) and 44% of those produced by the United States that year (6.1 $GtCO_2e$), the most recent in which official data were issued by the secretariat of the United Nations Framework Convention on Climate Change.

Of all the carbon market mechanisms, CDM has been the most widely used worldwide, accounting for 87% of transactions by volume and 91% by value. The CDM market has expanded rapidly in the last three years, reflecting the entry into force in 2005 of the Kyoto Protocol, which formalized the demand for certified reductions. The market also gathered momentum from the European Union's linkage of CDM into the European Union Greenhouse Gas Emission Trading Scheme before the Protocol came into force, since the European Union authorized regulated European facilities to use CERs generated under CDM to comply with the emissions limits allotted under its own scheme.

In 2005 the primary CDM market saw transactions of 341 $MtCO_2e$, equivalent to US$ 2.417 billion (at an average price of US$ 7.1 per ton of CO_2e reduced). In 2006 the market expanded to 537 $MtCO_2e$, or US$ 5.804 billion, at an average price of US$ 10.8 per ton of CO_2e reduced. By 2007, 551 $MtCO_2e$ were traded for almost US$ 7.426 billion, fetching an average price of US$ 13.5 per ton. This represented a rise of 2% in volume and 25% in price compared with 2006, showing that market activity has intensified in the last few years (World Bank, 2008a).

In 2007 the European countries were the main buyers in the CDM and JI markets, accounting for 79% of trade. The United Kingdom was the largest buyer, with 59%. Japan has also been very active in those markets, with an 11% share. Private firms in those countries have been the main buyers of CERs in the CDM market (World Bank 2007).

As shown in table VI.5, growth in the primary market slumped heavily in 2008, when CDM project transactions in developing countries dropped in value from US$ 7.4 to US$ 6.5 million, down 12% on the year before, even through the average price per ton stood at US$ 16.8. The market for joint implementation mechanisms showed a similar pattern. One of the causes of this decline was the global economic recession, which hurt the main demand-side markets for CDM projects, such as Europe and Japan (World Bank, 2009).

Analysis based on modelling (Mc Cracken and others, 1999) shows that the three flexibility mechanisms could more than halve the cost of complying with the aims of the Kyoto Protocol, compared to the cost in the absence of international trade in emissions reductions.

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[12] Official updated statistics on the CDM market are available at "CDM Statistics" [online] http://cdm.unfccc.int/Statistics/index.html and UNEP (2008).

[13] In order to become registered by the governing body of CDM —the Executive Board— projects must first be submitted for a validation process carried out by institutions accredited to the Executive Board for that purpose.

TABLE VI.5
ANNUAL VOLUME AND VALUES OF TRANSACTIONS OVER EMISSIONS REDUCTION PROJECTS, 2005-2008
(Millions of tons of CO_2e and millions of dollars)

Type of clean development mechanism market	2005		2006		2007		2008	
	(Volume)	(Value)	(Volume)	(Value)	(Volume)	(Value)	(Volume)	(Value)
Clean development mechanism-primary	341	2 417	537	5 804	552	7 433	389	6 519
Joint implementation	11	68	16	141	41	499	20	294
Voluntary market	6	44	14	70	43	263	54	397
Subtotal	358	2 529	567	6 015	636	8 195	463	7 .210
Clean development mechanism-secondary	10	221	25	445	240	5 451	1 072	26 277
Other mechanisms	20	187	19	76		na	na	na
Total	388	2 937	611	6 536	876	13 646	1 535	33 487

Source: World Bank /International Emissions Trading Association (IETA), *State and Trends of the Carbon Market 2007, 2008* and 2009 Washington, D.C.

1. Projects implemented under the clean development mechanism in the region

Initially, Latin America's carbon market was the greatest supplier of CDM projects, and the region had piloted projects prepared before the Kyoto meeting. Later the region figured prominently in the project portfolios associated with the first emissions reduction funds, such as those set up by the World Bank, This was thanks to the governments' openness to CDM projects, since they had relatively expedite approval arrangements and promotion initiatives in place for this type of project (Eguren, 2007). The share of the region is now smaller, however, in terms of both number of projects and volume of emissions reduced.

As shown in table VI.6, the Asia-Pacific region leads the way in annual CERs and in the total reductions expected to be generated by 2012. Latin America and the Caribbean accounts for 17.3% of total projects, generating 14% of the emissions reductions expected at 2012.

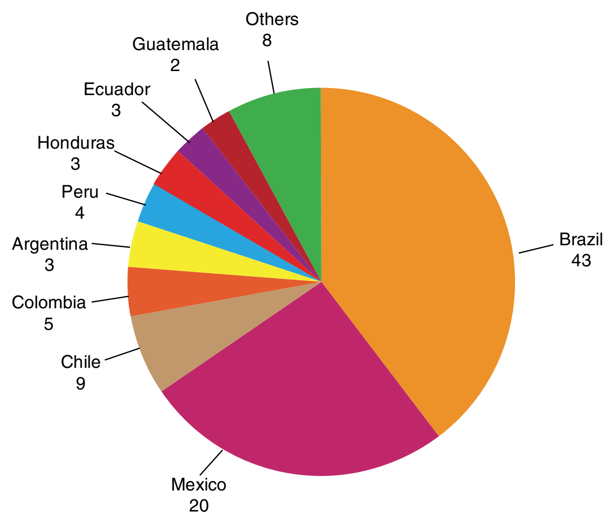
Brazil hosts 43% of the CDM projects undertaken in Latin America and the Caribbean, as shown in figure VI.10. The bulk of these correspond to biomass energy, landfill methane destruction, agriculture and renewable energies. Next comes Mexico, with 20% of the region's projects, mainly in agriculture, biogas and landfills, and Chile, with 9%, principally in biomass and landfill projects.

TABLE VI.6
PROJECTS UNDER THE CLEAN DEVELOPMENT MECHANISM, BY REGION

Total projects in the CDM pipeline	Projects		Certified Emissions Reductions	Certified Emissions Reductions at 2012		Population	Certified Emissions Reductions per capita, at 2012
	(Number)	(Percentage)	(Thousands)	(Thousands)	(Percentage)	(Millions of inhabitants)	(Number)
Latin America and the Caribbean	800	17.3	77 119	389 368	14.0	449	0.87
Asia-Pacific	3 628	78.3	522 884	2 263 323	81.2	3 418	0.66
Europe and Central Asia	46	1.0	4 605	18 483	0.7	149	0.12
Sub-Saharan Africa	111	2.4	20 504	82 759	3.0	891	0.09
North, Southern and Central Africa	46	1.0	7 224	32 858	1.2	186	0.18
All developing regions	4 631	100	632 336	2 786 791	100	5 093	0.55

Source: United Nations Environment Programme (UNEP), "UNEP Risoe CDM/JI Pipeline Analysis and Database" [online] http://cdmpipeline.org/ [date of reference: 8 August 2008], updated to 1 September 2009.

FIGURE VI.10
LATIN AMERICA AND THE CARIBBEAN: NUMBER OF CLEAN DEVELOPMENT MECHANISM PROJECTS
(Percentages)

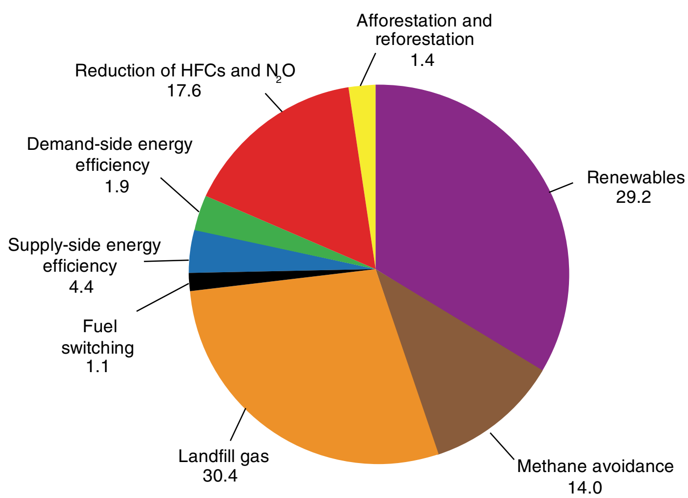


Source: United Nations Environment Programme (UNEP), "UNEP Risoe CDM/JI Pipeline Analysis and Database" [online] http://cdmpipeline.org/ [date of reference: 8 August 2008], updated to l September 2009.

Apparently, more opportunities for CDM projects are available in the larger economies and those that offer an investment-friendly and economically stable environment, such as Chile.

A large volume of the region's emissions reductions up to 2012 come from projects to reduce nitrous oxide (N_2O) and hydrofluorocarbons (HFCs), as shown in figure VI.11, although only two HFC projects are registered, one apiece in Mexico and Argentina. In the case of N_2O there are nine projects, most of them located in Brazil. The remaining projects are aimed at reducing CO_2 and methane. These proportions are accounted for by the fact that HFC has a warming potential 11,700 times greater than CO_2 and 310 times greater than N_2O. Reductions achieved in those gases have an impact equivalent to that of hundreds of CO_2 reduction projects.[14]

FIGURE VI.11
LATIN AMERICA AND THE CARIBBEAN: VOLUME OF CERTIFIED EMISSIONS REDUCTIONS, BY TYPE OF PROJECT, 2012
(Percentages)



Source: United Nations Environment Programme (UNEP), "UNEP Risoe CDM/JI Pipeline Analysis and Database" [online] http://cdmpipeline.org/ [date of reference: 1 September 2008].

Although there are few projects of this type involving the refrigeration, fertilizer and explosives industries in Latin America and the Caribbean, it is expected that future demand for reductions will be met through projects on renewable energy sources or more efficient use of fossil fuels.

The methane generated in landfills has a warming potential 21 times greater than CO_2. As such, it is the focus of much attention for CDM project developers in the region. This area offers major possibilities for reducing emissions, even if the projects registered are small in number (see figure VI.12).

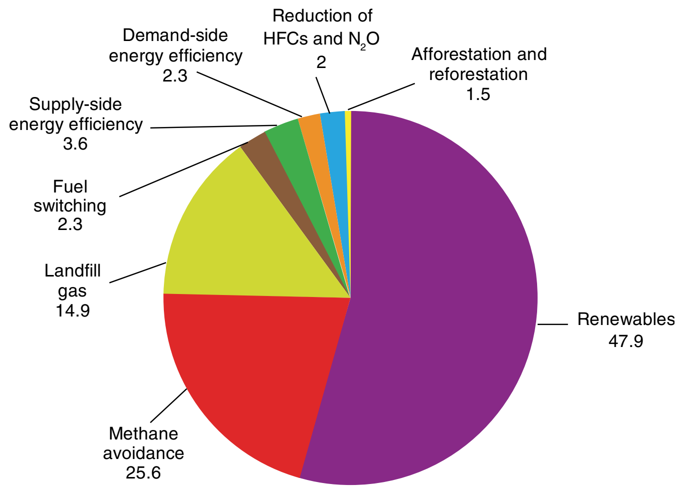
Most of the projects registered in the region concern renewable energy sources, as is apparent in figures VI.11 and VI.12. This is attributable to the volume of CERs[15] they can generate. Among these projects are biomass power generation and co-generation schemes, which are conducted

[14] Reductions achieved as a result of projects are expressed as CO_2 equivalent (CO_2e), which converts the tons of different GHGs reduced and their different warming potential into a common unit of measure.

[15] CER futures contracts are called emission reduction purchase agreements (ERPAs). Many developers of CDM projects sell the amount of CERs they estimate the project will generate in order to obtain financial flows in the present, rather than waiting out the full cycle of the project until the emission reductions are certified. Of course, the prices of these CER futures are heavily discounted in the international market, compared with CERs that are already certified, given that ERPAs carry project and certification risk. Approximately 85% to 95% of CERs that enter the registration process obtain final certification by the Executive Board of CDM.

principally by Brazil and involve the processing of sugarcane bagasse. Hydroelectric projects are distributed throughout Latin America. The scarcest categories, thus far, have been wind energy —in which most projects are located in Mexico and Brazil— and geothermal energy, with projects located in Central America. Agricultural projects involve mainly the capture and destruction of methane emissions from swine farms. These projects are to be found throughout the region, but are most common in Brazil, Chile and Mexico. In transport, despite the huge benefits to be gained from upgrading, only one project —a methodology for expanding the Transmilenio system in Bogota— has been approved under CDM.

FIGURE VI.12
LATIN AMERICA AND THE CARIBBEAN: PROJECTS IMPLEMENTED UNDER THE CLEAN DEVELOPMENT MECHANISM, BY TYPE
(Percentages)



Source: United Nations Environment Programme (UNEP), "UNEP Risoe CDM/JI Pipeline Analysis and Database" [online] http://cdmpipeline.org/ [date of reference: 1 September 2008].

2. Flows of resources under CDM[16]

According to a study by the World Bank (World Bank/IETA, 2007), between 2002 and 2006 reductions of about 920 $MtCO_2e$ were transacted under CDM (see figure VI.9), for a total value of US$ 7.8 billion. Half of those reductions had to do with the destruction of HFC and N_20 industrial gases, which mobilize little investment compared with renewable energy projects, whose ratio of investment to emissions reduction volume is much greater (9:1). During that period, US$ 2.7 billion was traded in Certified Emission Reduction (CER) futures contracts in clean energy projects alone —renewable energy, fuel switching, energy efficiency and methane recovery— which are estimated to have leveraged US$ 16 billion in addition to the funds that flowed into the respective projects under CDM.

Taking into account those additional investments in CDM projects and their location, the World Bank estimates that the cumulative total investment in projects during the period 2002-2006 was approximately US$ 21.6 billion.[17] Of this amount, about 66% of the investment was in renewable

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[16] Prepared on the basis of Acquatella (2008), Chapter 2, section 2.6.
[17] Estimates and investment data: World Bank/IETA (2007, page 30).

energy projects (approximately US$ 14 billion), 20% in biomass projects (some US$ 4 billion) and 15% in wind and hydroelectric energy projects (about US$ 3 billion). (World Bank/IETA, 2007).

It is estimated that Latin America and the Caribbean captured between 10% and 15% of those amounts; in other words, between US$ 2.1 and US$ 3.2 billion of the total investment for 2002-2006, which equals a total annualized investment of between US$ 420 million and US$ 640 million.[18] The Latin American and Caribbean region also accounts for between 10% and 15% of all Emissions Reduction Purchase Agreements (ERPAs) traded; that is, between US$ 780 million and US$ 1.17 billion, for that period, which represents flows of between US$ 195 million and US$ 292 million per year in CDM funds (Acquatella, 2008, section 2.6).

The magnitude of clean development investment flows —the sum of CDM funds plus investment— may be put into perspective by comparing them with the amounts spent in the region's housing sector to offset the impacts of last year's economic recession. For example, the Government of Argentina announced that it would allocated US$ 1.6 billion from pension contributions to the National Social Security Administrator (ANSES) to lines of credit for construction, extension, termination or purchase of new or used housing. Even more significant is the launch, in Brazil, of a US$ 8.96 billion housing programme (*Minha casa minha vida*) subsidized by the treasury. In both cases the amounts involved, for just one sector at the national level, exceed by over 100% the total annual investment mobilized by CDM for the whole of Latin America.[19]

However, specialists in the field have suggested that annual investments in the region's electric power sector have fallen far below those US$ 18 billion in recent years, which makes CDM flows greater in comparison. This mechanism offers an incentive for investment in renewable energy projects by improving their internal rate of return by between 0.5% and 3.5%. But CDM does not yet mobilize resources on a large enough scale to contribute to significant structural transformations in the energy sectors of most countries in the region.

E. Summary

- Latin America and the Caribbean emit 11.8% of the world's GHGs (2000), or 5 gigatons, 70% of which is produced by five countries: Mexico, Brazil, Argentina, the Bolivarian Republic of Venezuela and Colombia. Average per capita greenhouse gas emissions were 9.9 tCO_2e, compared with a world average of 7.2 tCO_2e.
- Latin America and the Caribbean emitted 3.1 tons of CO_2 per capita in 2004, in line with the respective indicator of the Millennium Development Goals, whereas the world average was 5.4.

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[18] This report states that the activities of projects during the 2002-2006 period involved investment commitments of US$ 21.6 billion. If this figure is compared with the total ERPAs (US$ 7.8 billion), the average benefit factor of investment in CDM is around 2.8. If the market share of the Latin American and Caribbean region is estimated at 10%, then the investment commitments in the region would be around US$ 2.1 billion, and application of the average leverage factor (2.8), would give the region about US$ 780 million in ERPAs. Another way to estimate this would be to consider that if the Latin America and Caribbean region has a 10% share of the market, it has 10% of the world's ERPAs. However, the first method shows that by considering an average leverage factor the investment in the region could be underestimated, because the region has fewer industrial gas projects than do other regions. These numbers may be adjusted many times over, however. If the World Bank 2008 report is used, with information from the close of 2007, committed investments for the period 2002-2007 are estimated at US$ 59 billion, and the leverage factor is 3.8, the explanation for the variance being that the registration of industrial gas projects peaked in 2005 and is currently on the decline. Based on these figures, investment in the region would be US$ 5.9 billion (10% of market share), with US$ 1.55 billion in ERPAs —double the figures cited in the text.

[19] The comparison can also be made based on traditional export products.For example, exports of coffee from Costa Rica and Colombia totalled US$ 230 milliion in 2006 and US$ 1.632 billion in 2005, respectively, which gives an idea of the smallness of total flows from CDM to the region, compared with other export activities.

- The funds mobilized by CDM have been marginal when compared to the mitigation requirements of the region. The mechanism's total contribution to investment has been about US$ 7.8 billion (2002-2006) and its significance to Latin America and the Caribbean has decreased compared with the volume of reductions transacted in Asia. CDM is estimated to raise projects' internal rates of return by 3%. Its total investment contribution to Latin America and the Caribbean in 2002-2006 is estimated at between US$ 2.1 billion and US$ 3.2 billion, or US$ 420 million to US$ 640 million per year. Over this period, CDM by itself is estimated to have brought in annual flows of between US$ 195 million and US$ 292 million, that is US$ 780 million to US$ 1.17 billion overall. This is a very small sum compared with traditional exports and the amounts expended to boost recovery from the economic crisis.
- To date, as a force for change in production and consumption methods, CDM has not been effective.
- The carbon markets have grown rapidly at the global level since 2005, when the Kyoto Protocol came into force. They will in all likelihood become more consolidated when national or sector targets are defined under the international climate change regime instituted as of 2012.
- The region should take advantage of the opportunities offered by little-explored large-scale projects, such as clustered schemes or programmes of activities, in order to make CDM a more relevant incentive and lower its transaction costs. It would also be beneficial for the region to strengthen CDM options related to forest and soil conservation, reforestation and reorganization of urban public transport, all of which are have been little used thus far.
- The countries will implement some mitigation options as a function of their national sustainable development policies. Others could be possible within the framework of a coordinated action within the region itself that improves environmental performance while protecting economic competitiveness, as is the case with energy efficiency regulations for tradable products.
- Another set of options will require additional financial and policy efforts, which will require the support of international cooperation funds.

VII. Latin America and the Caribbean and the international climate change framework

Despite the region's vulnerability to climate change and its unique situation in terms of the emissions generated by changes in land use, and even though, compared with the other States Members of the United Nations, its countries are those that display the closest affinities, the Latin American and Caribbean region does not have a voice of its own in international negotiations on climate change. This is partly due to the fact that Mexico belongs to the Organisation for Economic Co-operation and Development (OECD) and like Brazil, has come to a position of prominence in the developing world. Both countries, together with China, India and South Africa, are members of the Group of Five (G5), as it is called. This organization was legally set up in 2007 with the objective, among others, of reducing greenhouse gas emissions. As further progress is made towards the definitions for the second commitment period of the Kyoto Protocol to the United Nations Framework Convention on Climate Change, the Group has grown in stature, and the idea that a greater contribution can be made to climate change mitigation through commitments by the developing countries is gaining credence.

This situation is by no means new, as Latin American and Caribbean countries have often been submerged in the Group of 77 and the vastly diverse realities it encompasses. Those that joined this group did so in order to present a united front in the face of the developed world and its pressures, but they did not manage at the same time to forge a regional identity and a forum of their own for reflection and the exchange of information.

Once established, regional consultation forums usually operate on an ad hoc basis and only deal with a few issues. This is the case of the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme). Other forums, such as the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI), function irregularly and in parallel with formal organizations. Some degree of periodicity has been achieved thanks to constructive efforts, such as the Ibero-American Network of Climate Change Offices (RIOCC), whose meetings are facilitated by Spanish cooperation agencies.

Lack of budgetary and human resources has been a persistent constraint on their efforts to make their needs and special situation known to the rest of the world, and to cope with an agenda that has been becoming increasingly complex, in terms of both subject matter and discussion forums.

Consequently a very small number of specialized officials must attend various meetings and staff turnover in the relevant bodies is often high.

Since 2005, ECLAC, the body which serves the entire region, has been striving consistently to open up forums for reflection and dissemination of information on successful policies and initiatives relating to climate change. The Andean Development Corporation (CAF) has been doing the same for some time now, within the limits of its own smaller regional scope.

A few countries in the region did not welcome the idea of having discussion forums and stressed the importance of pursuing negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). Their argument deserves consideration, but should not rule out taking the opportunity to exchange information on the follow-up of conversations and the region's own policy advances. The relative position of strength of the major countries will not be diminished by this type of exchange; indeed, such exchanges will simply enable the region to build up its position and to have a better idea of the various points of view in a relationship that does not amount to a zero sum game.

The volume of resources used in adaptation measures, the negotiations for the regime beyond 2012, or second commitment period, the new mitigation modalities linked to the reduction of carbon emissions caused by deforestation and forest degradation and the urgent need to encourage developing countries to make a contribution through appropriate incentives, among other factors, point to the importance of strengthening the region's role on the international stage.

A. Latin America and the Caribbean in the negotiations of the United Nations Framework Convention on Climate Change and the Kyoto Protocol

A handful of developing countries were included among the countries that were in a position to make pledges during the Kyoto Protocol's first commitment period (2008-2012). They included the Republic of Korea and Mexico, both of which had recently been admitted to OECD in 1994. Just two years previously, the United Nations Framework Convention on Climate Change had included in Annex 1 (countries with specific obligations in terms of emissions reductions) Parties that were OECD members and those that were economies in transition, such as the former Soviet Union; on the other hand, only the OECD countries were included among the countries with commitments to help to finance emissions reductions at the international level). The entry of the Republic of Korea and Mexico to OECD was not subject to their acceptance of the commitment to be part of Annex 1, so that their situation was different from that of the other members.[1]

Adopted in 1995, the Berlin Mandate established that the developing countries would not take on additional emissions reductions commitments during the negotiations that were due to culminate in 1997 in the Kyoto Protocol. Thus, even their voluntary commitments remained excluded from the discussions and during the following 10 years, the topic did not appear on the agenda.

However, as the negotiations on the second commitment (post 2012) period move into higher gear, the issue of reduction commitments by developing countries has again been brought up for discussion. The resurgence of this debate follows the declaration by the United States that its fulfilment of its emissions reductions obligations would be conditional on the assumption of commitments (which have not yet been clearly spelled out) by those countries, such as G5 members, which are now considered to play a key role.[2]

[1] Nevertheless, both of these countries were under strong pressure to take on emissions reductions commitments similar to those applicable to the other Annex 1 countries.

[2] The modalities being discussed include lowering the rate of increase of emissions, reducing emissions on the basis of GDP and certain specific commitments which provide energy-saving opportunities and which are in keeping with domestic objectives for sustainable development, such as lower local pollution levels.

During the negotiations, it may be decided to adopt the criterion of setting emissions reduction commitments on the basis of certain parameters such as income level, the volume of emissions per capita, growth rate and other country indicators. Mexico made an important step in December 2008 at the fourteenth meeting of the Conference of Parties, when it announced that it would cut back its emissions by 50% of 2002 levels by the year 2050 (following a 10% reduction by 2012), the objective being to bring them in line with average world per capita emissions. In November 2009, Brazil announced its intention of reducing CO_2 emissions by close to 40% by 2012 (compared with the 2005 level). This initiative is being processed through Congress with a view to its inclusion in the national policy on climate change and it has already been approved by the Senate Infrastructure Committee.

The national targets of the developing countries and the United States will probably be incorporated into the revised instrument for the next commitment periods as nationally appropriate mitigation actions (NAMA), which will be subject to verification.

A second modality seeks to include high polluting energy-intensive sectors, with production centres in developing as well as industrialized countries and which constitute global markets. This is the case of the cement, steel, and paper and cellulose industries as well as the machine tool industry, chemicals and aluminium, which would continue to be subject to an emissions cap and which could engage in reduction swaps between the most and least efficient plants in order to fulfil sector commitments. This modality could be applied to international aviation and shipping. Under this scheme, the industries would be subject to a regime similar to that adopted for the developed countries. In order to be feasible, this scheme must be accepted by the Governments and, in particular, by economic authorities in the developing countries, who must be willing to expose some of their polluting sectors to a global restriction. This is by no means a simple matter, since these industries usually have a great deal of influence and strong bargaining power with their respective Governments; thus, it will be difficult to implement this approach, despite the fact that the industries in question have sufficient economic resources and technological know-how to improve their environmental performance. One variant of this modality is Brazil's effort to halt land-use change in the Amazon by means of an international fund (the Amazon fund 2008), subject to rules for disbursement based on the fulfilment of certain previously established mitigation goals. Nevertheless, Brazil's sectoral effort, as announced in its nationally appropriate mitigation actions, may be based on the criteria of the first modality above referred.

The third scheme under consideration was discussed in the chapter relating to adaptation and consists in imposing barriers on the import of goods from developing countries, whether on the basis of the product's carbon content, including the transport component, or on the basis of protectionist measures adopted by the exporting countries.

The fourth modality being discussed is the application of a tax agreed internationally but collected at the national level, on the carbon content of the various fossil fuels. This alternative is favoured by many countries, research centres and think tanks, which view it as less distortionary and consider that it sends appropriate price signals for the adoption of decisions by individuals and firms.

This last option was introduced by the Government of Switzerland in 2007 and included the possibility of depositing part of the resources collected by the countries in an international fund; it was also submitted to the Madrid Club for its consideration.

The impact of the four alternatives identified above on the countries of Latin America and the Caribbean will be different depending on the situation in each country. A scheme based on the adoption of criteria for establishing emissions reduction commitments could be applied in those that display high growth rates and high emissions levels, such as the Bolivarian Republic of Venezuela, Chile and Trinidad and Tobago.

In terms of border measures that developed countries could apply to their imports, owing to the growing share and competitiveness of exports from the so-called environmentally sensitive industries (see chapter IV), the South American countries stand to suffer the worst impact, as they are further away from the export markets in the developed countries.

The risk with this modality is that increasingly the burden of mitigation actions is passed on to the developing countries, thus eroding the multilateral nature of the different levels of responsibility for a problem, such as climate change, which affects all countries.

An emissions reduction commitment by sector could significantly affect foreign direct investment in Latin America and the Caribbean, which, increasingly, has been targeting energy-intensive industries.

This is why the national incentives for change, whether geared towards obtaining environmental benefits at the local level or towards economic efficiency, are being complemented by a further argument: the need to be not too close to the threshold where countries with high growth indicators, high pollution rates and export-intensive economies are obliged to accept commitments that will translate into a series of restrictions. In view of this situation, it would be best to follow a prudent emissions policy, since, in the long term, other considerations, such as convergence towards a level of emissions or particulate concentration that is considered safe for human health, could be brought to bear.

1. Financing for development

Reference should be made to two further aspects of the international negotiations: first, the resources needed for implementing adaptation measures and, second, the possible evolution of carbon markets.

Both the region as a whole and the different countries seeking to implement adaptation measures approach the donors in an uncoordinated manner, without any clear or coherent definition of their requirements in that regard. Currently, the funds seem to be directed towards mitigating the impact of natural disasters and, in some cases, just a few, towards conserving the environment. Donors, such as Spain, have placed emphasis on strengthening scientific and technological know-how with a view to constructing climate change models in the region.

2. Adaptation

The bulk of the resources for implementing adaptation measures come from South-South cooperation through the 2% tax on the sale of certified emission reductions under the clean development mechanism. Following the Bali negotiations, the Parties to the Framework Convention were asked to give their views during 2008 on the feasibility of also using the other market mechanisms, such as the exchange of assigned amount units of emissions between Annex 1 countries and the trade in emission reduction units generated through joint implementation projects in order to obtain resources for the Adaptation Fund. During the period 2008-2009, the developing countries will need to ensure that this comes to fruition and that cooperation for adaptation purposes also has a North-South component.

3. Mitigation and the clean development mechanism

As indicated in the foregoing chapter, the clean development mechanism is still too weak to bring about major changes in the production structure and the amount of funding being negotiated through related transactions is still limited. Adaptation requirements are estimated to run into billions of United States dollars, but the clean development mechanism only channels tens of billions, or at best a few hundred billion, towards the region.[3]

The Bali Action Plan reflects the will for the mechanism to include the trade in emission reductions achieved through deforestation which had been avoided in the first commitment period. This, undoubtedly, is good news for Latin America and the Caribbean. However, in some countries in

[3] The threshold for natural growth of the clean development mechanism in the region runs into billions of United States dollars, but in any event the amount traded is less than the cost of adaptation measures.

the region which have a significant potential for forest conservation, this has aroused fears that the oversupply of certified emission reductions will result in a fall in the price for these certificates and that projects in the energy sector will be abandoned in favour of those relating to the land-use sector. Should this occur, Latin America and the Caribbean will not be the only region affected, since demand will be geared towards the lower marginal costs of mitigation in order to promote the placement of the additional supply.

Nevertheless, a decline in the cost of certified emission reductions would demonstrate that the number of economically viable reductions is greater and that the developed countries could increase their commitments. Once again, this is good news from the point of view of climate change. Therefore, there should be a quid pro quo between the new sources of emissions reductions and the commitment to further cutbacks in the developed world. In the context of international negotiations, this would imply agreeing to increasingly ambitious targets in view of the expanding supply of certified emission reductions. This would provide economic security to all the Parties, since the price would fluctuate around an average, and global mitigation would increase.

However, one response to this additional supply that is under consideration is the possibility of segmenting the market on the basis of the origin of the emissions, by distinguishing between certified reductions arising from energy use and land use, so that the developed countries use them to fulfil their obligations in proportion to the extent of the relevant sector's contribution to the problem. This proposal caters for short-term concerns. Market segmentation could lead to the definition of additional categories, such as the contribution of transport to global emissions, which would make the task of administering the carbon market increasingly complex. There are other countries in the region which would prefer the reductions to continue to be functional irrespective of their origin.

One noteworthy initiative relating to forest conservation emissions mitigation is the Coalition for Rainforest Nations' proposal for the creation of a parallel mechanism to the clean development mechanism, which would be designed specifically to reduce emissions by preventing deforestation and degradation. In this case, the same rationale applied earlier could be used: setting up specific mechanisms for each source of emission can increase costs and seriously impede North-South transfers. In this regard, perhaps a better option would be to carry out a thoroughgoing reform of the clean development mechanism in which all the new requirements identified are taken into consideration, together with provisions for guaranteeing the required demand, should supply increase.

A number of financial initiatives have been put forward in the region in an effort to improve funding and fund management. One proposed by Brazil seeks to maintain territorial control of Amazonia and to channel the funds assigned to forest conservation through Government-to-Government programmes instead of private international operations. Mexico has also come up with a proposal: to set up a mechanism for increasing the availability of funding for adaptation and mitigation. Based on contribution and withdrawal criteria, this mechanism will ensure a more balanced institutional governance by countries and enable them to secure more resources than those currently available through the Convention mechanisms. In either case, the amount and the implicit price per ton of carbon released or retained as well as the criteria for the contribution and withdrawal of funds would need to be defined.

In terms of the opportunity niches for the region, part of the problem is that projects for reducing carbon emissions from deforestation and forest degradation cannot be developed without substantial funding. The same applies to global projects and programmes of activities which, while they have great potential, are costly and difficult to coordinate.

The Government of Germany conducted an auction of emission rights in different sectors under which some of the funds collected will be set aside for international cooperation in the area of mitigation, with special emphasis on forest conservation.

The most important issues for the continuity of the international agreements include:

- the decision not to exceed a given concentration of greenhouse gases in the atmosphere by a given deadline and to determine at which point the maximum level of emissions based on climate security is reached;
- the inclusion of the United States in the reduction commitments being discussed in the context of the Convention, which this country did, indeed, ratify. It is estimated that this could occur from 2010, once the United States Senate adopts the 2009 clean energy and security act and declares, at the sixteenth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, or earlier, that that act constitutes its set of nationally appropriate mitigation actions. While the act is innovative, it establishes border measures against imports (as from 2020) and represents a modest contribution to global reductions, more comparable to the effort expected of a developing country (20% reduction in relation to 2020);
- inclusion of the Group of 5 (G5) countries (Brazil, China, India, Mexico and South Africa) in the emission reduction commitments through nationally appropriate mitigation actions;
- inclusion of the programme for reducing carbon emissions from deforestation and forest degradation in market mechanisms;
- the agreement on reduction commitments in globalized production sectors, including possibly international air and maritime transport;
- increasing the funds for adaptation, including evaluation of all market mechanisms that can help to finance it;
- securing a longer commitment period than the earlier phase, which is only five years;
- laying the foundations for an adjustment of the international regime, which will include criteria for promoting binding commitments on other countries and for advancing towards climate equity based on emissions per capita;
- reforming or complementing the clean development mechanism using sufficiently powerful market incentives to reactivate it and redirect it towards development;
- creating mechanisms geared to facilitating the transfer of specific technologies, lowering costs and eliminating barriers such as licences and patents, or both, and
- creating commitment monitoring mechanisms.

The international consensus in this area is still not substantial enough for addressing the long-term impacts on agriculture, food security and international migration flows.

At the regional level, more and deeper economic analyses of the effects and opportunities generated by climate change, including the mitigation of carbon dioxide emissions, will need to be made in Latin America and the Caribbean. Steps in this direction were made in 2008 and 2009.

B. Opportunities for regional cooperation in the area of climate change

UNEP (2007) prepared a comprehensive analysis of cooperation arrangements, which range from institutional frameworks to the various regional and subregional agreements and initiatives formed by entities such as the Ibero-American Network of Climate Change Offices (RIOCC) and the Ibero-American Programme on Impacts, Vulnerability and Adaptation to Climate Change (PIACC), as well as the consultations held by ECLAC and the Andean Development Corporation. Funding and support from the international community are fundamental to the establishment and functioning of regional forums for dialogue. In this regard, the central objective of PIACC is to strengthen climate and meteorological research institutes, and the Government of Spain has provided funding for major training activities in this field. RIOCC has successfully set up a stable communications forum among the authorities designated by the Ibero-American countries.

Another significant initiative sponsored by Spain is the reform of the Araucaria Programme for Biodiversity Conservation in Ibero-America, which establishes links between biological conservation and climate change (for example through agrobiological diversity). The Nature Conservancy, ECLAC and the United Nations Development Programme (UNDP) have launched projects for a natural heritage audit, including an assessment of the climate change risks that can affect that heritage. The Government of Germany has supported discussions for implementing the programme for reducing carbon emissions caused by deforestation and forest degradation in the region and for evaluating action plans and other initiatives for sharing experiences. The United Kingdom has been instrumental in promoting a series of regional consultations in Latin America and the Caribbean as well as a similar effort in the region of Asia and the Pacific and it has introduced studies on the economics of climate change in Latin America and the Caribbean. The World Bank has headed an agenda for assessing the impact of climate change in the Andean region and in the Caribbean. A vast number of initiatives may be cited which seek to build synergy between international cooperation programmes and initiatives in the region. The Summit of Heads of State and Government of Latin America and the Caribbean and the European Union and the Euroclima initiative provide a new environment for coordination at the regional level. However, the preparation of a regional agenda based on South-South interests is still pending. In terms of the opportunities for analysis that arose within the framework of the fifteenth and sixteenth sessions of the Commission on Sustainable Development, ECLAC (ECLAC, 2007f) has identified areas for possible South-South collaboration which promise to be highly productive. These include:

1. Having an up-to-date list of initiatives launched by the different countries to improve their natural disaster prevention and response capacities and their capabilities as regards of adaptation and mitigation. In addition, preparing a website that provides material in Spanish and Portuguese on the discussions geared to creating and managing a climate regime.

2. Preparing or completing specific studies for evaluating the economic impacts of climate change in the various subregions, based on various scenarios in order to determine the need for adaptation and mitigation opportunities. With support from the Government of the United Kingdom, studies of this type have been undertaken throughout the region. These studies can be deepened or complemented by related research projects to provide an assessment, albeit partial, of natural heritage losses due to climate change, to estimate the cost of preventing natural disasters and to evaluate the fiscal vulnerability of countries in Latin America and the Caribbean. Moreover, methodological harmonization of these studies will enhance the comparability of results in order to provide a regional picture of these issues.

3. Conducting policy development support programmes in areas such as: energy efficiency of industries and buildings, including future low-cost housing; clean production; use of biofuels in industry; perfecting regulations for competitive export sectors; and internalizing externalities in assessing the costs of public and private investment projects. In general, analysing the options and joint benefits of the progression towards low-carbon economies.

4. Fostering and sharing experiences in project design for the carbon market, particularly in the case of action programmes, group projects and projects for reducing emissions from deforestation and forest degradation.

5. Cooperating in adapting national finance institutions and facilities to the requirements of projects for mitigating the impact of climate change.

6. Increasing the number of accredited regional organizations whose operating and management costs are lower than those of extraregional organizations and which will be familiar with the region's specific features.
7. Coordinating the different approaches in order to increase the region's relative influence and obtaining joint access to international funds for capacity-building and technology transfer.
8. Agreeing on necessary carbon market reforms, including the evaluation of mechanisms used to finance adaptation measures.
9. Coordinating policies for boosting investments with a low carbon content.
10. Protecting the base lines through early identification.

The region has a broad scope for moving towards the preparation of its own climate change agenda based on both South-South and North-South cooperation; in this way the environment and economic development will be mutually reinforcing.

C. Summary

- The negotiations for the second commitment period (post 2012) introduce variants in the global regime which not only deepen the obligations of the developed countries in terms of the adoption of nationally appropriate mitigation actions but can be reflected in commitments for the different sectors and for developing countries on the basis of criteria for responsibility and capacity (per capita GDP and emissions per capita). In future negotiations, calls may be made for emissions reductions in a growing number of developing countries —including those of Latin America and the Caribbean— in order to maintain climate security and stabilize emissions at those levels. A future where there is limited general access to the environmental service that the atmosphere performs as a carbon sink cannot be ruled out.
- In the region, a few steps have been taken to reduce emissions on the basis of economic development and domestic sustainability criteria. In this regard, it is important to have baseline protection mechanisms that adequately reflect the advances achieved, especially in light of future mitigation requirements.
- It is important for the region that the contribution made by forest conservation and appropriate land use to climate security and to emission mitigation efforts be recognized in payment mechanisms for environmental services. Reduction of emissions from deforestation and forest degradation must be part of the climate regime's market mechanisms. Even if there is an increase in the supply of certificates in emission reductions generated by less significant changes in land use, greater reduction efforts must be made by the developed world in response to this situation; these could have economic benefits (stability in the price of emission reduction certificates) as well as benefits for the international climate regime.
- Since the region does not play a very influential role on the international scene, it must now strive to improve its coordination mechanisms to enable it to participate in global negotiations with a regional agenda of its own; similarly, it must seek to implement coordinated initiatives for improving the economy and the environment and establish priorities relating to access to international cooperation funds for adaptation and mitigation. Closer regional coordination and a deeper knowledge of the economic implications of climate change are needed to further the climate-change and development agenda.

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