Summary 2009

Economics of Climate Change in Latin America and the Caribbean

UNITED NATIONS

ECLAC

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CONTENTS

Figures

Boxes

Maps

FOREWORD

Global climate change, which is associated basically with increases in the average temperature, changes in precipitation patterns, rising sea levels, the reduction of the world's ice masses and snow deposits, and the modification of extreme weather patterns, is one of the major challenges facing humankind this century. Its impacts on economic activities, populations and ecosystems are undoubtedly significant and in many cases irreversible. The challenge of simultaneously adapting to new climatic conditions and participating in an international mitigation strategy will entail costs of such a magnitude that climate change will heavily condition the nature of economic development in the decades ahead.

The socio-economic, institutional and geographical features of Latin America and the Caribbean make climate change a particularly pressing issue in the region. The acute sensitivity to climate shifts of some of its economic activities, such as agriculture and tourism, the potential loss of biodiversity or of human life or even the exposure to extreme weather events show how important it is to conduct an economic analysis of climate change in order to construct a sustainable long-term development strategy that is based on sound science and backed by broad social consensus. The global scope of climate change, its impact as a negative factor in economic development, the high levels of uncertainty surrounding the subject and the need for an effective risk management scheme are fuelling a heated debate encompassing the ethical aspects and equity, the size of the phenomenon across different periods of time, the channels through which the damages are transmitted, the economic costs involved and the best options for confronting them.

This document presents an aggregate economic analysis of climate change in Latin America and the Caribbean based on the national studies carried out on the topic in the region. It summarizes the results obtained and examines certain topics in detail. The conclusions are still preliminary; they seek to enhance understanding of the economic dimension of climate change and contribute to the search for possible solutions. This study was carried out during a relatively short timeframe in close collaboration with the Governments of Denmark, Germany, Spain and the United Kingdom, as well as with the European Union and Governments of countries in the region, the Inter-American Development Bank (IDB), the Global Mechanism of the United Nations Convention to Combat Desertification and a broad network of academic and research institutions. Responsibility for the economic estimates presented herein, however, should be wholly attributed to the authors and not to the aforementioned institutions.

The national studies reveal the diversity of the situations present in the region, as well as the richness and intensity of the debate surrounding the topic. They also spell out the significant, non-linear economic consequences of climate change in the region, which vary according to each country's socio-economic conditions. Furthermore, failure to tackle the issue is shown to be gradually turning into an additional limitation on economic growth. These analyses have generated new information and new capacities in the countries of Latin America and the Caribbean; the next step is to establish a forum for ongoing research and dialogue on the economics of climate change.

In the twenty-first century, the economies of Latin America and the Caribbean will have to take on the challenge posed by climate change, including the costs of adaptation and mitigation. They will simultaneously have to address other outstanding issues, such as sustained economic growth, job creation and poverty reduction. The region moreover faces the paradox of being a minimal contributor to climate change that nevertheless suffers a sizeable proportion of the worst consequences; yet its position would be made much more vulnerable by failure to engage in mitigation efforts within the framework of multilateral agreements entered into with the problem's greatest begetters.

International agreements on the topic must recognize the different levels of development and asymmetries between the countries or regions that most contribute to climate change through their GHG emissions and those that suffer the worst consequences. Designing proposals and strategies to tackle climate change should not be seen as running counter to the pursuit of economic growth. Solutions to the problems that climate change poses will be attainable only within a fair multilateral international agreement that acknowledges not only the global scope of the issue and the shared responsibilities involved, but also the historical differences between countries and provides for additional financial resources to be made available for tackling the challenges of mitigation and adaptation in the developing countries. Unilateral actions that curb existing flows of funding and access to additional financial resources are not long-term solutions and will only exacerbate the region's problems.

The private sector, the public sector and citizens in general must in their own ways actively contribute to the adjustments that will have to be made to secure a more viable future. Innovative solutions to the problems brought about by climate change will involve redirecting the economy towards low-carbon growth that is compatible with sustainable development. The atmosphere must be viewed as a public good and its preservation for future generations as an ineluctable duty of the generation of today.

The countries of Latin America and the Caribbean must build their future on the action of the present and seize the opportunity to improve quality of life and move towards a more sustainable pattern of development. The United Nations Conference on Climate Change (Copenhagen, 2009) represents an invaluable opportunity for the international community to formulate an inclusive, fair and equitable strategy in which the exercise of the precautionary principle can prevent irreversible damage. At the same time, fundamental development problems persist in the region, and these need to be tackled hand in hand with those arising from climate change.

I. INTRODUCTION

Climate change is without a doubt one of the greatest challenges facing humanity in the twenty-first century. The increase in greenhouse gases (GHGs), which is fundamentally linked to various anthropogenic activities, is causing changes to climates, such as gradual but steady increases in temperature, alterations in precipitation patterns, the reduction of the cryosphere (the world's ice masses and snow deposits), rising sea levels and changes in the intensity and frequency of extreme weather events (IPCC, 2007a).[1] The consequences of climate change for economic activity, populations and ecosystems are without a doubt immense. They will also increase over the course of the century and in many cases be difficult to reverse. In this context, the size of the estimated economic costs of the impacts (including those associated with adaptation) and of mitigation suggest that climate change will play an essential part in determining the characteristics and options for economic development in this century. The countries of Latin America and the Caribbean will therefore have to tackle the twin challenges of adapting to new climate conditions and participating in several international mitigation strategies. They will also have to ensure their economies are on the road towards sustainable development. The magnitude of the task requires the construction of a long-term strategy backed by sound science and a broad social consensus.

The economic analysis of climate change can provide essential input for identifying and drawing up strategies to help move countries closer towards solving the problems associated with climate change and towards attaining sustainable development. Such analysis is a complex undertaking, however: natural, economic, social, technological, environmental and energy processes are involved, as are certain aspects of international politics. It deals with very long timeframes and has to take into account planet-wide natural phenomena, non-linear impacts, specific limits, asymmetric causes and consequences, intense feedback processes, high levels of uncertainty and complex risk management calculations, as well as ethical considerations. In this regard, it is important to acknowledge two fundamental aspects of the economic analysis of climate change:

- The uncertainty margins are large because the analysis includes the complex process of assessing the risks associated with weather events that are sometimes catastrophic. The projections are thus merely scenarios that have a certain probability of occurring; they are not specific prognoses. There is an ethical component to the economic analysis of climate change inasmuch as it refers to the well-being of future generations and touches on matters that have no explicit market value, such as biodiversity and human life.

- Designing proposals and strategies to tackle climate-change problems should not be seen as countering the pursuit of economic growth. On the contrary, it is failing to address the issue that will have a negative impact on economic growth. Tackling the problems brought about by climate change means redirecting the economy towards low-carbon growth that is compatible with sustainable development.

[1] GHG emissions are expressed in equivalent CO_2 in terms of global warming potential measured over 100 years as set out in the IPCC Second Assessment Report (IPCC, 1996). The GHGs included are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and those with high warming potential, such as hydrofluorocarbon (HFC), perfluorocarbon (PFC) and sulphur hexafluoride (SF_6). In keeping with the reports submitted by countries for the United Nations Framework Convention on Climate Change (UNFCCC), the energy sector, industrial processing and agriculture are taken into account, as well as land-use change, forestry and waste levels. The energy sector is broken down into electricity and heating, transportation, manufacturing and construction, other types of fuel burn and fugitive gas emissions.

The purpose of this study is to present an aggregate economic analysis of climate change in Latin America and the Caribbean based on the national studies carried out on the topic, with a view to increasing understanding of the economic dimension of the issue and contributing to the discovery of possible solutions and alternatives. It should be noted that the estimates presented are preliminary and incomplete. They are the result of various restrictive assumptions made about the economies of the region based on data that are comparable but do not necessarily coincide with official figures. In all events, the goal of the analysis is to identify aggregate trends for the region, not to present specific cases. The estimates for each country do not necessarily coincide with the aggregate results and are reported in the individual country studies.

II. METHODOLOGICAL CONSIDERATIONS

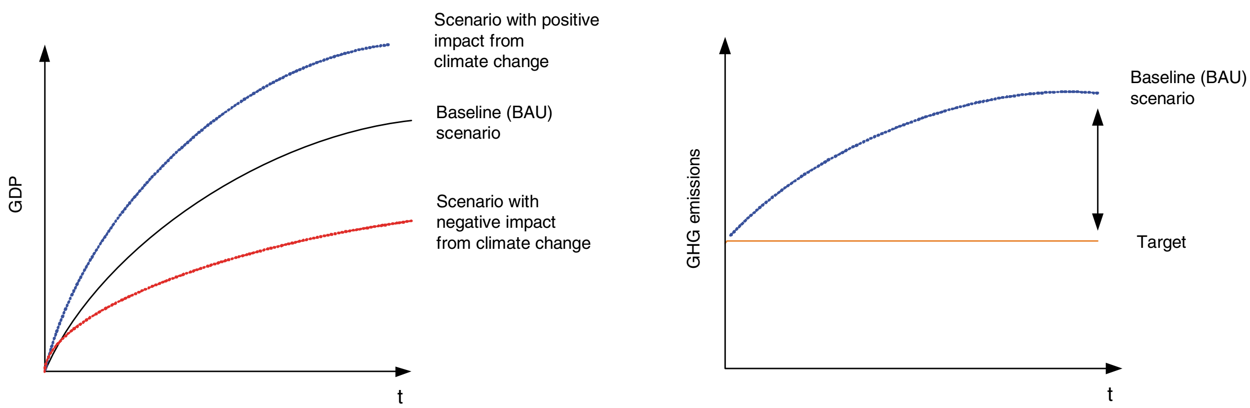
The economic analysis of climate change is controversial. It employs a range of methods and techniques (Nordhaus and Boyer, 2000 and Stern, 2007), each with its own advantages and biases, and no single one stands out as superior to the others. All start with the definition of the baseline or business as usual (BAU) scenario as a point of comparison for estimating the economic impacts of climate change and the effects of adaptation and mitigation. Two basic strategic lines of enquiry are pursued:

- The analysis of the economic impacts of climate change starts with the construction of a baseline scenario for economic activity that does not take the impact of climate change into account and then projects economic growth for each sector and the economy as a whole under the impact of climate change (see figure II.1(a)). The difference between the two curves, which are adjusted according to the chosen discount rate, represents the economic consequences of climate change. It should be borne in mind that adaptation to climate change will significantly modify the final result and some of the more transcendental effects of climate change have no direct economic value.

- The economic analysis of mitigation is based on the construction of the baseline scenario for GHG emissions by the economy as a whole or by certain economic sectors or activities. The costs associated with lowering GHG emissions from this baseline level according to specific targets (through what are known as “wedges”) are then estimated and a discount rate is applied (figure II.1(b)).

Figure II.1
CLIMATE CHANGE: ECONOMIC IMPACT AND MITIGATION SCENARIOS

(a) Economic impact scenarios (b) Mitigation scenarios



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

Given the diverse situations in the region and the existence of conditions and effects that are specific to individual countries, a range of analytical methods were used in this study. In all instances, however, rigorous methodologies were applied within a consistent theoretical framework wherever possible, and certain empirical regularities have made it possible to present an informed and comparable overview of climate change from the economic perspective. All the studies define a baseline as the point of reference and then consider the inherent features of climate change, which determine the specific type of analyses that are to be performed.

III. CLIMATE CHANGE SCIENCE

According to the global scientific evidence available (IPCC, 2007a), significant changes in climate are occurring, basically as a result of a set of anthropogenic activities, the signs of which include:

- A gradual and steady increase in the average temperature of the planet, albeit with significant differences between regions and between land and sea temperature patterns (IPCC, 2007a). The average temperature in fact rose by 0.8 ^{o}C between 1850-1899 and 2001-2005, with the sharpest rises being recorded in the last few decades. This has been reflected in an increase in the number of extremely hot days and a decline in the number of extremely cold days (IPCC, 2007a). Historical data in fact confirm that the current average temperature is the highest in the last 500 years, that the temperature during the last 50 years is unusual in relation to the last 1,300 years, and that 11 of the 12 hottest years since 1859 occurred between 1995 and 2006 (IPPC, 2007a, page 5).

- Significant changes in worldwide precipitation patterns, with an intensification of hydrological cycles. Furthermore, the correlation between higher temperatures and lower precipitation levels heightens the impact of weather phenomena (Madden and Williams, 1978; and Trenberth and Shea, 2005).

- Ocean temperatures are rising, although at different rates, in association with a gradual but significant decline in the cryosphere and the melting of glaciers in both hemispheres (IPCC, 2007a, page 5). Aditionally, the melting of the ice caps is contributing to the rise in the sea level (IPCC, 2007a, page 5).

- Modifications in the types and in the intensity and frequency patterns of extreme weather events. Temperature rises make alterations in the frequency and intensity of extreme weather events more likely although doubts still surround the expected changes in their probability distributions (Vincent and others, 2005; Aguilar and others, 2005; Kiktev and others, 2003; IPCC, 2007a, page 300; Marengo and others, 2009a.

The evidence for the influence of anthropogenic activity on climate is strong according to various models and at different levels of uncertainty, and there is high confidence that current climate patterns are associated with GHG emissions (IPCC, 2007a). Climate change can therefore only be properly simulated by simultaneously considering natural and anthropogenic forcings (IPCC, 2007a). The volume of GHGs in the atmosphere has increased sharply since the start of the industrial revolution. Current concentrations are the highest in 420,000 years (Siegenthaler and others, 2005 and IPCC, 2007a, page 465). The projections and simulations performed using climate models (IPCC, 2007a and 2007b) suggest that if the inertial growth in GHG emissions continues unabated, the average temperature could rise by between 1ºC and 6ºC, depending on the emissions scenario used. This increase in temperature would be accompanied by a rise of 18-59 centimetres in sea levels and other climate phenomena such as changes in global precipitation patterns, a reduction of the cryosphere and glaciers and an increase in the number and severity of extreme weather events. The effects of feedback are likely (albeit with a high degree of uncertainty) to intensify the projected changes in global climate.

IV. CLIMATE CHANGE IN LATIN AMERICA AND THE CARIBBEAN

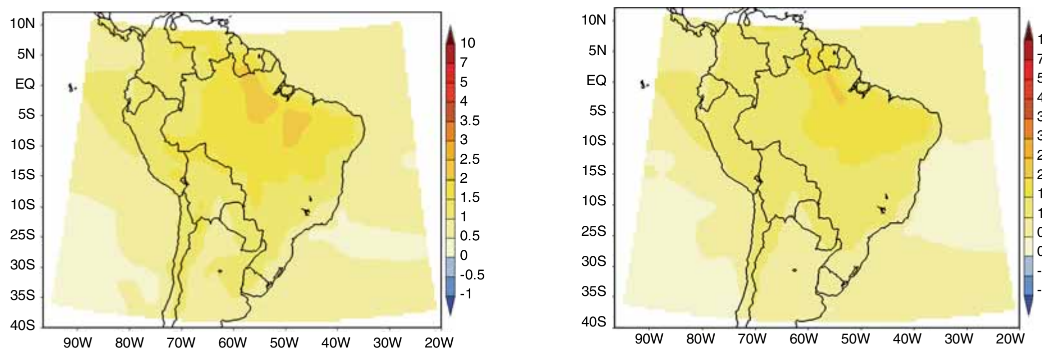
Climate projections for Latin America and the Caribbean indicate that the average temperature will continue to rise gradually but persistently and at different rates across the region and that there will be changes in the volume, intensity and frequency patterns of precipitation (see map IV.1). Climate will become increasingly variable, and the incidence of extreme temperature events, such as heat waves, will therefore increase. The average temperature in South America is projected to rise steadily, by between 1°C and 4°C under the lowest-emissions (B2) scenario, and by between 2°C and 6°C under the highest-emissions (A2) scenario (see map IV.1).[2]

[2] The A2 scenario is based on a buoyant international economy and intensive fossil fuel consumption that generates GHG concentrations in the atmosphere far above those observed at present. The B2 scenario is based on lower GHG concentrations and hence on lower impact from global warming.

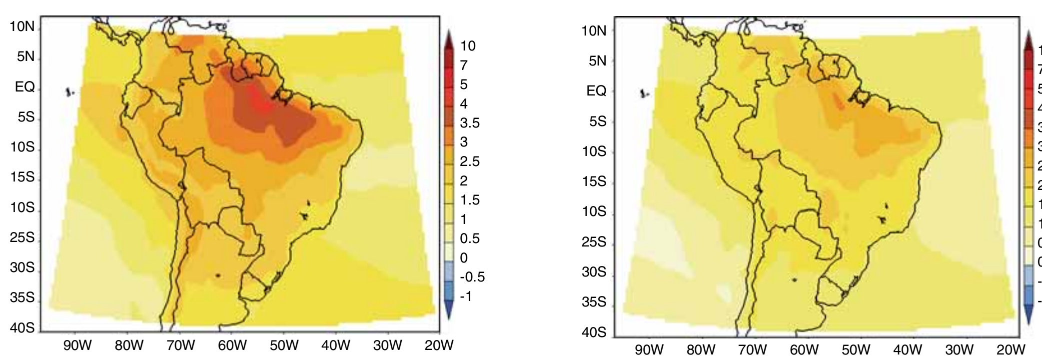
Map IV.1
SOUTH AMERICA: TEMPERATURE PROJECTIONS [a]
(Centigrade)

Scenario A2 | Scenario B2

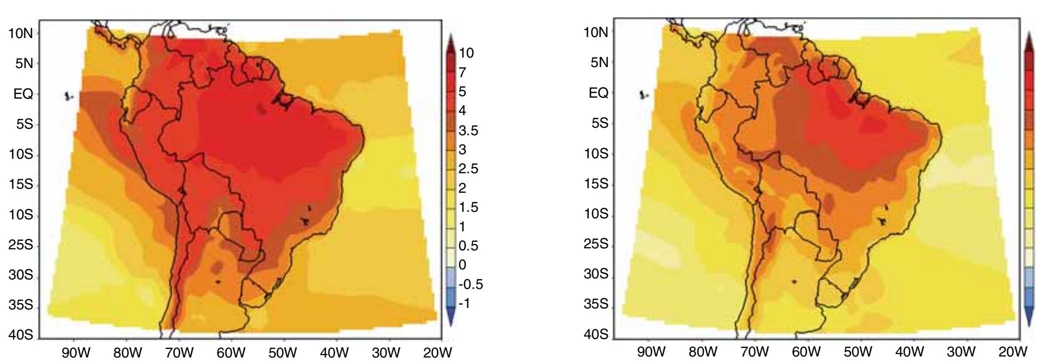
2011-2040



2041-2070



2071-2100



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from National Institute of Space Research (INPE) of Brazil.

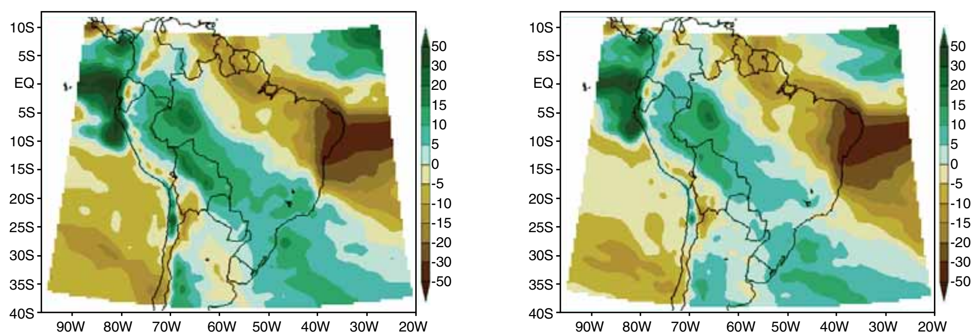
[a] Annual atmospheric temperature changes projected for 2011-2040, 2041–2070, 2071–2100 for the A2 and B2 scenarios derived from the HadRM3P model. The colour scale is shown to the right of each image.

Precipitation projections are more complex, and the ones for the region are particularly uncertain. Precipitation forecasts for the central and tropical regions of South America range from 20%-40% reductions to 5%-10% increases over the period 2071-2100 (see map IV.2).

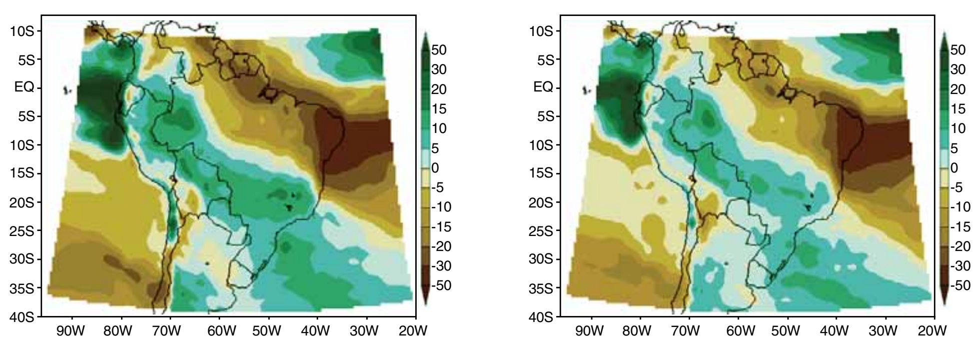
Map IV.2
SOUTH AMERICA: PROJECTED CHANGES IN PRECIPITATION [a]
(Percentages)

Scenario A2 | Scenario B2

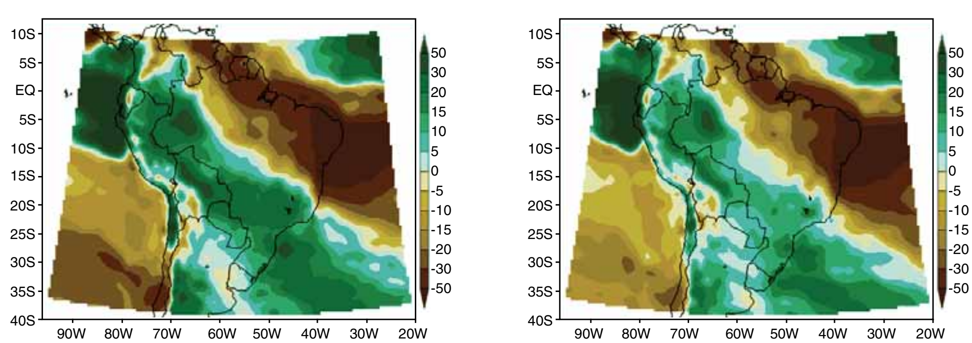
2011-2040



2041-2070



2071-2100



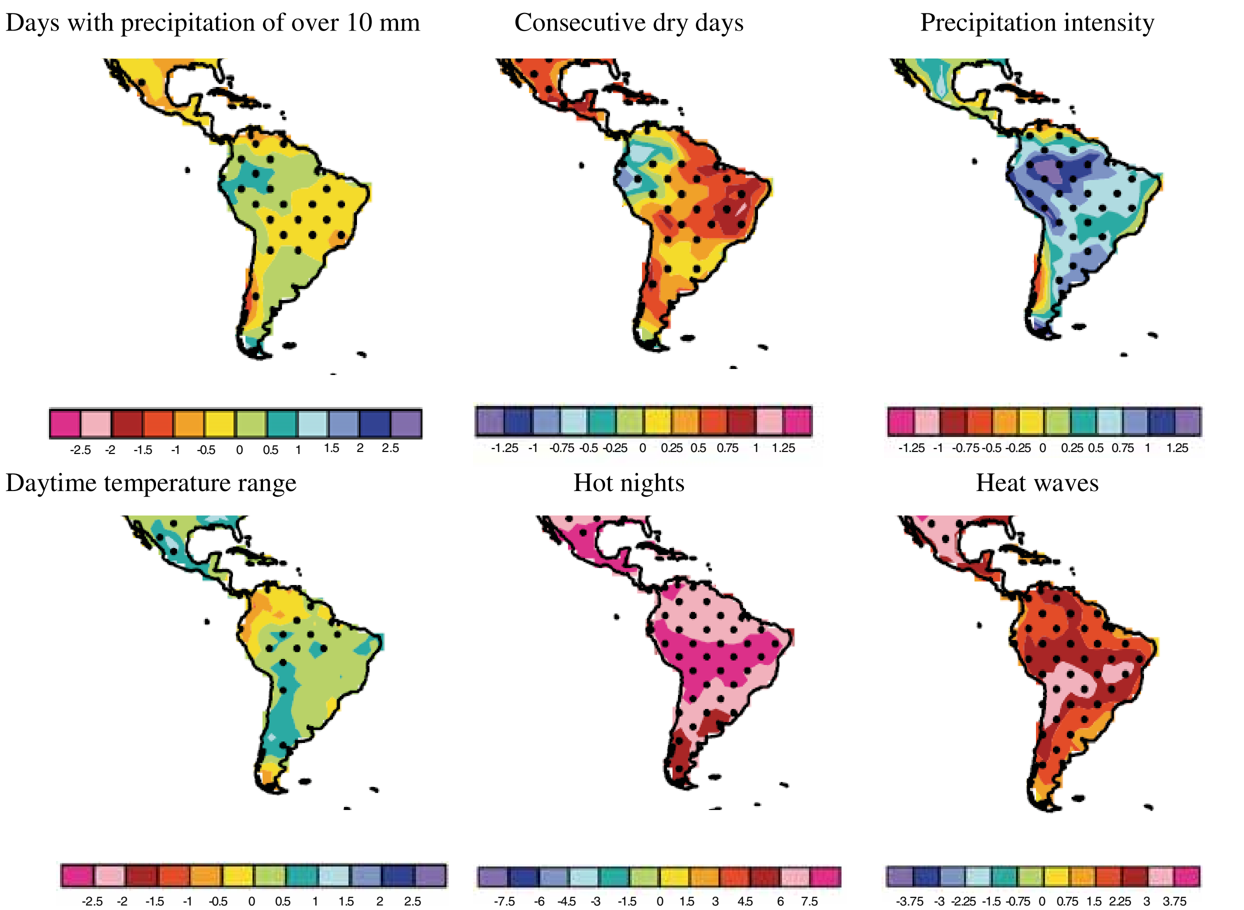
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from National Institute of Space Research (INPE) of Brazil.

[a] Annual atmospheric temperature changes projected for 2011-2040, 2041–2070, 2071–2100 for the A2 and B2 scenarios derived from the HadRM3P model. The colour scale is shown to the right of each image.

Climate projections show a steady increase in extreme weather events (see map IV.3). Rainfall is expected to increase over central Mexico and the tropical and south-eastern parts of South America. Climate models reveal a 10% average increase and a rising trend in precipitation in north-eastern Ecuador, Peru and south-eastern South America and a drop in rainfall in eastern Amazonia and the north-east of Brazil, the central-northern parts of Chile and most of Mexico and Central America. Continuous dry spells will tend to increase in Mexico, Central America and all of South America (except Ecuador, north-eastern Peru and Colombia) because precipitation levels are projected to change (rise or fall) by less than 10%. Although the intensity of precipitations is expected to increase in general in Latin America and Central America, dry spells between rainy periods will become longer and average precipitation levels will drop. Temperatures are rising in most of South and Central America, and heat waves are expected to become increasingly common all over the region, especially in the Caribbean, south-eastern South America and Central America. There is also expected to be a steady and significant increase in hotter nights across Latin America, especially in Mexico and Central America and the subtropical parts of South America.

Map IV.3

LATIN AMERICA AND THE CARIBBEAN: MULTI-MODEL AVERAGES OF SPATIAL PATTERNS OF CHANGES IN EXTREMES UNDER SCENARIO A1B [a]



Source: C. Tebaldi and others, “Going to the extremes: an intercomparison of model-simulated historical and future changes in extreme events”, *Climatic Change*, vol. 79, 2006.

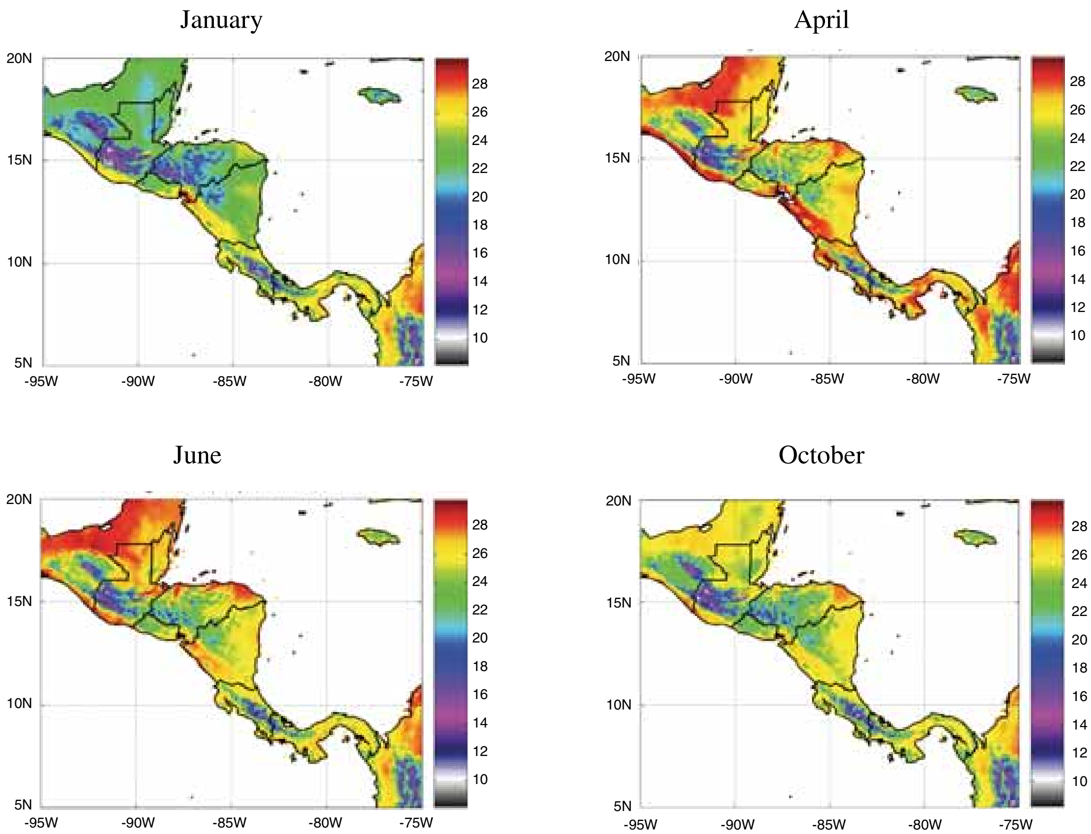
[a] The figure shows the difference between the averages for two twenty-year periods (2080–2099 and 1980–1999). The values for each model were standardized, and then a multi-model average was calculated. The dotted sections indicate areas in which at least five of the nine models concur that the change is statistically significant.

The available evidence on Central America for 1950-2000 shows temperatures rising and more volatility (see map IV.4). Precipitation maps reveal the concentration of rainfall in the period spanning approximately May to October and the difference between rainfall patterns along the Atlantic and Pacific coasts and between the northern and southern parts of the isthmus (map IV.5). Year-on-year variations in rainfall are high, associated with El Niño - Southern Oscillation. The projected changes in climate are summarized in table IV.1.

Map IV.4

CENTRAL AMERICA: AVERAGE TEMPERATURES IN THE MONTHS OF JANUARY, APRIL, JUNE AND OCTOBER, 1950-2000

(Centigrade)

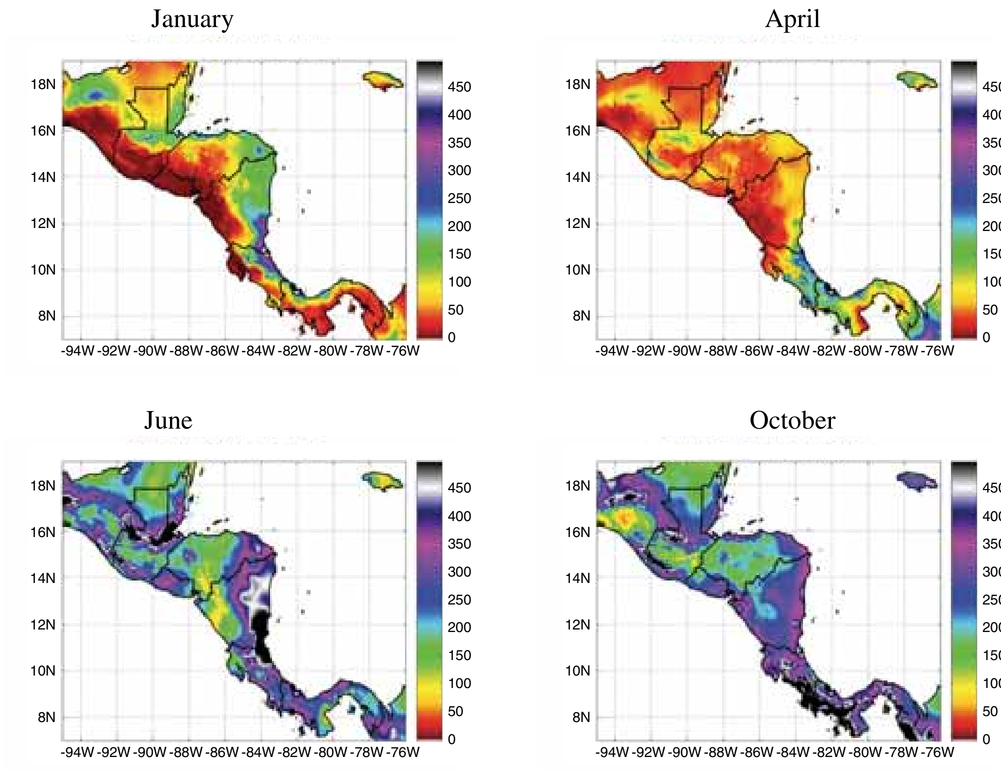


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Atmospheric Sciences Centre, National Autonomous University of Mexico (UNAM).

Map IV.5

CENTRAL AMERICA: AVERAGE PRECIPITATION IN THE MONTHS OF JANUARY, APRIL, JUNE AND OCTOBER, 1950-2000

(Millimetres)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Atmospheric Sciences Centre, National Autonomous University of Mexico (UNAM).

Table IV.1

CENTRAL AMERICA: PROJECTED CHANGES IN TEMPERATURE AND PRECIPITATION, 2020, 2050 AND 2080

Season	Changes in temperature (Centigrade)		
	2020	**2050**	**2080**
Dry	+0.4 to +1.1	+1.0 to +3.0	**+1.0 to +5.0**
Rainy	+0.5 to +1.7	+1.0 to + 4.0	**+1.3 to + 6.6**
	Changes in precipitation (Percentages)		
	2020	**2050**	**2080**
Dry	–7 to +7	–12 to +5	–20 to +8
Rainy	–10 to +4	–15 to +3	–30 to +5

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.

There is a high degree of uncertainty about the climate scenarios for the Caribbean (IPCC, 2007). Nevertheless, the projections for both the Atlantic and the Caribbean are presented in table IV.2. Evidence points to an increase in extreme weather events, mainly in the form of hurricanes.

Table IV.2
THE CARIBBEAN: CLIMATE SCENARIOS

Variable	**Scenario**
Temperature	Increase of between 0.8°C and 2.5°C by 2050 and of between 0.9° and 4°C by 2080
Precipitation	Variation of between -36.3% and +34.2% by 2050 and of between -49.3% and +28.9% by the end of the century
Sea level	Could rise by 35 cm by the end of the century
Extreme weather events	The frequency of hurricanes increases by 5%-10% over the course of the century

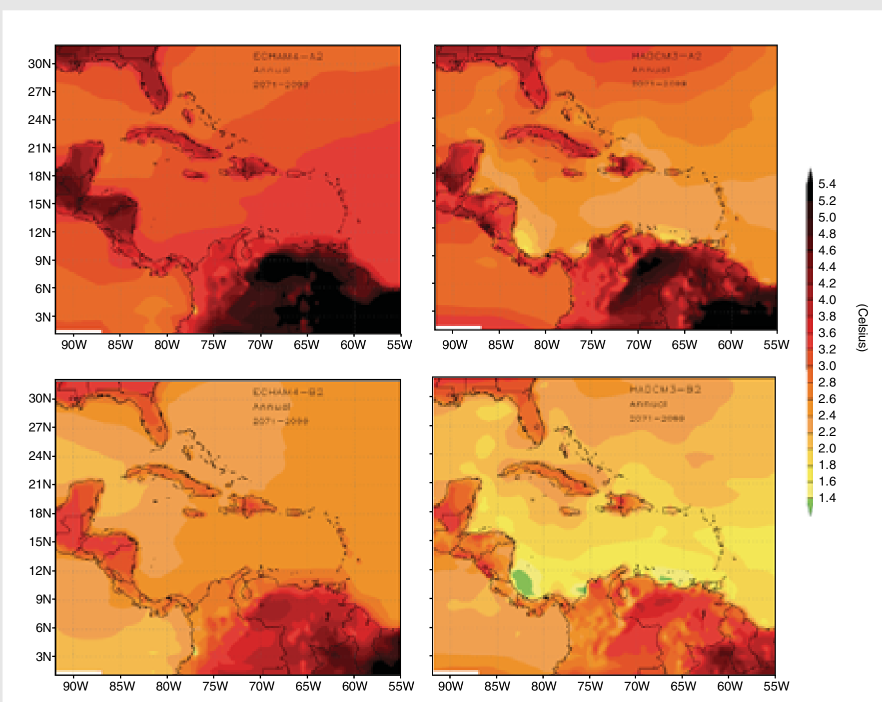
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007 - The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC*, Cambrigde University Press, 2007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

Box IV.1
THE CARIBBEAN: CLIMATE SCENARIOS

The different climate scenarios suggest that changes in temperatures and rainfall patterns could vary significantly in the Caribbean, as shown in maps 1 and 2. Nevertheless, average temperatures are expected to rise by between 2.3°C and 3.4°C for the region as a whole (Centella and others, 2008)

Map 1
ANNUAL TEMPERATURE VARIATIONS

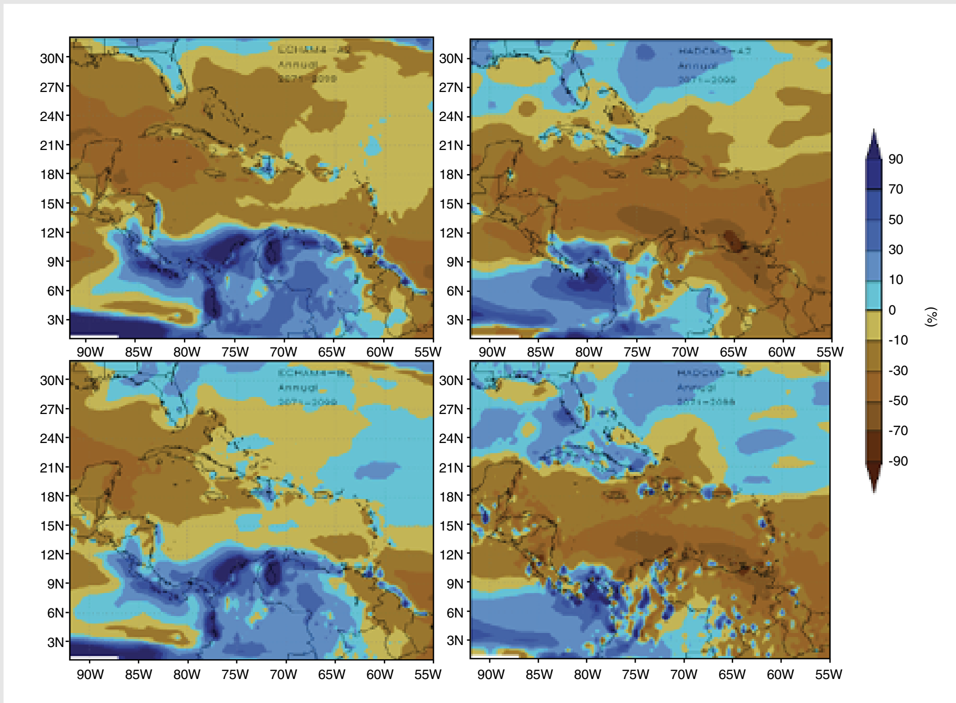
ECHAM4 **HadAM3P**



Box IV.1 (concluded)

Map 2
PROJECTED CHANGES IN PRECIPITATION LEVELS

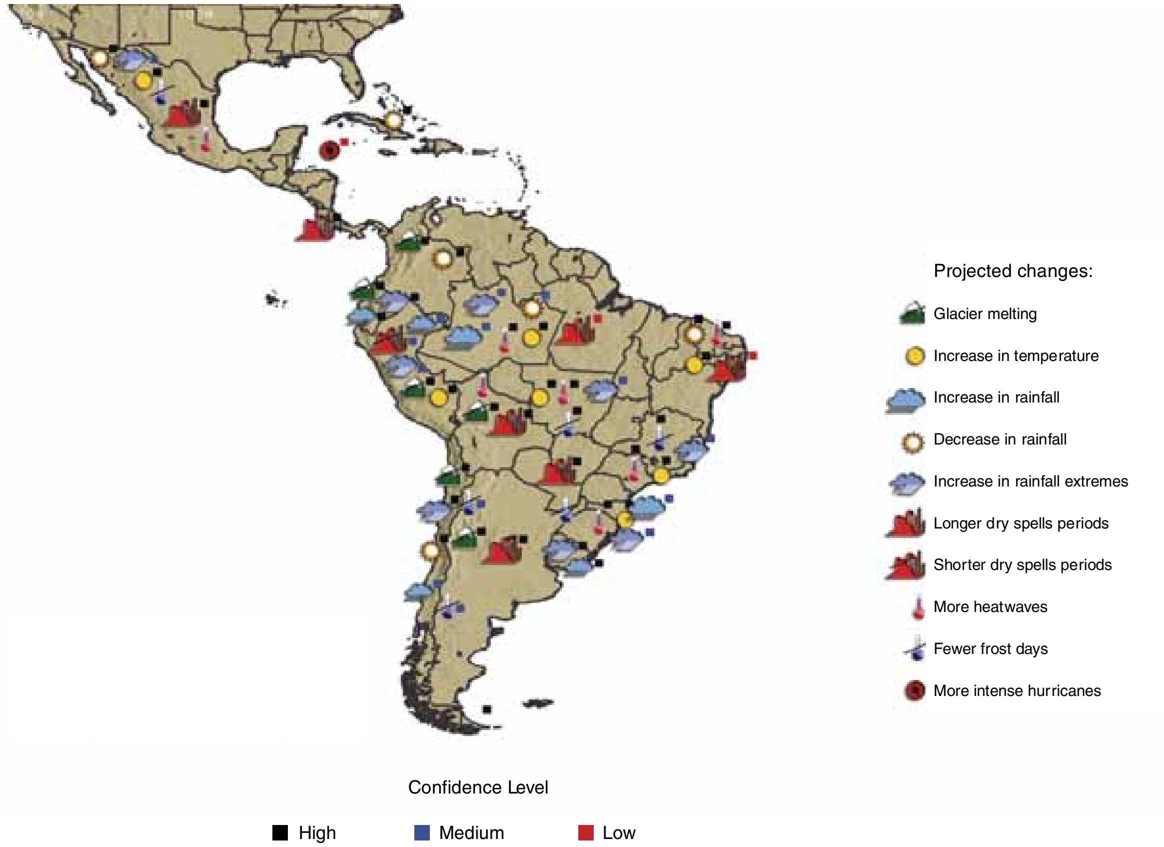
ECHAM4 **HadAM3P**



Source: A. Centella, A. Bezanilla and K. Leslie, *A Study of the Uncertainty in Future Caribbean Climate Using the PRECIS Regional Climate Model*. Technical Report, Belmopan, Caribbean Community Climate Change Centre (CCCCC), 2008.

The climate change patterns projected for 2010 in Latin America are summarized in map IV.6. The figures are based on the projected changes in climate averages and extremes as shown in Meehl and others (2007, chapter 10), Christensen and others (2007, chapter 11, cited in IPCC, 2007a), and Magrin and others (2007, cited in IPCC, 2007b).

Map IV.6
LATIN AMERICA AND THE CARIBBEAN: SUMMARY OF CLIMATE CHANGE PATTERNS PROJECTED FOR 2010 [a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from National Institute of Space Research (INPE) of Brazil.

[a] The confidence levels are based on the statistically significant levels of coincidence determined for the sign of change by a certain number of models (at least 80% for high confidence, 50%-80% for medium confidence and less than 50% for low confidence).

Main messages

The available scientific evidence shows that the global warming associated with the increase in GHGs generated by anthropogenic activity is creating noticeable changes in climate, such as: higher temperatures, alterations in precipitation patterns, the reduction of the cryosphere, rising sea levels and changes in extreme weather patterns. Projections suggest that it is highly likely that temperatures will rise on average by between 1°C and 6 °C and that precipitation patterns will change, with rainfall rising in some cases by 5%-10% and falling in others by 20%-40%. Furthermore, part of the glaciers in the Andean countries are expected to melt, extreme weather events in the Caribbean, Central America and the tropical and subtropical parts of South America will probably increase, and changes may occur in climate events like El Niño.

V. THE MACROECONOMIC SITUATION

The long-term growth of the economies of Latin America and the Caribbean is obviously shaped by a complex web of interrelated factors. Nevertheless, it is possible to identify a set of regular empirical patterns on which to construct future scenarios and their respective baselines or BAU counterparts. Altogether, in the economies of the region, as in modern economies on the whole, over the long term GDP and per capita GDP follow an upward trend with oscillations that are usually auto-correlated (Hodrick and Prescott, 1997, Blanchard, 1997, Fisher, 1994). The adequate identification of the trend and its respective probabilities distribution allows for long-term projections to be made by taking into consideration the levels of uncertainty determined on the basis of the historical evidence available for each country.

Historically, GDP and per capita GDP trends in the region have varied considerably, with average growth rates differing across countries and periods (see figure V.1). In Latin America and the Caribbean as a whole, growth was more sluggish in 1980-2008 than in 1950-1980 (see figure V.2), while GDP and per capita GDP, to different degrees, remained volatile (see figure V.1), as reflected in the oscillations around an average growth rate that varied from country to country and sometimes changed over time.

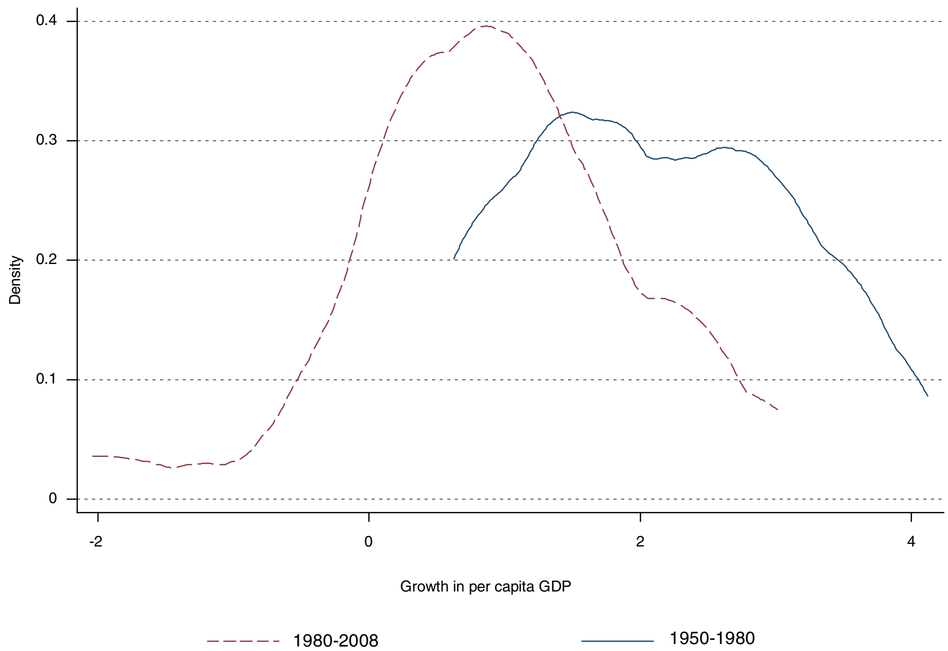
Figure V.1
LATIN AMERICA AND THE CARIBBEAN: ANNUAL STANDARD DEVIATION AND AVERAGE GROWTH RATE OF PER CAPITA GDP
(Percentages)

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Economic Indicators and Statistics Database (BADECON) for GDP at 2000 constant prices and Social Indicators and Statistics Database (BADEINSO) for population data.

Figure V.2

LATIN AMERICA AND THE CARIBBEAN: DISTRIBUTION OF ECONOMIC GROWTH RATES, 1950-1980 AND 1980-2008

(Percentages)



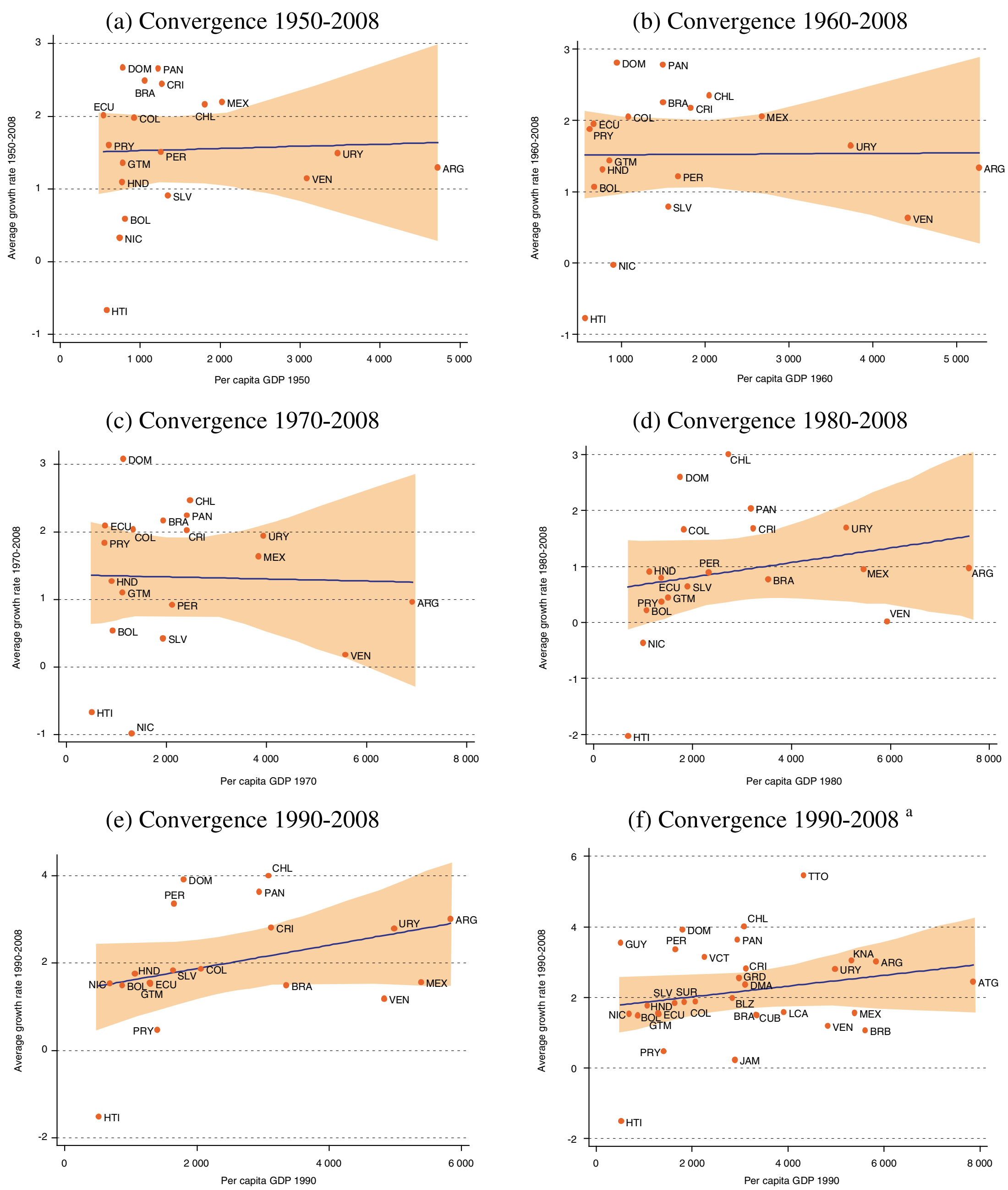
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices and Social Indicators and Statistics Database (BADEINSO) for population data.

The available evidence suggests that the per capita growth curves of the countries of Latin America and the Caribbean are not on course for absolute convergence (β-convergence) or for convergence of the dispersion in per capita GDP (σ-convergence) (Barro and Sala-i-Martin, 1992). In other words, the growth of the countries with lower per capita GDP is not greater than the growth of the countries with higher per capita GDP. As shown in figure V.3, the relationship between these variables alters over time, and, for some decades, there is no statistically significant relationship between them whatsoever or there is a slightly positive one. During the whole period under consideration in this study (1950-2008), the relationship between average per capita GDP growth (as a percentage) and per capita GDP (in 2000 dollars) weakened.

Figure V.3

LATIN AMERICA AND THE CARIBBEAN: PER CAPITA GDP VERSUS AVERAGE PER CAPITA GDP GROWTH RATE

(Percentages and 2000 dollars)



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 and Social Indicators and Statistics Database (BADEINSO) for population data.

[a] Includes the countries for which per capita GDP figures have been available since 1990: Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia, Suriname and Trinidad and Tobago.

This does not mean, of course, that no conditional convergence is observed in per capita GDP or no convergence among groups of relatively similar countries, when adjustments are made for a set of variables (Barro and Sala-i-Martin, 1992) and the probability of changing group is low.

The results show that the GDP and per capita GDP paths projected per country are consistent with the historical data available and that the historical evidence on each country can provide a reasonable prediction of the future. The economies of the region are thus expected to perform over the next few decades as they have done historically.

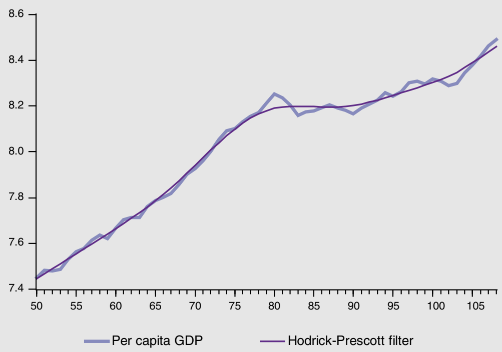
Box V.1

LATIN AMERICA AND THE CARIBBEAN: PER CAPITA GDP PROJECTIONS

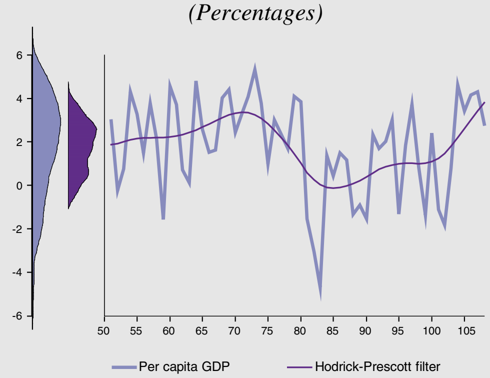
The trend for per capita GDP in Latin America and the Caribbean is upward, but with oscillations and at different paces. The average growth rate of per capita GDP over 1950-2008 was 1.8%; but in 1950-1980, the rate was much higher, over 2%. In 1980-2000, per capita GDP growth fell and was even negative for some of those years before picking up again as of 2001. The projections suggest that per capita GDP growth for the region as a whole will be 1.8%, with a 60% probability that it will be between 1.15% and 2.5%.

LATIN AMERICA AND THE CARIBBEAN: PER CAPITA GDP AND PER CAPITA GDP GROWTH, WITH THE HODRICK-PRESCOTT FILTER AND THE RESPECTIVE FAN CHART, 1950-2009 [a]

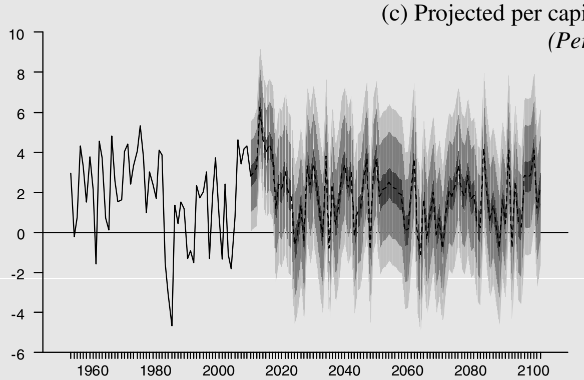
(a) Per capita GDP
(Logarithms)



(b) Growth rate
(Percentages)



(c) Projected per capita GDP growth, 2009-2010
(Percentages)



Scenario probability	Lower limit	Average	Upper limit
60	1.1	1.8	2.5
20	-2.0	-0.7	1.1
10	2.6	4.3	5.7

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 and Social Indicators and Statistics Database (BADEINSO) for population data.

[a] Only those countries for which data have been available from 1950 onwards are included in the per capita GDP calculations for Latin America and the Caribbean.

Main messages

The analysis of climate change uses various methods but generally involves the construction of a baseline (business as usual) scenario as a point of reference. The analysis of the impact of climate change uses this economic scenario as its baseline and the analysis of mitigation uses emission levels.

The economic analysis of climate change requires the construction of long-term economic scenarios that should not be used for making short-term projections. The macroeconomic scenarios constructed for each country are based on historical evidence and regular patterns detected in the economies over the last 50 years. These reveal three notable characteristics:

- The basic trend in the economies of Latin America is positive growth with oscillations.

- Annual growth rates oscillate considerably, and structural changes in their average trajectories can be used to mark the divisions between growth periods. This shows an initial period of relatively high growth was followed by a period of more sluggish growth and then the recovery witnessed in more recent years prior to the present crisis.

- There is no absolute convergence in per capita GDP among the countries of Latin America.

These characteristics suggest that:

- The projected economic scenarios are consistent with the evidence that there is no absolute convergence under way in the region.

- The per capita GDP growth rate projections are based on the assumption that growth will continue to be similar to that observed in the last two decades.

VI. ECONOMIC IMPACTS OF CLIMATE CHANGE IN LATIN AMERICA AND THE CARIBBEAN

The impacts of climate change in the region are multiple, heterogeneous, nonlinear and of differing magnitudes, and they are certainly significant despite some considerable lingering uncertainty about their transmission channels and their magnitude (Samaniego, 2009). Further, vulnerability to extreme climatic events is high (for example, the increase, over the past three decades, in El Niño-Southern Oscillation events, in the frequency and intensity of hurricanes in Central America and the Caribbean, and in extreme rains in the south-east region of South America). On the basis of information available from Regional Studies on the Economics of Climate Change (RECC), these impacts through 2100 can be synthesized in the following points:

The results as a whole show that there is solid evidence to support the argument that climate change is associated with significant economic impacts on the agricultural sector in the Latin America and the Caribbean region. These impacts are, however, very heterogeneous by country and region and also demonstrate nonlinear behaviour. Because of this, some regions and countries will enjoy temporary windfalls as a result of moderate increases in temperature and changes in precipitation, though the negative impacts will prevail in the long term. Therefore, the major impacts of climate change on the agricultural sector in the Latin America and the Caribbean region are likely to be as follows:

(i) Countries situated in the southern region of the continent, such as Argentina, Chile and Uruguay, with temperatures rising by between 1.5°C and 2°C over the period 2030-2050, could experience positive effects in agricultural productivity, though this does not take into consideration potential problems related to the appearance or the spread of pests and diseases, nor does it reflect water-supply constraints as a result of melting glaciers (especially in Chile and western Argentina). However, beyond this threshold the effects on agricultural production will turn negative.

(ii) In Paraguay, under global emissions scenario A2, significant drops in wheat and cotton yields are expected as of 2030, with soy production decreasing as of 2050, whereas corn, sugar cane and cassava production may increase.

(iii) In the Plurinational State of Bolivia, the agricultural frontier is expected to continue to expand and agricultural production and employment will continue to be essential to the country throughout the remainder of the century. The results of crop and municipal studies show that, on the whole, agricultural yields will be higher in areas with moderate temperatures and precipitation and might increase in higher-altitude areas, though impacts would be significant in regions that have extreme temperatures and precipitation.

(iv) In Chile, the forestry and agriculture sector will be affected severely, with yields increasing for some crops and regions as restrictively low temperatures rise (southern Chile), while other crops and regions of the country will see sharp declines due to shortages in irrigation water and rainfall (central and northern regions of the country).

(v) In Ecuador, climate impacts will have consequences that differ among agricultural production units. For example, for subsistence farms, a 1°C rise in temperature would cause an increase in crop yields, but this would be reversed once a 2°C threshold is crossed. For intermediate farms, a 1°C increase would affect banana, cocoa, and plantain production. In Colombia a possible 4°C rise in average temperatures is forecast by the end of the twentieth century, which will mean an approximate 700-metre rise in the altitude band that marks the optimal temperature threshold for some crops.

(vi) In Central America it is observed that, on average, the maximum temperature has already exceeded by several degrees the optimal for the crop yield index for several crops, which suggests further losses as temperatures continue to rise. Also, on average in Central America during the rainy season, cumulative precipitation levels are greater than the optimal for maximizing productivity, which suggests that a minor reduction could improve yields, but a significant reduction could mean losses. A more disaggregated analysis suggests possible losses in basic grains in regions with less precipitation, such as the Pacific slope.

(vii) For the Caribbean, the results obtained show that increasing precipitation levels could cause positive impacts on agricultural production in Guyana, whereas yields in Trinidad and Tobago could decline, owing mainly to increased incidence of farmland flooding. In the Netherlands Antilles, rising temperatures would benefit agriculture as a whole; the Dominican Republic would experience a similar impact. Generally, rising temperatures are not expected to affect sugar cane production any significant way, whereas crops, such as plantain, cocoa, coffee and rice are likely to be more susceptible.

The final net result of climate change impacts on agriculture also depends on a wide range of variables (these include the spread of pests, diseases and weeds, soil degradation and shortages of water for irrigation) and can change according to the capacity of CO_2 in fertilization for reversing the negative effect of rising temperatures and water deficits and as a function of the processes of adaptation and technological innovation.

Soil degradation is without a doubt a fundamental long-term problem in the Latin American and the Caribbean region and will increasingly affect production conditions for the agricultural sector. Available land degradation evidence is summarized in table VI.1, which shows that in the Plurinational State of Bolivia, Chile, Ecuador, Paraguay and Peru the areas that will potentially be degraded by the year 2100 are significant and vary from 22% to 62% of the territory, with Paraguay and Peru standing out as extreme cases.

Table VI.1
ESTIMATED LOSSES CAUSED BY LAND DEGRADATION IN SELECTED COUNTRIES

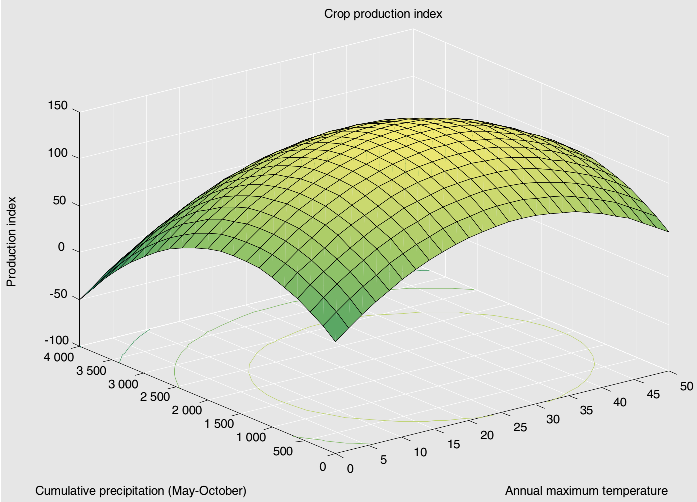
	Degraded area (Km2)	**Percentage territory**	**Degraded area (Km2)**	**Degraded area (km2)**	**Percentage territory (2050)**	**Percentage territory (2100)**
Bolivia (Plurinational State of)	60 339	5.5	123 301	243 979	11.2	22.2
Chile	77 230	10.2	157 818	312 278	20.8	41.2
Ecuador	40 136	14.2	82 017	162 289	28.9	57.2
Paraguay	66 704	16.4	136 308	269 716	33.5	66.3
Peru	197 211	15.3	402 996	797 418	31.3	62.0

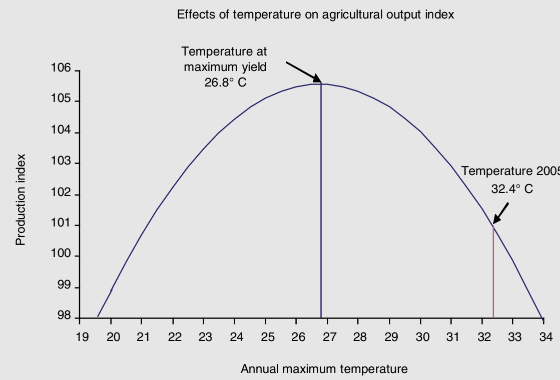
Source: Prepared by the author on the basis of Global Mechanism of the United Nations Convention to Combat Desertification, Global Land Degradation Assessment (GLADA) Regional Studies on the Economics of Climate Change (RECC) of the Economic Commission for Latin America and the Caribbean (ECLAC).

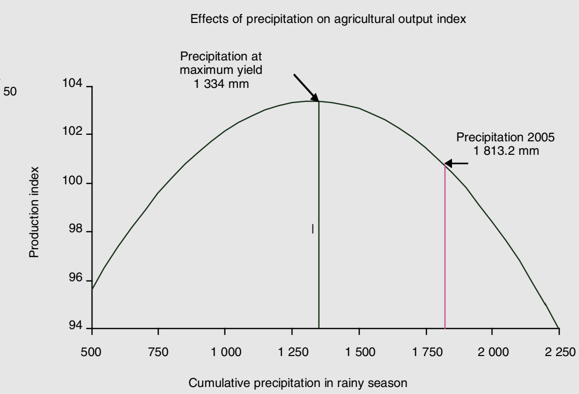
Box VI.1
EFFECTS OF TEMPERATURE AND PRECIPITATION ON AGRICULTURE

Central America:

Generally, the impacts of climate change are heterogeneous and nonlinear, as different crops have specific limits of tolerance and resistance. Accordingly, inflection points can occur in impact patterns. Conventional specifications for identifying climate impacts in agriculture assume a concave ratio to yields and production or both; this means that temperature and/or precipitation initially stimulate crop growth and later stymie it (Stern, 2007).







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

Areas of South America that are currently relatively dry will experience a decrease in the availability of water. Thus, a decrease of up to 30% in annual precipitation may be observed as a result of a 2°C increase in global temperatures and of between 40% and 50% with a 4°C increase (Warren, and others, 2006). This will substantially increase the number of persons who will have difficulty accessing clean water in 2025. Some areas of Latin America are expected to experience severe water stress, which will affect the water supply and hydroelectric power generation (particularly in the Andean countries and in the subtropical region of South America, which are highly dependent on hydroelectric energy). In addition, some glaciers will shrink or disappear, which will also cause water shortages and reduce hydroelectric power generation (CEDEPLAR/UFMG/FIOCRUZ, 2008). Under any climate scenario, Central America is expected to see its water availability affected by variations in temperature and precipitation, particularly on the Pacific slope, with increased salt content in coastal aquifers and in aquifers with high evaporation rates. The region is also expected to face greater problems with water quality and higher demand. For the Caribbean subregion, reduced water availability is expected, despite projected increases in precipitation as a consequence of the variability of rainfall. Furthermore, there is evidence that the number of dry days will increase. Cloudiness is also expected to increase, as is the intensity of tropical storms and cyclones.

The health impacts of climate change in the region will be related mostly to heat stress, malaria, dengue fever, cholera, respiratory illnesses and other conditions related to changes in precipitation, the availability of water and air quality (Githeko and Woodward, 2003; CEDEPLAR/UFMG/FIOCRUZ, 2008). Also, as a result of the loss of stratospheric ozone and increased ultraviolet rays, cases of non-melanoma skin cancer will increase in the southernmost regions of the continent (parts of Chile and Argentina) (Magrin, and others, 2007), as will morbidity and mortality due to heat waves. It is worth mentioning that the northeastern region of Brazil will be especially sensitive to climate-change-related health issues.

The rise in sea level will increase the numbers of people displaced and the land lost due to permanent flooding. Small Caribbean islands will be strongly impacted. The rising sea level will cause the disappearance of mangroves on the lower coasts (northern coasts of Brazil, Colombia, Ecuador, French Guyana and Guyana), damaging fishing grounds. Coastal flooding and land erosion will affect water quantity and quality. The intrusion of seawater could exacerbate socio-economic and health problems in these areas (Magrin, and others, 2007). Furthermore, there are serious threats to the coastal areas of the River Plate (Argentina and Uruguay) due to increasing storm waves and rising sea levels.

According to some weather models, a 3°C increase in global temperatures could translate into sharp declines in precipitation in the Amazon region, which will cause substantial deterioration of jungles that are home to one of the world’s greatest concentrations of biodiversity (Stern, 2008) and the risk even exists that some parts of the Amazon jungle will become savannah. On the continental and insular coasts of the Caribbean Sea, 1°C to 2°C increases will trigger increasingly frequent incidents of coral reef bleaching. Due to the concentrations of endemic species in the region, Latin America hosts seven of the world's 25 most critical biodiversity sites. Thus, climate change is putting at risk a significant portion of the planet’s biodiversity (see box VI.2).

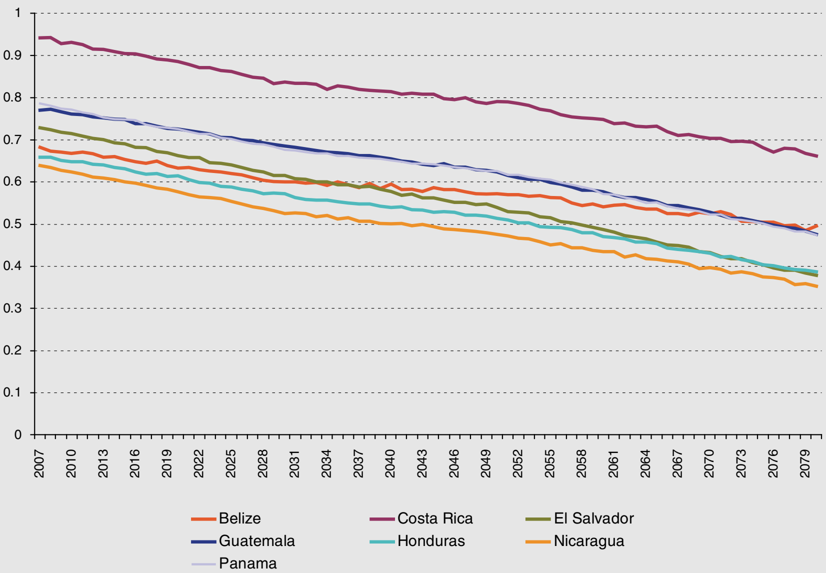
The countries of the Latin American and Caribbean region will be affected by climate variations and extreme events, which include, for example, the El Niño-Southern Oscillation (ENSO) and its counterpart, La Niña, extreme precipitation events and tropical storms (Zapata-Martí and Sadaña-Zorrilla, 2009). In 2100 the cost of climatic disasters, in constant 2008 prices, will move from an annual average of almost US$ 8.6 billion for the 2000-2008 period to i) US$ 11 billion at a 4% discount rate; ii) US$ 64 billion at a 2% discount rate; and iii) US$ 250 billion at 0.5% discount rate. (see figure VI.1) (Zapata-Martí and Saldaña-Zorrilla, 2009).

Box VI.2

BIODIVERSITY IN CENTRAL AMERICA

According to the National Institute of Biodiversity (INBio) of Costa Rica, Central America's great geologic, geographic, climatic and biotic diversity represents 7% of the planet's biodiversity. Multiple factors, such as deforestation, soil and air pollution, have negative effects on biodiversity that vary from country to country. Beyond these existing pressures, climate change will exert additional pressure through altered precipitation patterns, rising temperatures and larger numbers of extreme events, all of which translate into significant losses of biodiversity. A potential biodiversity index has been constructed to help identify the impacts of climate change. The figure below presents results of climate change simulations under scenario A1B, which show a decline in the index for all countries of the region.

CENTRAL AMERICA (7 COUNTRIES): EVOLUTION OF THE POTENTIAL BIODIVERSITY INDEX, BASED ON SCENARIO A1B



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

The direct market costs of biodiversity related to ecotourism, live animals, animal products, certified forest production (sustainable), organic farming, non-timber forest production and bioprospecting are estimated at US$ 179.81 million for the entire Central American region. Indirect costs were obtained using an agricultural production function that includes the biodiversity index and the marginal contribution of biodiversity to production and, thereby, the shadow price for ecosystem-related services. The average estimated cost for the region in 2080, with a discount rate of 0.5%, could be around 8.33% of GDP. The direct costs are estimated based on biodiversity market values and the indirect costs have to do with agricultural production. As in other cases, the costs are relatively low up to 2030 and then start to climb, rising very rapidly after 2050.

Scenario A1B

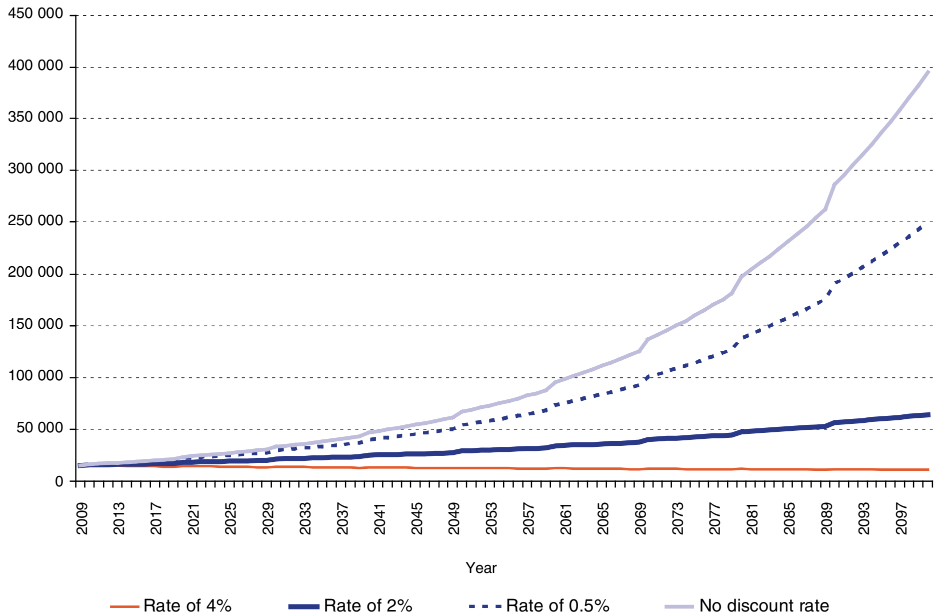
CENTRAL AMERICA: PRESENT VALUE OF ESTIMATED CUMULATIVE COSTS BY CUT-OFF YEAR IN THE BIODIVERSITY SECTOR UNDER CLIMATE CHANGE SCENARIO A1B

(Percentages of 2008 GDP)

Years	Discount rate		
	0.50%	**2.0%**	**4.0%**
2020	0.17	0.15	0.12
2030	0.55	0.44	0.34
2050	2.06	1.36	0.82
2080	8.33	3.95	1.65
2100	19.63	7.26	2.33

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

Figure VI.1
LATIN AMERICA AND THE CARIBBEAN: COST OF CLIMATE DISASTERS, 2009-2100
(Millions of constant 2008 dollars)



Source: Zapata-Martí and Saldaña-Zorrilla, 2009.

Main messages

The empirical evidence for the Latin American and Caribbean region shows that climate change does have significant impacts on the region's economies. However, these effects are extremely heterogeneous by regions and over time, with nonlinear behaviour, different magnitudes and, in some cases, irreversible consequences. Examples of these impacts are:

- The impacts of climate change in the agricultural sector differ by crop, region, type of land and economic agents. Thus, in parts of Argentina, Chile and Uruguay and in some regions of countries with temperate climates, a moderate rise in temperature could have positive impacts on the agricultural sector in some areas and for certain time frames. On the other hand, in tropical regions and in Central America, rising temperatures will have gradually worsening negative impacts. Furthermore, the impacts of climate change on soil degradation are significant and negative in all instances.

- Climate change will generally cause additional pressures on water resources in Argentina, Chile, Brazil, Ecuador, Peru, Central America and the Caribbean, as a consequence of changes in precipitation, rising temperatures and increased demand. This will have major negative consequences principally for agricultural production and the use of hydroelectric dams. Short-term, in some regions, a phenomenon might occur by which water availability will increase as a result of glacial melting, but long-term this may actually exacerbate water stress.

- Great uncertainty persists about the possible impacts of climate change on morbidity and mortality related to diseases such as malaria and dengue fever. However, the information available suggests that the spread of these diseases will extend beyond current geographical boundaries, increasing the number of people affected.

- The rise in sea level will cause the disappearance of mangroves in the lower coastal areas of the northern coasts of Brazil, Colombia, Ecuador, French Guyana and Guyana, as well as coastal flooding and land erosion. It will also affect infrastructure and buildings near the coasts, such as along the River Plate (Argentina and Uruguay), and will significantly damage activities such as tourism, particularly in the Caribbean.

- Climate change will cause significant, often irreversible, losses in biodiversity, which is particularly serious in a region that encompasses several of the most biodiverse countries in the world. Nevertheless, these physical losses have no established economic value because a significant portion of ecosystem-related services cannot be adequately quantified or included in the market.

- The evidence available about extreme events, such as intense rains and prolonged dry periods and heatwaves, suggest that changes in patterns, frequency and intensity will result in increased costs. These changes will have major impacts on subregions, such as Central America and the Caribbean, and on economic activities such as tourism, as well as triggering extreme precipitation events over a large portion of Latin America and the Caribbean. Seventy per cent of the continent currently suffers recurring flooding, and intense droughts are punishing the region’s most important productive systems.

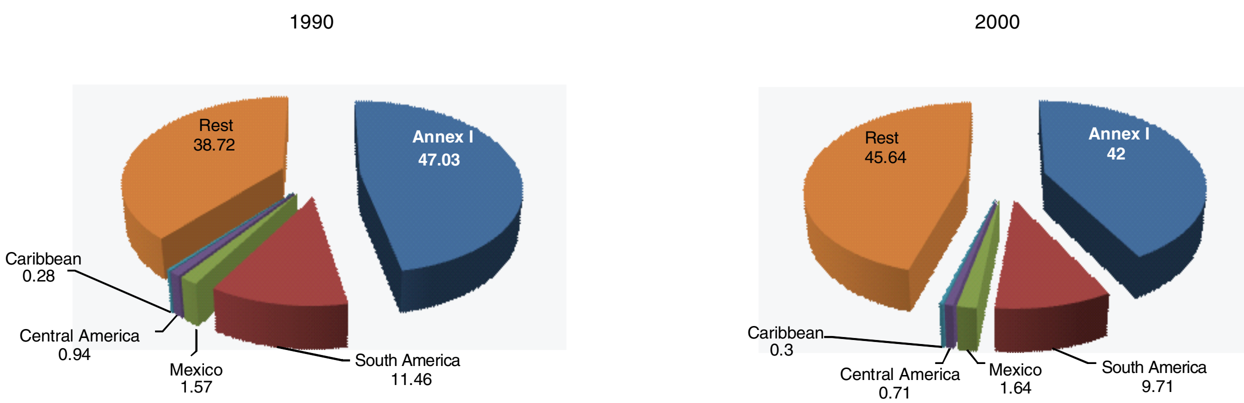
In this context, it is essential to design a regional strategy aimed at reducing the severest impacts and preventing those that are unacceptable, such as the irreversible loss of biodiversity, human lives and livelihoods.

VII. MITIGATION PROCESSES

The projected emission scenarios have climatic consequences that are unquestionably significant. They imply, for example, a high probability of a temperature rise of 2°C by 2050 and 3°C or even 4°C by the end of the century (IPCC, 2007b).

Emissions of greenhouse gases (GHGs) by the Latin American and Caribbean region show complex behaviour over time, as a result of the interaction of multiple factors. Latin America's total emissions represent a small share at the global level and, moreover, decreased as a proportion of total emissions between 1990 and 2000. South America's share dropped from 11.5% of the total in 1990 to 9.71% in 2000; Central America's fell from 0.94% to 0.71% and that of the Caribbean edged up from 0.28% to 0.30% (see figure VII.1).[1] This pattern is the net result of two opposing trends: a steady rise in emissions from energy consumption and, recently, an overall reduction in emissions from land-use change. In absolute terms, emissions are concentrated in a few countries, especially Argentina, the Bolivarian Republic of Venezuela, Brazil, Colombia, Mexico and Peru, with the other countries accounting for a smaller proportion.

Figure VII.1
LATIN AMERICA AND THE CARIBBEAN: SHARE IN TOTAL GHG EMISSIONS (INCLUDING LAND-USE CHANGE) [a]
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009.

[a] Includes carbon dioxide (CO_2), ammonium sulphate (NH_4), nitrous oxide (N_2O) and high global warming potential gases: perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6). Land-use change data are not available for Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

Globally speaking, 60% of emissions come from the burning of fossil fuels and cement production, followed by those generated by land-use change and the agricultural sector. In South

[1] For purposes of comparability, the information on emissions is taken from the Climate Analysis Indicators Tool (CAIT) Version 6.0 (WRI, 2009), which occasionally does not coincide with the official emissions inventories. For that reason, this information should be treated with due caution.

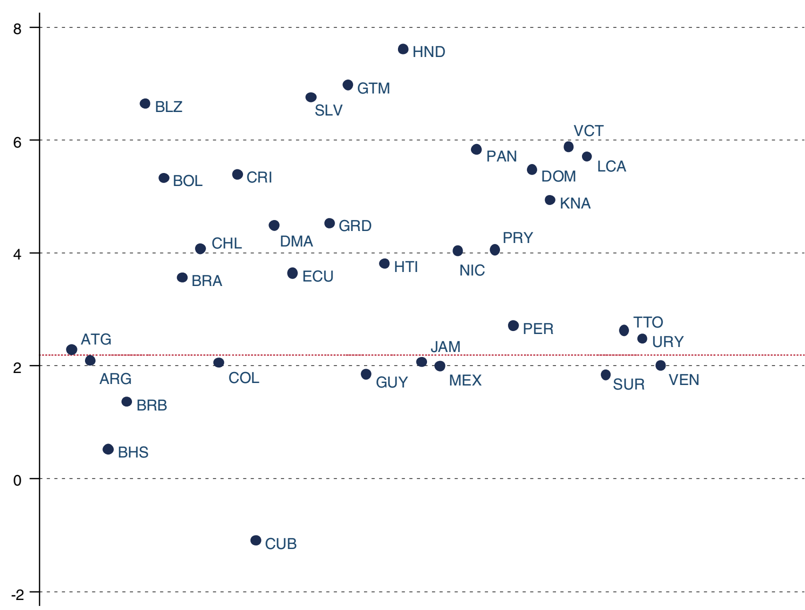
America, however, the energy sector generated only 21%, land-use change 51% and agriculture 24% of all emissions. In Central America, the energy sector produced 13% and land-use change 85% of the total. In the Caribbean, the energy sector represented 97% of total emissions, although data are lacking for most of the countries of the subregion. So, compared with world averages, the Latin American and Caribbean region produces more emissions from land-use change and fewer from the energy sector.

GHG emissions from the energy sector and cement production in Latin America and the Caribbean still represent a small proportion of total global emissions, although they have been on the rise: from 7% in 1990 to 8.2% in 2000. In 1990-2000, this category of emissions posted a growth rate of 2.9% for South America, 3.0% for Central America and 1.2% for the Caribbean, compared with the worldwide increase of 1.0%. This is evidence that, overall, emissions from the energy sector in the Latin American and Caribbean countries are still relatively small, although they are increasing faster than the world average, albeit with large differences from one country to another. The process of urbanization, access to energy, industrialization, and lifestyles and modes of transport, among other things, are factors driving this pattern.

1. Emissions and energy in Latin America and the Caribbean

CO_2 emissions associated with energy consumption and cement production in the region overall are tending to rise, showing a growth rate of 2.2% (simple average) for the period 1990-2005 (see figure VII.2).

Figure VII.2
LATIN AMERICA AND THE CARIBBEAN: AVERAGE GROWTH RATES OF CO_2 EMISSIONS, 1990-2005
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009 and Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices.

The relations between GHG emissions originating in the energy sector and cement manufacturing with respect to energy consumption, GDP and population may be formalized using the IPAT or Kaya identity (O'Neill and others, 2001). Greater economic growth (reflected in rising per capita GDP) and/or an increase in the population may be expected to lead to higher levels of emissions and greater energy consumption. However, a gradual process of energy decoupling (ratio of energy to GDP) and decarbonization (ratio of emissions to energy) may be expected to occur in the higher per capita income countries.

(1) $$\Delta\frac{CO_{2t}}{POB_t} = \Delta\left[\frac{PIB_t}{POB_t}\right] * \Delta\left[\frac{ENRG_t}{PIB_t}\right] * \Delta\left[\frac{CO_{2t}}{ENERG_t}\right]$$

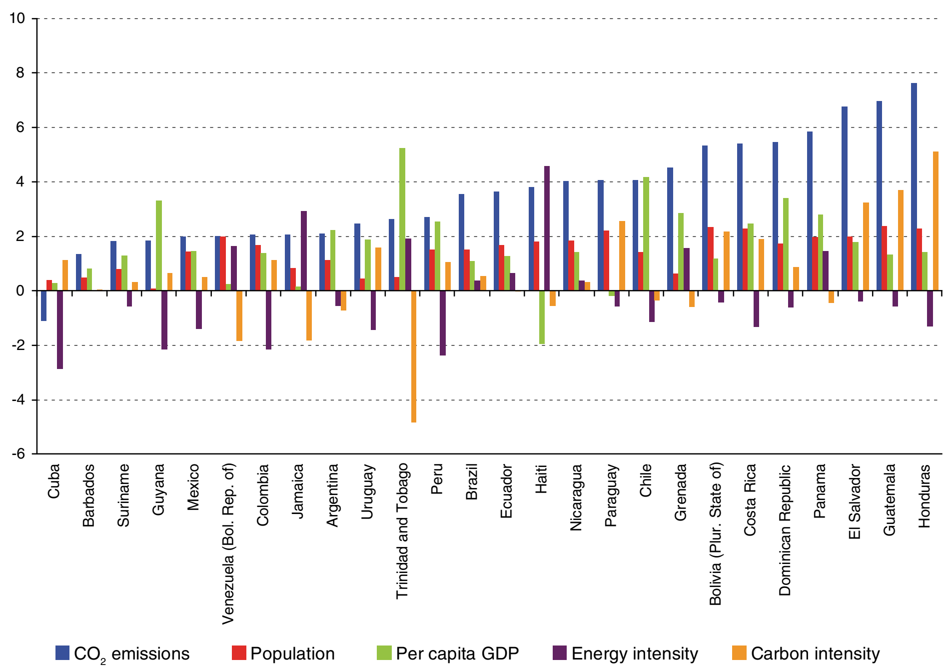
(2) $$\Delta CO_{2t} = \Delta\left[POB_t\right] * \Delta\left[\frac{PIB_t}{POB_t}\right] * \Delta\left[\frac{ENRG_t}{PIB_t}\right] * \Delta\left[\frac{CO_{2t}}{ENERG_t}\right]$$

Historical trends in GHG emissions in the Latin America and Caribbean region indicate that, generally speaking, emissions are negatively correlated with energy decoupling and decarbonization, and positively correlated with population and per capita income, although to different extents from one country to another (see figure VII.3).

Figure VII.3

LATIN AMERICA AND THE CARIBBEAN: AVERAGE ANNUAL GROWTH RATES OF CO_2 EMISSIONS AND THEIR COMPONENTS, 1990-2005

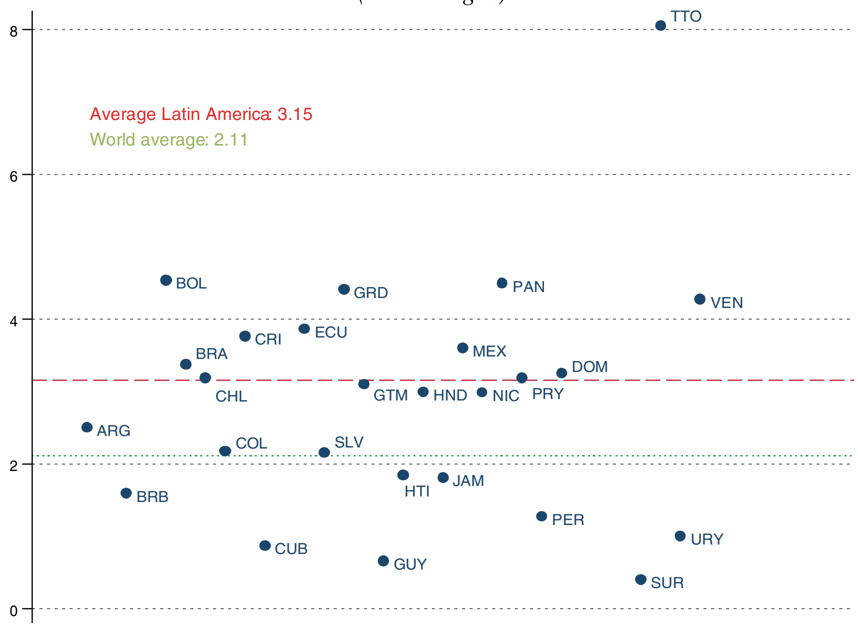
(Percentages)



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

The evolution of energy consumption in Latin America and the Caribbean shows an overall upward trend, reflected in a higher growth rate than the world average. Energy consumption rose at a rate of 3.15% for Latin America and the Caribbean overall in 1970-2007, above the global average of 2.11%, with the level of consumption and rate of increase varying among countries (see figure VII.4). Energy consumption rose at a faster rate than emissions.

Figure VII.4
LATIN AMERICA AND THE CARIBBEAN: GROWTH OF ENERGY CONSUMPTION, 1970-2007
(Percentages)



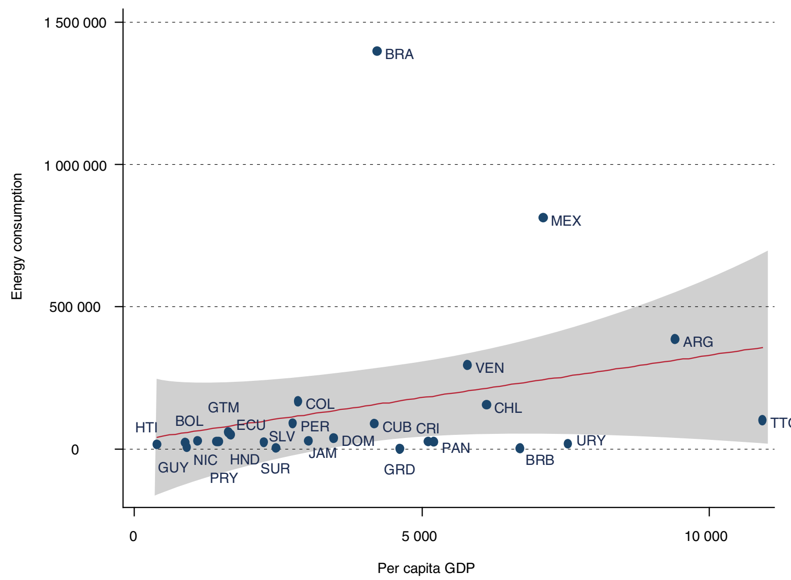
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE), for total energy consumption statistics.

The evidence available for Latin America and the Caribbean shows a strong positive association between energy consumption and per capita GDP (see figure VII.5) and between per capita energy consumption and per capita GDP (see figure VII.6).

Figure VII.5

LATIN AMERICA AND THE CARIBBEAN: RATIO OF ENERGY CONSUMPTION TO PER CAPITA GDP, 2007

(Thousands of barrels of oil equivalent and 2000 dollars)

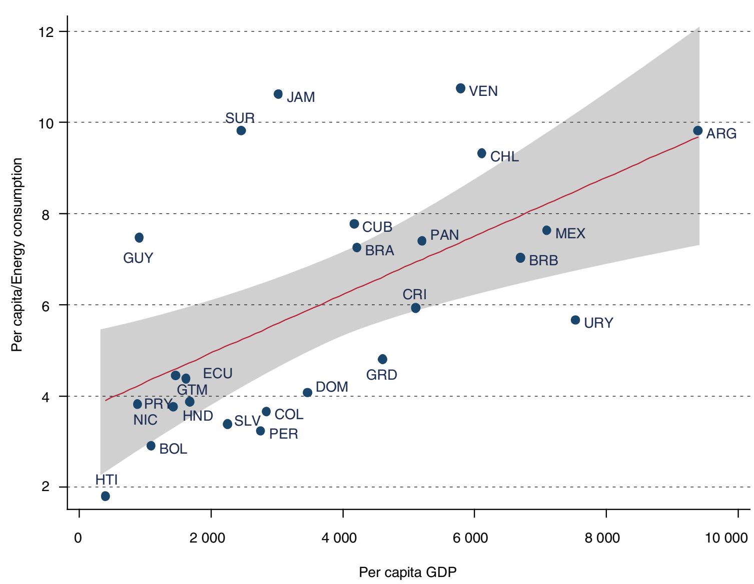


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE), for total energy consumption statistics and Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices.

Figure VII.6

LATIN AMERICA AND THE CARIBBEAN: RATIO OF PER CAPITA ENERGY CONSUMPTION TO PER CAPITA GDP, 2007

(Thousands of barrels of oil equivalent and 2000 dollars)



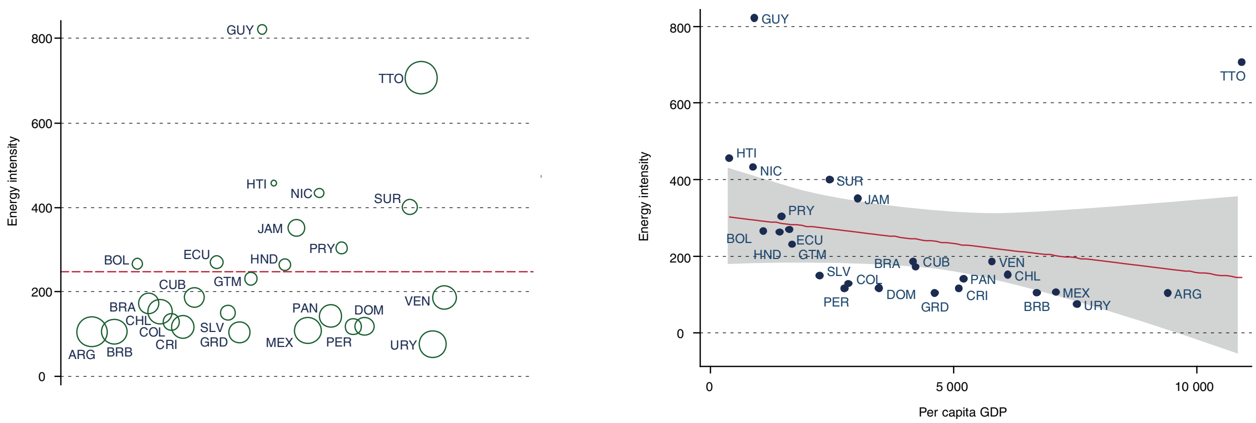
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE), for total energy consumption statistics and Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices.

Energy intensity (the ratio of energy consumption to GDP) varies by country in Latin America and the Caribbean (see figure VII.7) but, in general, it is still below the world average. There is an inverse correlation between energy intensity and per capita GDP (see figure VII.7(b)). This process of energy decoupling is not yet enough to halt growth in energy consumption in Latin America and the Caribbean in absolute terms, however, since the prevalent style of growth today still requires high energy consumption. Accordingly, any agreement that caps total energy consumption must be approached with extreme caution in the region.

Figure VII.7

LATIN AMERICA AND THE CARIBBEAN: PER CAPITA GDP AND ENERGY INTENSITY, 2007 [a]

(Thousands of barrels of oil equivalent and 2000 dollars)

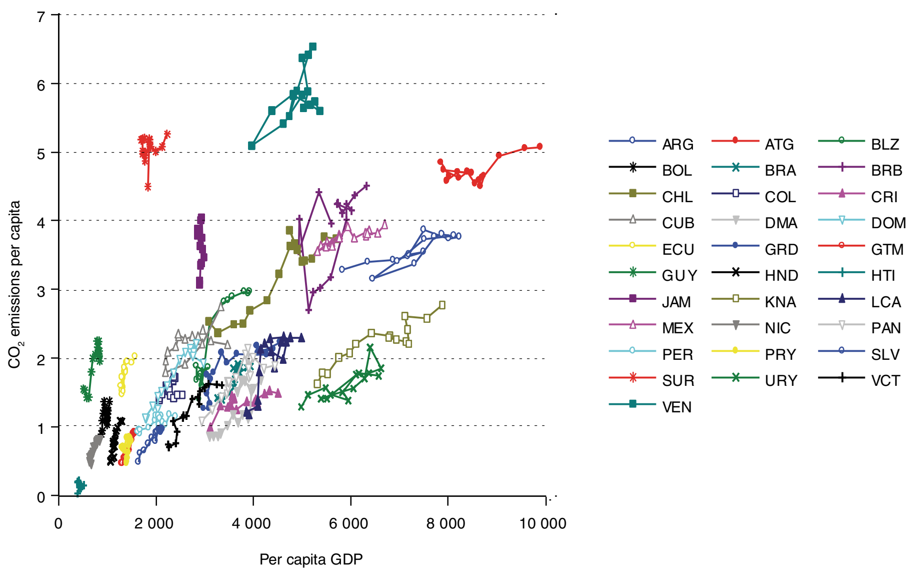


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE) for total energy consumption statistics, and Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices.

[a] The size of the circumferences is relative to the per capita GDP of the respective country.

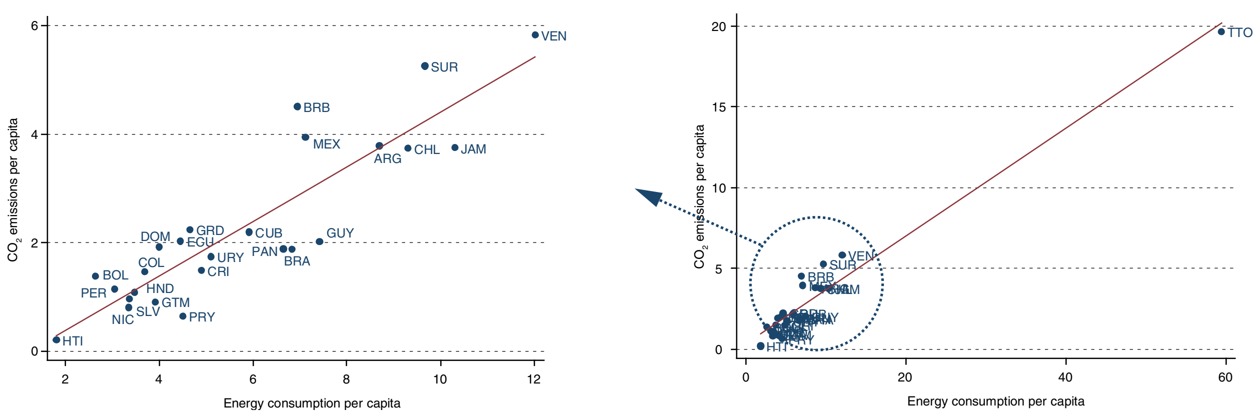
Per capita CO_2 emissions with respect to energy consumption and cement production in Latin America and the Caribbean also show an upward trajectory, although with non-linear oscillations and major differences among countries (see figure VII.8). These per capita emissions trajectories in the countries are positively correlated with the evolution of energy consumption and per capita GDP (see figures VII.9(a) and VII.9(b)). So, for the Latin American and Caribbean countries, there is a positive association between per capita emissions, per capita energy consumption and per capita GDP (see figure VII.10) (Stern, 2007).

Figure VII.8
LATIN AMERICA AND THE CARIBBEAN: PER CAPITA CO_2 EMISSIONS AND PER CAPITA GDP, 1990-2005
(Metric tons and dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), “Climate Analysis Indicators Tool (CAIT) Version 6.0” [online] www.cait.wri.org, 2009 for CO2 emissions statistics and information from Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices.

Figure VII.9
LATIN AMERICA AND THE CARIBBEAN: PER CAPITA CO_2 EMISSIONS AND PER CAPITA ENERGY CONSUMPTION, 2005
(Tons per inhabitant and barrels of oil equivalent per inhabitant)

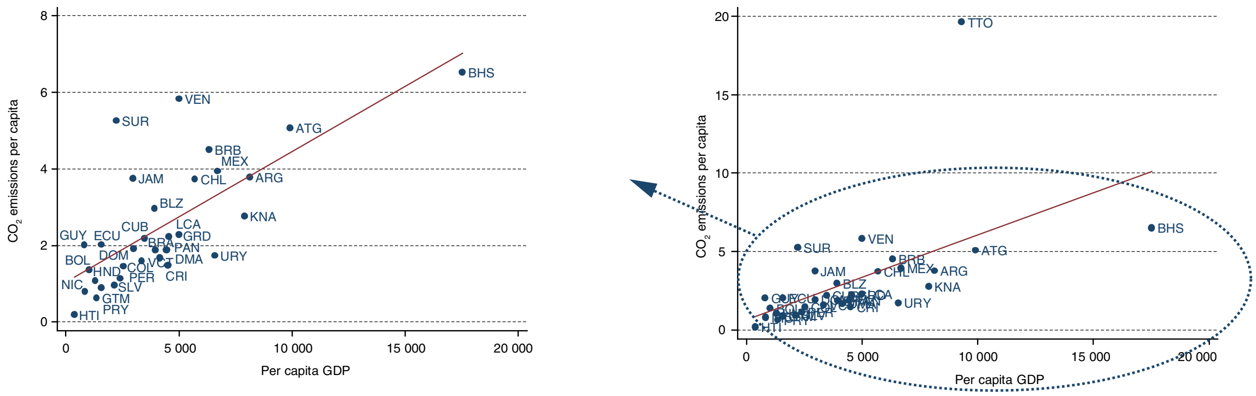


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), “Climate Analysis Indicators Tool (CAIT) Version 6.0” [online] www.cait.wri.org, 2009, for CO2 emissions statistics and information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE) for total energy consumption statistics.

Figure VII.10

LATIN AMERICA AND THE CARIBBEAN: PER CAPITA CO_2 EMISSIONS AND PER CAPITA GDP, 2005

(Tons per inhabitant and barrels of oil equivalent per inhabitant)



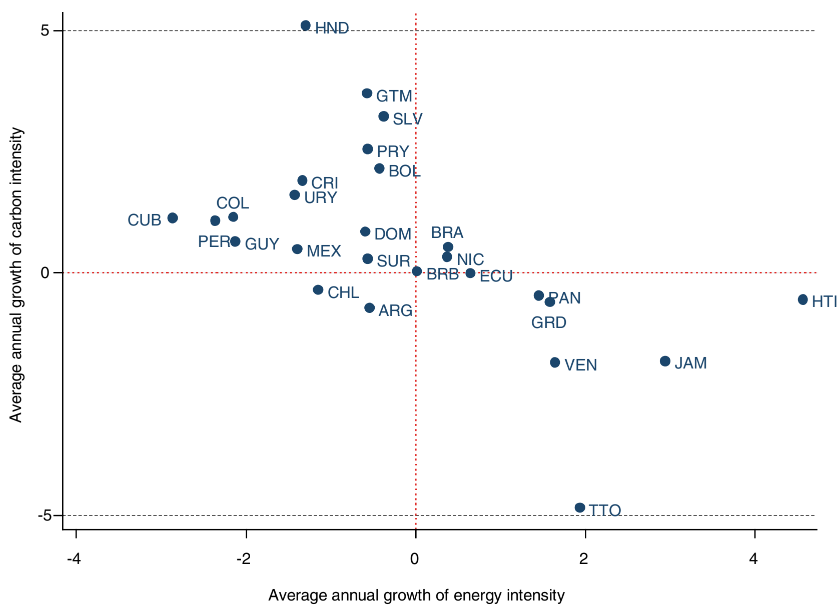
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009, and Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices.

Trends in the CO_2 intensity of energy and the energy intensity of GDP for Latin America and the Caribbean overall are mixed, although reductions are more frequent in energy intensity than in carbon intensity (see figure VII.11).

Figure VII.11

LATIN AMERICA AND THE CARIBBEAN: AVERAGE ANNUAL GROWTH RATES OF ENERGY INTENSITY AND OF CARBON INTENSITY, 1990-2005

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009; Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices and information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE), for total energy consumption statistics.

Trajectories for energy intensity and decarbonization oscillate somewhat over time and show large differences from one country to another. This suggests that these two processes may change significantly and that the BAU scenario is merely one possibility. Consideration of the full array of variations may even lead to the formulation of opposing scenarios. In general, however, for the region overall, the only way of reducing emissions in absolute terms would be by means of energy decoupling, decarbonization or both at the floor level of emissions records for the period. Projections to 2100 (Samaniego and Galindo, 2009a) show that:

- In Latin America and the Caribbean per capita CO_2 emissions will grow at an average annual rate of 2.3% under the assumptions of the BAU scenario.

- In the BAU scenario, by 2100 seven countries will exceed 19.9 tons of CO_2 emissions per capita —the current figure for the United States— associated with energy consumption and cement production.[2]

- It is important to note that under extreme scenarios or higher growth rates in energy and carbon intensity, several countries post rapid and unsustainable growth rates, reaching over 100 tons of emissions per capita.

- For most of the countries, scenarios incorporating an increase in energy or carbon efficiency result in decreases in per capita emissions of CO_2, or moderate growth of under 1%, with very few exceptions.

The importance of energy decoupling and decarbonization may be demonstrated by means of an exercise estimating per capita CO_2 emissions for the Latin American and Caribbean region, based on comparisons with the world's largest emitters. Supposing constant per capita GDP in Latin America and the Caribbean for 2005, the exercise estimates the level of per capita emissions the region would produce if its energy intensity and decarbonization rates were similar to those of the United States, the European Union or China. The results show that, in general, the countries of the region would produce lower per capita emissions with an energy intensity and decarbonization structure similar to that of the United States and the European Union, and higher per capita emissions if its structure were similar to that of China. Overall, the region's per capita emissions performance improves under the first two scenarios, with per capita emissions declining from 2.6 to 2.3 tons of CO_2 applying the structure of the United States and from 2.6 to 2 tons of CO_2 applying the European Union structure. However, the region's emissions rise to 12.8 tons of CO_2 per capita if the values corresponding to China's economy are applied.

Accordingly, it may be observed that Latin America and the Caribbean needs to maintain a strong growth rate in the coming decades and that its per capita emissions are notably lower than those of the developed countries. This means that the region has some room for manoeuvre that it must use to put in place a long-term strategy for moving onto a trajectory of energy decoupling and decarbonization.

2. Energy demand and energy intensities

The evolution of energy intensity depends on a broad range of factors, including: evolution and changes in the sectoral structure of GDP (for example, stronger development of energy-intensive industries);

[2] This does not include the particular case of Trinidad and Tobago, which already matches the United States in terms of emissions per capita.

relative prices both of energy and of machinery and equipment; technological changes and shifts in modes of production; the urbanization process under way in the region; policies relating to access to new and modern sources of energy; trends in equipment efficiency and access to it; better satisfaction of needs and improvements in well-being, reflected in energy services; the existence of institutional barriers; and the public policies applied.

Econometric estimates of energy demand run for South America using cointegration methods indicate that, although demand varies by country, its per capita income elasticity (η_y) is generally very high (even higher than 1), but its price elasticity (η_p) is very low, moving between values of 0 and -0.2 (see table VII.1). This points to the importance of income in facilitating access to equipment. Equipment and equipment prices could therefore be a more important variable than energy prices themselves in explaining the evolution of consumption, at least in end-consumption sectors. In production sectors, inasmuch as energy consumption is a derived demand, activity levels appear repeatedly as the most important variable in explaining energy demand patterns. All in all, these estimates indicate that continuous economic growth in the region will be accompanied by rising energy demand. The low price elasticity of energy demand reflects multiple factors, such as those already mentioned, which would have to be analysed in detail on a case-by-case basis, in order to determine the possible scope of pricing policy for controlling short-run demand.

Table VII.1
LATIN AMERICA: ESTIMATED ENERGY DEMAND ELASTICITIES, 1985-2007

	η_y	t-stat	η_p	t-stat
Argentina	1.20	7.67	-0.02	-4.14
Bolivia (Plurinational State of)	2.36	4.78	-0.01	-0.02
Brazil	1.94	8.29	-0.01	-9.16
Chile	0.99	27.44	-0.07	-4.16
Colombia	0.34	2.38	-0.15	-5.28
Ecuador	1.45	7.76	-0.07	-7.20
Paraguay	0.65	1.95	-0.22	-8.64
Peru	0.70	15.14	-0.01	-6.71
Uruguay	0.63	4.68	-0.03	-3.18
Venezuela (Bolivarian Republic of)	0.36	2.28	-0.11	-17.25
Group	1.06	26.04	-0.07	-20.79

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE) for total energy consumption statistics and Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices.

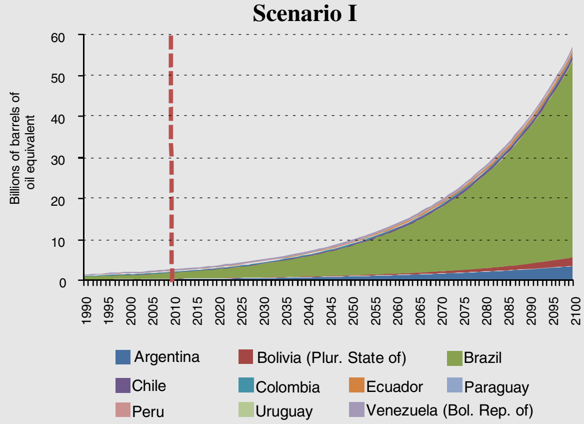
Box VII.1
PUBLIC POLICIES LABORATORY

Econometric estimates of energy demand can be used to simulate different public policy alternatives. Generally speaking, the results show that demand for energy is highly sensitive to income trends, albeit perhaps somewhat lagged (Galindo, 2009), and that it is fairly insensitive to changes in relative prices. The low price sensitivity of energy consumption in the region suggests that it is necessary to promote mechanisms to increase that elasticity. This requires economies to have suitable substitution alternatives. However, the negative externalities associated with the consumption of fossil fuels suggest that the energy prices are likely to increase in the future, as a result of either a carbon tax (Nordhaus, 2008) or rising oil prices. This would mean realigning the vector of relative prices in the economy including wages, the real exchange rate, energy prices and interest rates. With this in mind, the consequences of different pricing policies were simulated, using the following scenarios:

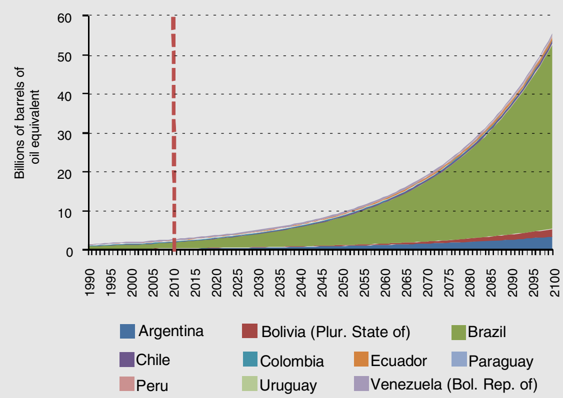
(i) A per capita GDP growth rate of 2% in all the countries with no changes in relative energy prices.
(ii) A per capita GDP growth rate of 2% in all the countries with a 2% increase in relative energy prices.
(iii) A per capita GDP growth rate of 2% in all the countries with a 4% increase in relative energy prices.

The results show that in scenario I, aggregate energy consumption would rise by an average annual rate of 3.36% up to 2100. A 2% rise in relative energy prices (scenario II) brings an average annual increase of 3.33% for the same period. Lastly, a 4% rise in relative energy prices (scenario III) would generate an average annual increase of 3.31% in energy consumption. These simulations are summarized in the figure below, which shows that energy consumption continues to rise in all cases regardless of price increases. So, given the current price elasticities of energy demand, it is highly unlikely that demand patterns can be controlled simply by raising prices, although the responses vary by country. Such a policy would, however, have significant impacts on tax collection.

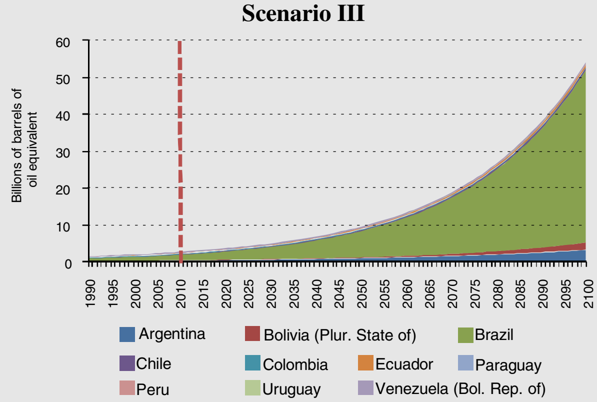
Scenario I



Scenario II



Scenario III



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Latin American Energy Organization (OLADE), Energy-Economic Information System (SIEE) for total energy consumption statistics and Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices.

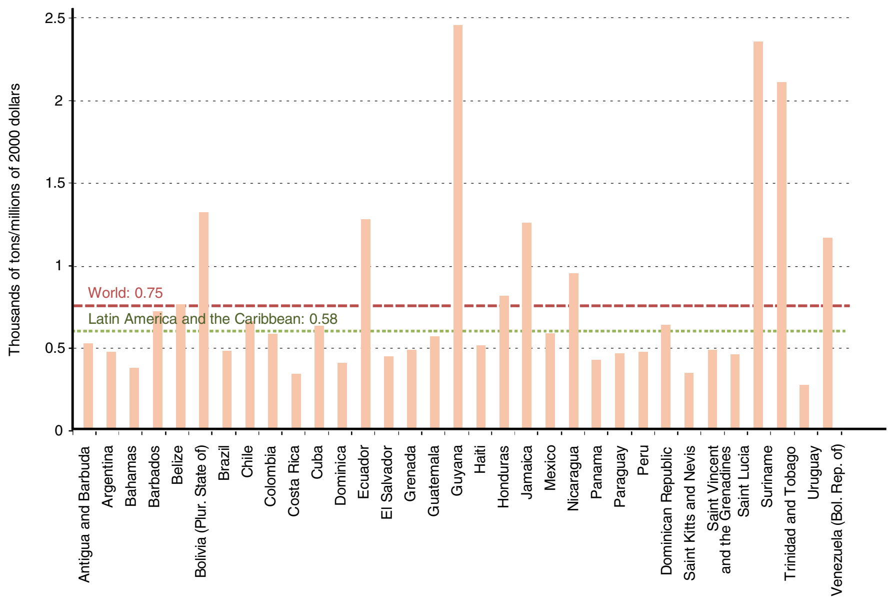
3. Emissions, productivity and convergence in Latin America and the Caribbean

Emissions per unit of GDP are different for each of the Latin American and Caribbean countries but, in general, they are lower than the world average (see figure VII.12). Accordingly, the region has a strong competitive advantage in an international scenario of caps or taxes on CO_2 emissions. The emissions intensity of GDP falls as per capita GDP rises, although at rates that differ in a non-linear fashion from one country to the next and by groups of countries. This is borne out by the econometric estimations of smooth transition autoregressive (STAR) models (González, Teräsvirsta and Van Dijk, 2005), which show the per capita income elasticity of emissions declining in the region. Reductions in response sensitivities of emissions to per capita income are, however, insufficient to decouple trajectories of growth in per capita income and in GHG emissions.

Figure VII.12

LATIN AMERICA AND THE CARIBBEAN: CO_2 EMISSIONS PER UNIT OF GDP, 2005

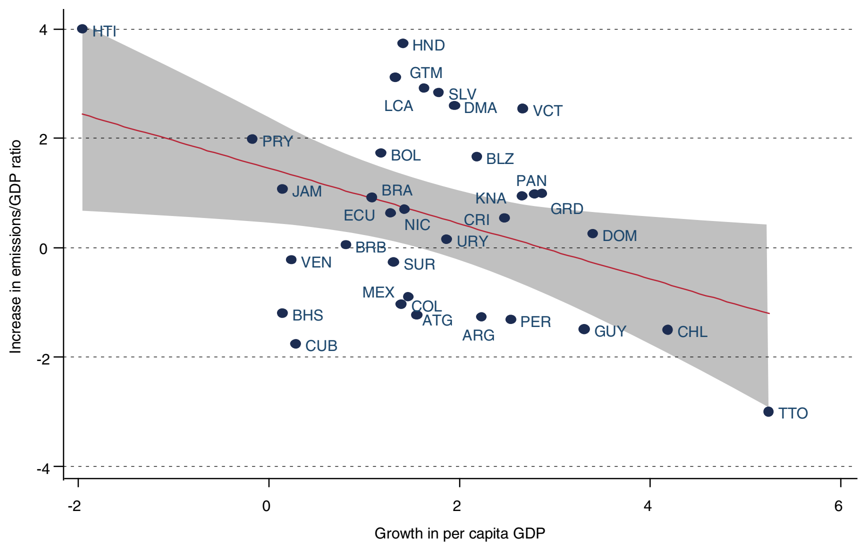
(Thousands of tons and millions of 2000 dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009, Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices and Social Indicators Statistics Database (BADEINSO) for population data.

There is a correlation between the rate of decoupling of emissions from GDP and the growth rate of per capita GDP (*Vivid economics*, 2009). Countries with a higher rate of per capita economic growth are also those that most rapidly reduce their emissions per unit of GDP, though this is highly variable (see figure VII.13). A high rate of economic growth is therefore not inconsistent with the ability to reduce emissions per unit of output. Accordingly, economic growth can be combined with transition towards a low-carbon economy, although at present the decoupling rate is still too low.

Figure VII.13
LATIN AMERICA AND THE CARIBBEAN: PER CAPITA GDP GROWTH AND RATE OF DECOUPLING OF CO_2 EMISSIONS FROM GDP, 1990-2005 [a]
(Percentages)



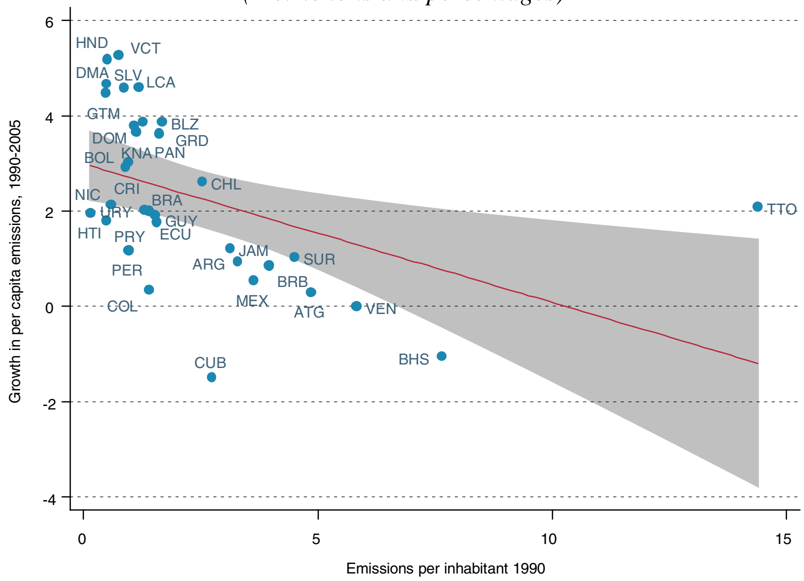
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009, Economic Indicators and Statistics Database (BADECON) for GDP constant at 2000 prices and Social Indicators Statistics Database (BADEINSO) for population data.

[a] The decoupling rate is defined as the inverse of the growth rate of the ratio of CO_2 emissions to GDP, i.e., a reduction in this ratio implies an increase in the decoupling rate, and vice versa.

Trajectories of per capita emissions are seen to show a process of absolute convergence (β-convergence) or convergence in the distribution of per capita CO_2 emissions (σ-convergence) (Barro and Sala-i-Martin, 1992). In other words, the emissions of countries with lower per capita increase at a faster rate than the emissions of countries whose initial rates are higher (see figure VII.14). Econometric analysis of cross section and panel data confirm this process of absolute convergence in per capita emissions (see box VII.2).[3] This suggests that in the coming decades per capita emissions will increase for the region overall and will tend to converge in absolute terms if the inertial or baseline scenario is maintained.

[3] Changes in the production structure, gains in production efficiency, relative price trends and more stringent regulations in more developed countries are some of the factors involved in accounting for this.

Figure VII.14
LATIN AMERICA AND THE CARIBBEAN: PER CAPITA EMISSIONS AND GROWTH IN PER CAPITA EMISSIONS, 1990-2005
(Metric tons and percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009 and Social Indicators Statistics Database (BADEINSO) for population data.

Box VII.2
LATIN AMERICA AND THE CARIBBEAN: EMPIRICAL EVIDENCE OF ABSOLUTE CONVERGENCE IN PER CAPITA EMISSIONS

The presence of convergence may be investigated using the following equation:

$$(1)\quad \left[\frac{[\log(CO2n]_{i,t})}{[\log(CO2n]_{i,t-1})}\right] = \alpha + \beta * \log\left(CO2n_{i,t-1}\right) + \varphi\chi_i + u_i$$

where a ratio of β<0 indicates absolute convergence. The coefficient α captures the specific effects by country and X_t represents a set of additional factors that enable the possibility of conditional convergence to be identified. Estimation of the equation (1), based on cross-section and panel data (Wooldridge, 2003; Baltagi, 2005) for 1990-2005 for the countries of Latin America is given in equations (2) and (3). Estimation of equation (3) allows rejection of the null hypothesis of the Hausman test (1978), so random effects specification can be rejected in favour of fixed effects. Moreover, the statistical significance of the dummy variables by counties reflects regional differences (Romer, 1989; Barro, 1991). These results indicate that a process of absolute convergence is under way in the region. The t statistics shown in brackets are robust to heteroskedasticity.

$$(2)\quad \frac{\log[([(CO2n]_{i,t}))}{[(CO2n]_{i,t-1})} = 0.16 - 0.23 * \log\left(CO2n_{i,t-1}\right) + u_i$$

(9.90) (-3.99)

$$(3)\quad \frac{\log[([(CO2n]_{i,t}))}{[(CO2n]_{i,t-1})} = 0.16 - 0.23 * \log\left(CO2n_{i,t-1}\right) + u_i \qquad \chi^2(1) = 71.50(0.00)$$

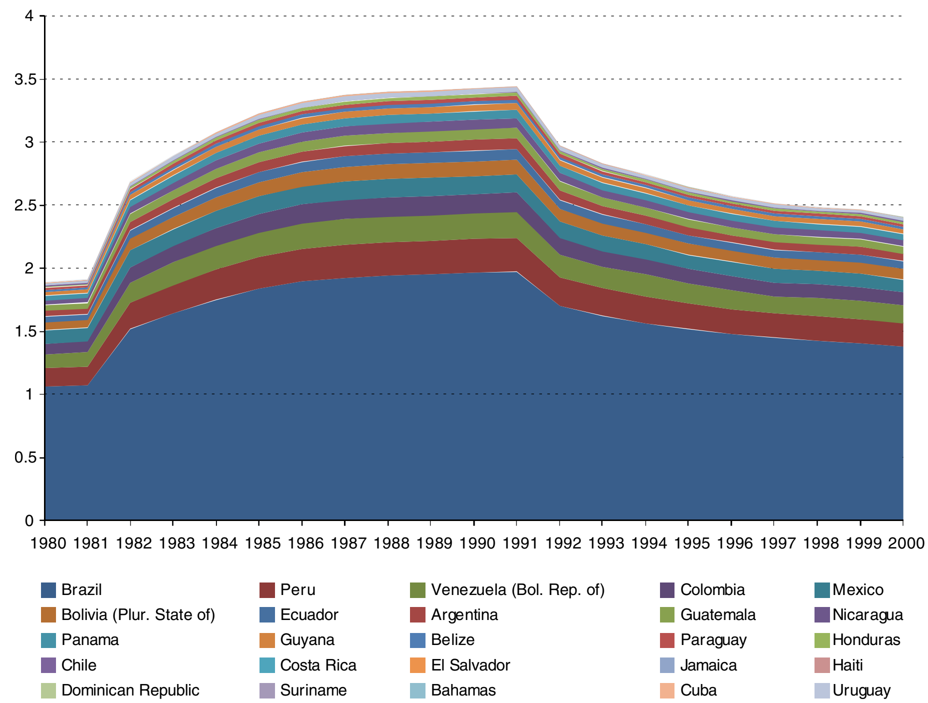
(2.19) (-2.04)

Source: J.L. Samaniego and L.M. Galindo, "Cambio climático y la demanda de energía en América Latina: estimaciones preliminares", Santiago, Chile, Economic Commission for Latin America and the Caribbean (ECLAC), unpublished.

4. Emissions and land-use change in Latin America and the Caribbean

GHG emissions from land-use change in the Latin American and Caribbean countries show a substantial 6.1% increase between 1980 and 1990, which was partially offset by a 3.5% fall in emissions between 1990 and 2000 (see figure VII.15).

Figure VII.15
LATIN AMERICA AND THE CARIBBEAN:[a] CO_2 EMISSIONS FROM LAND-USE CHANGE, 1980-2000
(Billions of metric tons)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009.

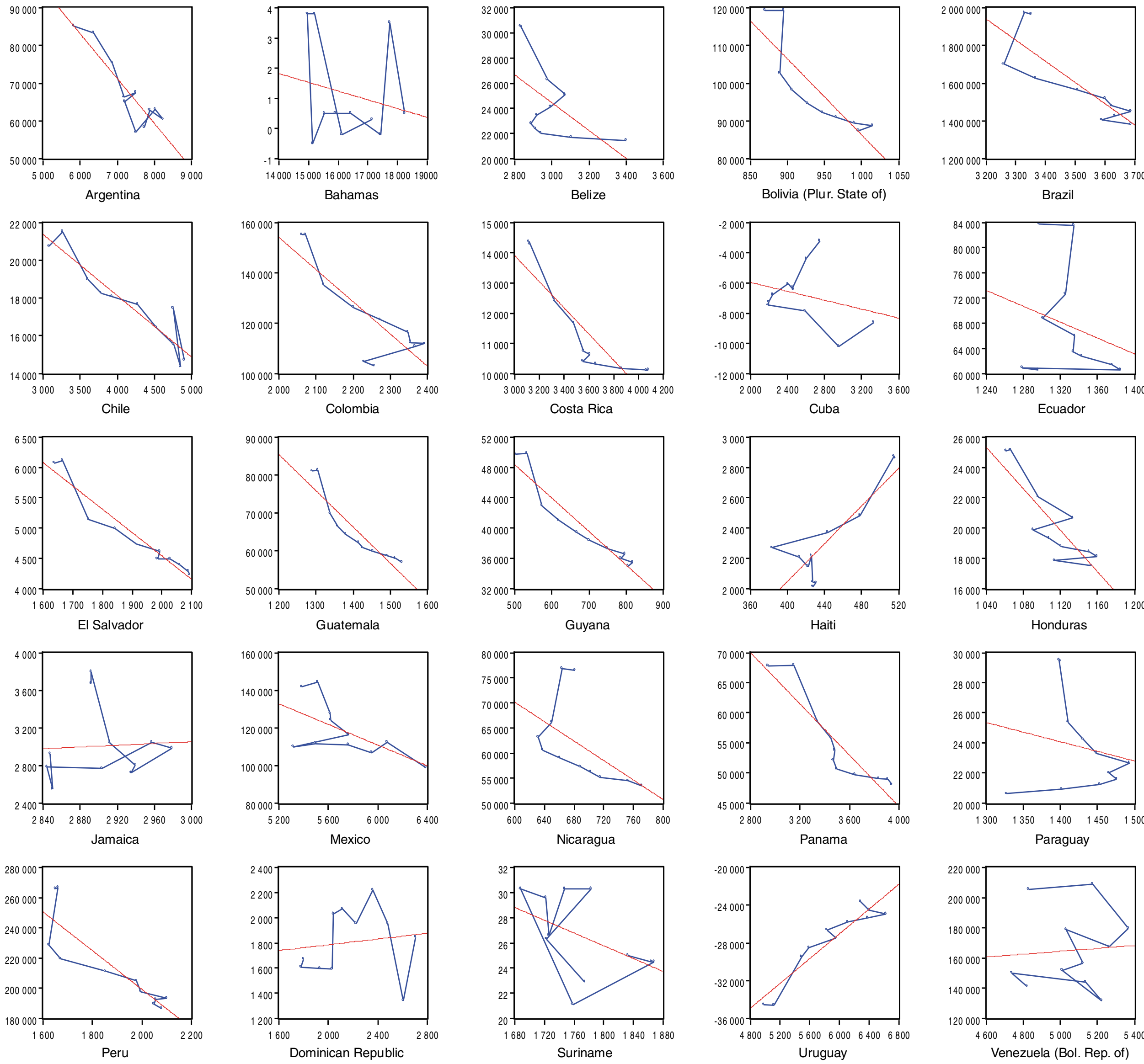
[a] The countries are ordered by magnitude of emissions as of 2000. Data not available for Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia and Trinidad and Tobago.

Emissions from land-use change generally have a non-linear inverse association with per capita GDP (see figure VII.16).

Figure VII.16

LATIN AMERICA AND THE CARIBBEAN: PER CAPITA GDP AND CO_2 EMISSIONS FROM LAND-USE CHANGE, 1990-2000 [a]

(2000 dollars and metric tons)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009,Economic Indicators and Statistics Database (BADECON) for GDP 2000 constant prices and Social Indicators Statistics Database (BADEINSO) for population data.

[a] The countries are ordered by magnitude of emissions as of 2000. Data not available for Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

This reduction in emissions with respect to per capita GDP is captured by identities (3) and (4). Identity (3) assumes a coefficient that is constant over time. In identity (4), the first term represents the increase in emissions between time t and time t+1, assuming a constant ratio between emissions intensity and per capita GDP. The second term represents the increase or decrease in emissions at t+1 caused by changes in the emissions coefficient. Accordingly, the second term should be negative for an economy that becomes more efficient over time.

(3) $$EM_t = \frac{EM_t}{YPC_t} YPC_t = \alpha_{0t} YPC_t$$

(4) $$EM_{t+1} - EM_t = \alpha_{0t}(YPC_{it+1} - YPC_{it}) + YPC_{it+1}\,(\alpha_{1t+1} - \alpha_{0t})$$

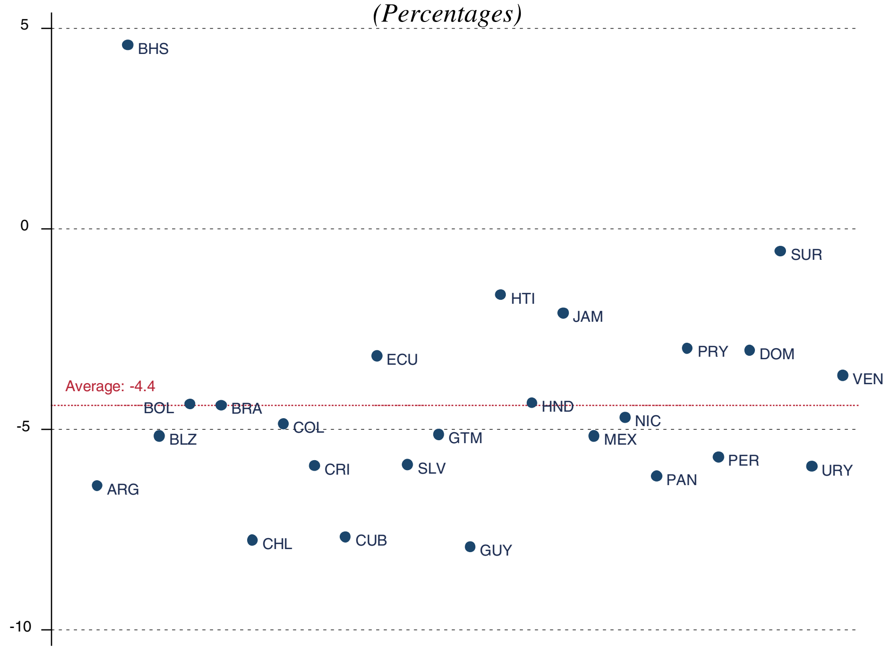
where EM_t represents GHG emissions and YPC_t is per capita GDP.

The data available on the ratio of emissions from land-use change (LUC) to per capita GDP in Latin America and the Caribbean shows mixed trends although the ratio is tending to fall in most of the countries (see figure VII.16). The simple average annual rate of decrease in the intensity of LUC emissions for all the countries examined is -4.4% for 1990–2000, although with significant differences between countries (see figures VII.17 and VII.18).

Figure VII.17

LATIN AMERICA AND THE CARIBBEAN: AVERAGE ANNUAL GROWTH IN THE LUC CO2 EMISSIONS INTENSITY OF PER CAPITA GDP, 1990-2000 [a]

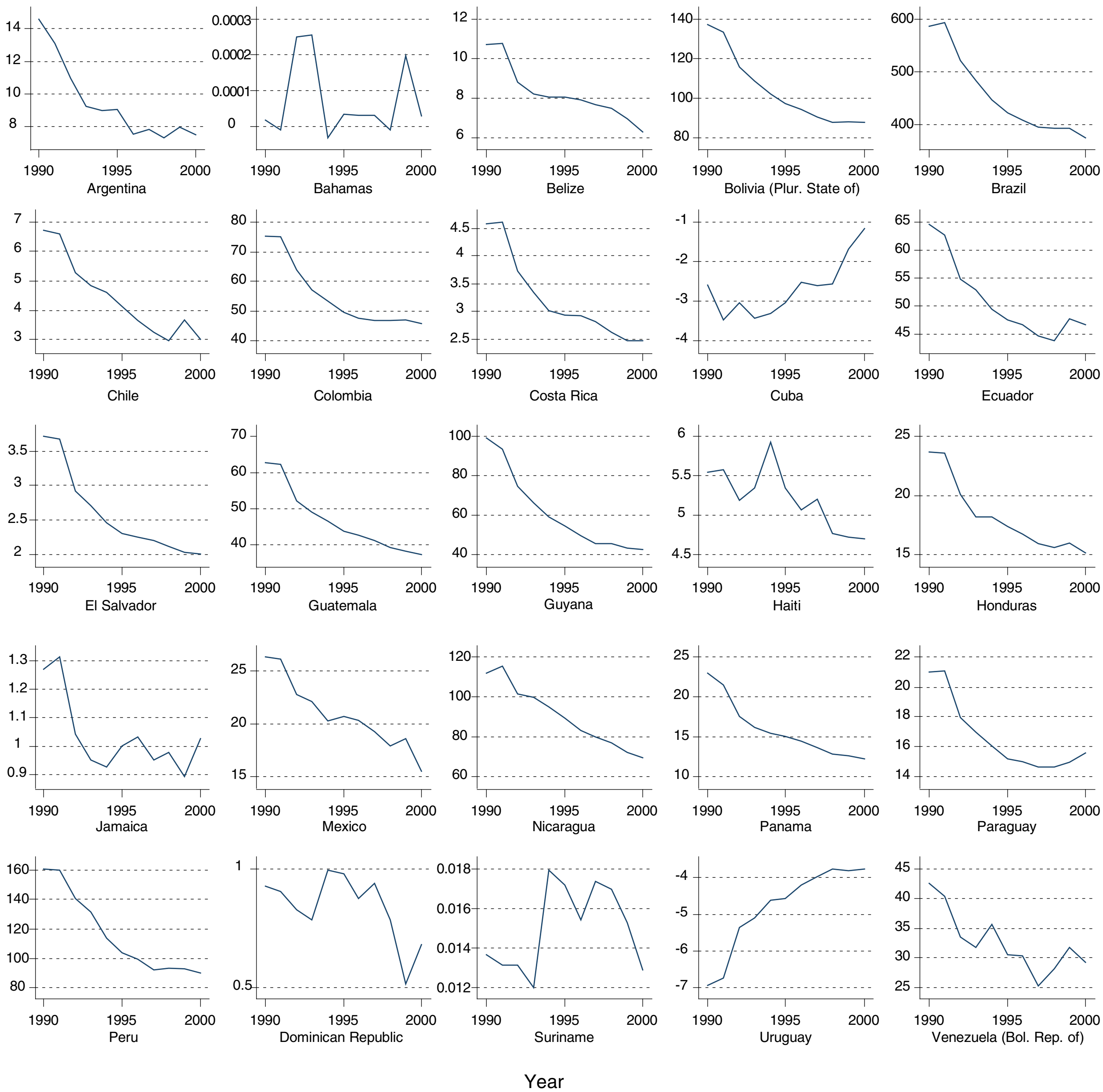
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009, Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices and Social Indicators Statistics Database (BADEINSO) for population data.

[a] The countries are ordered by magnitude of emissions in 2000. [a] Data not available for Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

Figure VII.18
LATIN AMERICA AND THE CARIBBEAN: LUC EMISSIONS INTENSITY OF PER CAPITA GDP, 1990-2000 [a]
(Metric tons and thousands of 2000 dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009, Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices and Social Indicators Statistics Database (BADEINSO) for population data.

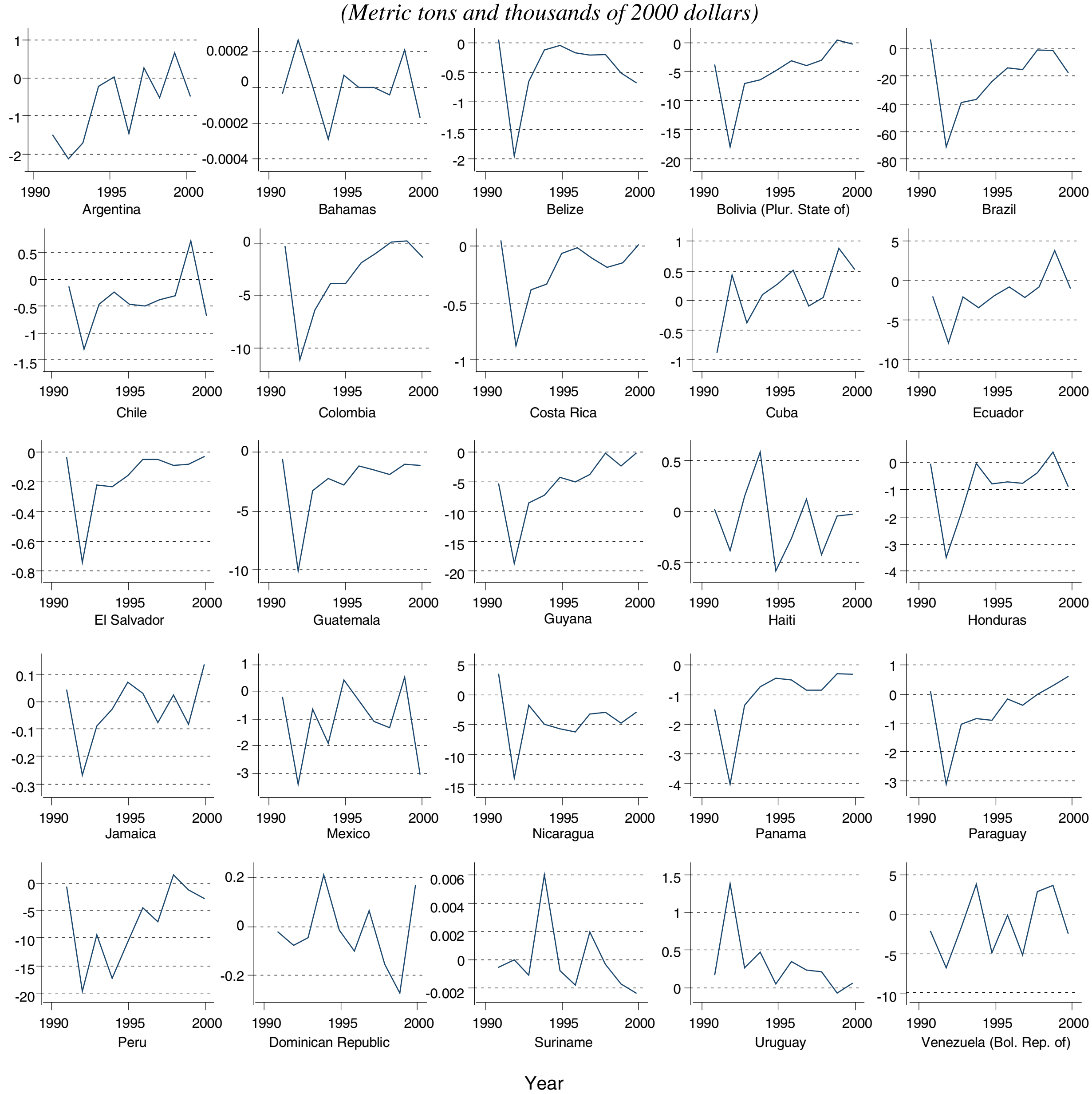
[a] The countries are ordered by magnitude of emissions in 2000. Data not available for Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

The increase in the efficiency of the Latin American and Caribbean countries is reflected in the second term of identity (4), which is generally negative for 1990-2000 (see figure VII.19).

Figure VII.19

LATIN AMERICA AND THE CARIBBEAN: RATE OF CHANGE IN LUC EMISSIONS INTENSITY OF PER CAPITA GDP (α_{1t+1} - α_{0t}), 1990-2000 [a]

(Metric tons and thousands of 2000 dollars)

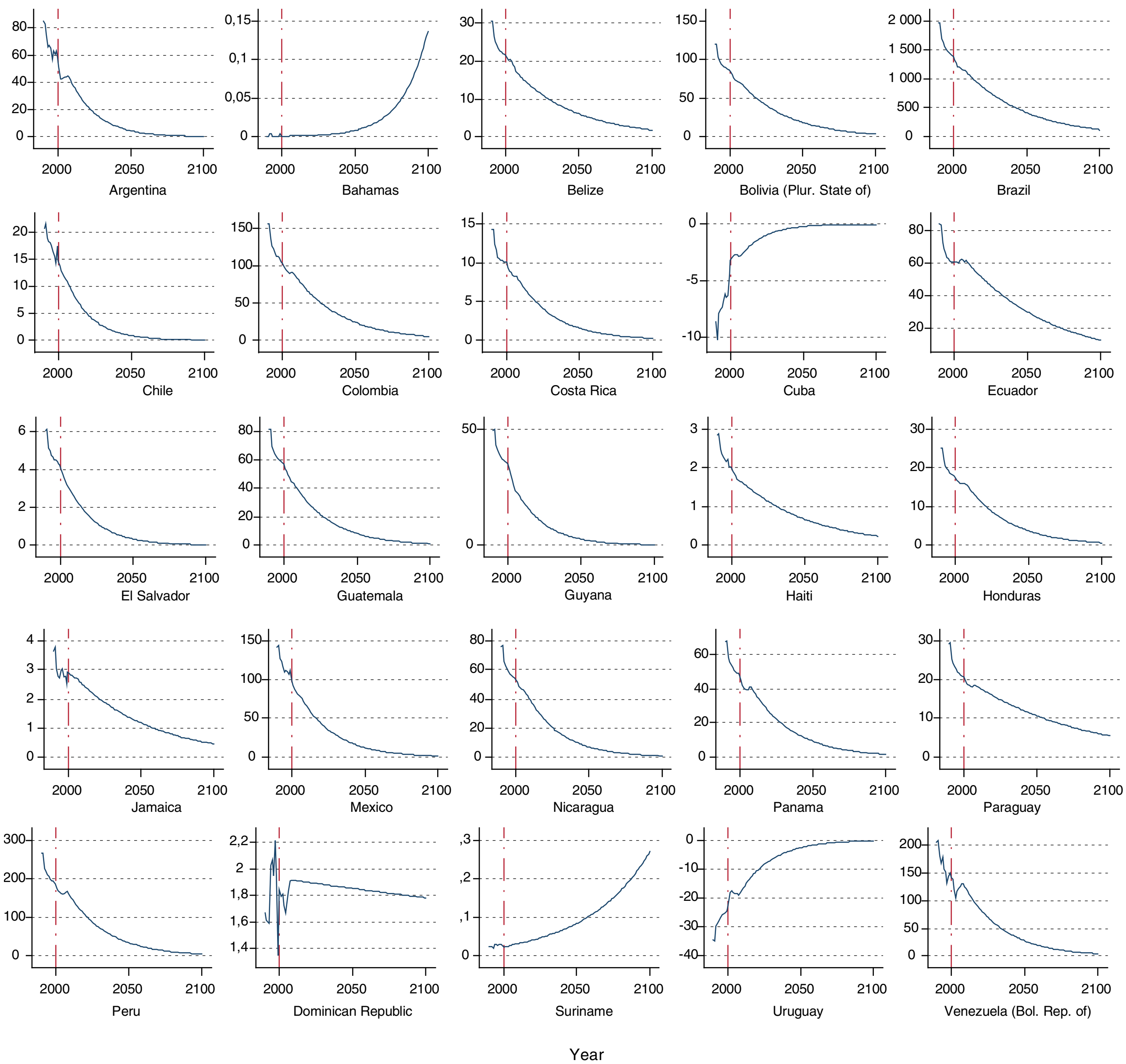


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009, Economic Indicators and Statistics Database (BADECON) for GDP at constant 2000 prices and Social Indicators Statistics Database (BADEINSO) for population data.

[a] The countries are ordered by magnitude of emissions as of 2000. Data not available for Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

A first approach to the evolution of LUC emissions may be simulated by assuming a coefficient of LUC emissions to per capita GDP falling in line with its historical average (1990-2000) in each country. These simulations are summarized in figure VII.20 which shows that CO_2 emissions from land-use changes tend to decline in the BAU scenario.

Figure VII.20
LATIN AMERICA AND THE CARIBBEAN: PROJECTIONS OF GROWTH IN LUC CO_2 EMISSIONS, 2000-2100
(Millions of metric tons)



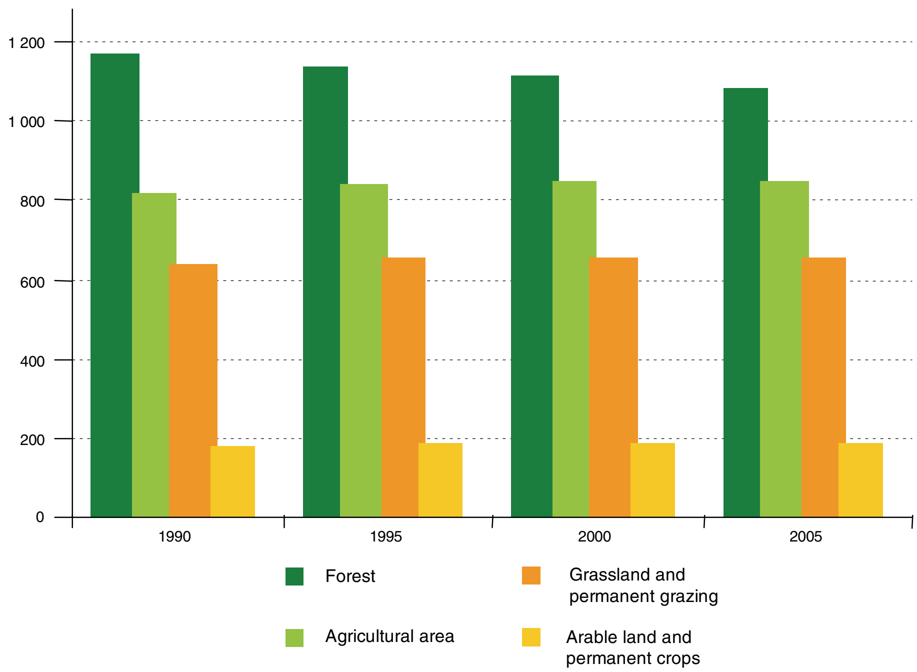
Source: Economic Commission for Latin America and the Caribbean (ECLAC).

In general, in this scenario, Latin America and the Caribbean would reduce its LUC emissions by 2.6% per year for the period 2001–2100. This reduction is unlikely, however, since the projected level of LUC emissions involves complex processes and many variables. Accordingly, constant LUC emissions are assumed for 2005–2100.

5. Emissions and deforestation rates

Deforestation is one of the principal factors in LUC emissions and in the occurrence of severe negative externalities. In Latin America and the Caribbean, deforestation is also one of the main obstacles to sustainable development. The surface area of forested land decreased between 1990 and 2005 in the region overall (see figures VII.21 and VII.22).

Figure VII.21
LATIN AMERICA AND THE CARRIBEAN: 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.

Figure VII.22

LATIN AMERICA AND THE CARIBBEAN: ANNUAL AVERAGE GROWTH IN FORESTED AREAS, 1990-2005 [a]

(Percentages)

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of statistics of Food and Agriculture Organization of the United Nations (FAO).

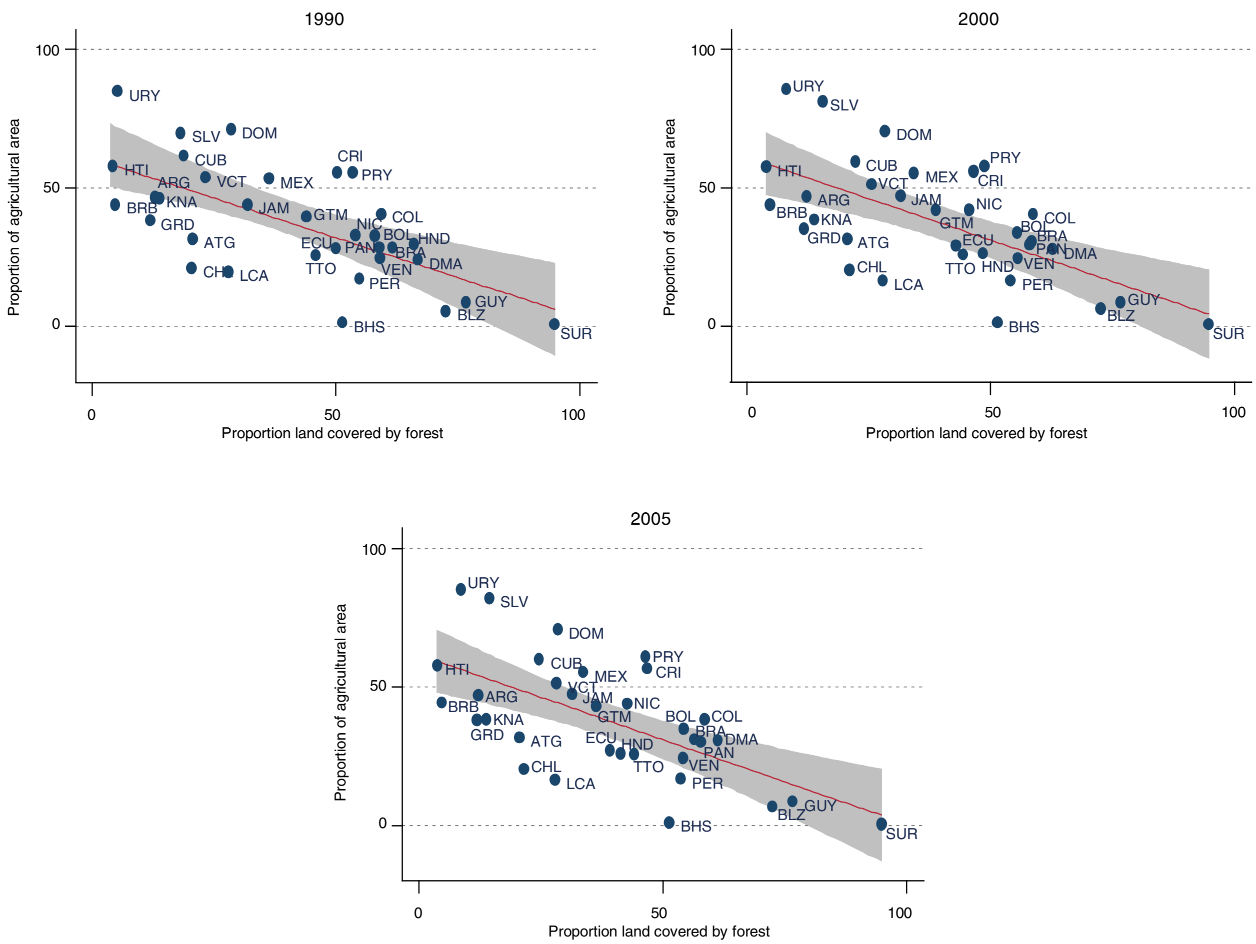
[a] Does not include countries whose forested areas showed no variation.

Deforestation is influenced by economic, social, political, demographic and institutional factors. Generally speaking, the economic agents with the greatest impact on deforestation are acknowledged to be agricultural and livestock producers and the array of associated agents (Torres, 2009). This is reflected, for example, in an inverse correlation between forested and agricultural areas (see figure VII.23). Demographic pressures, reflected in the proportion of the rural population, also relate inversely to forested areas, although to a lesser degree (see figure VII.24).

Figure VII.23

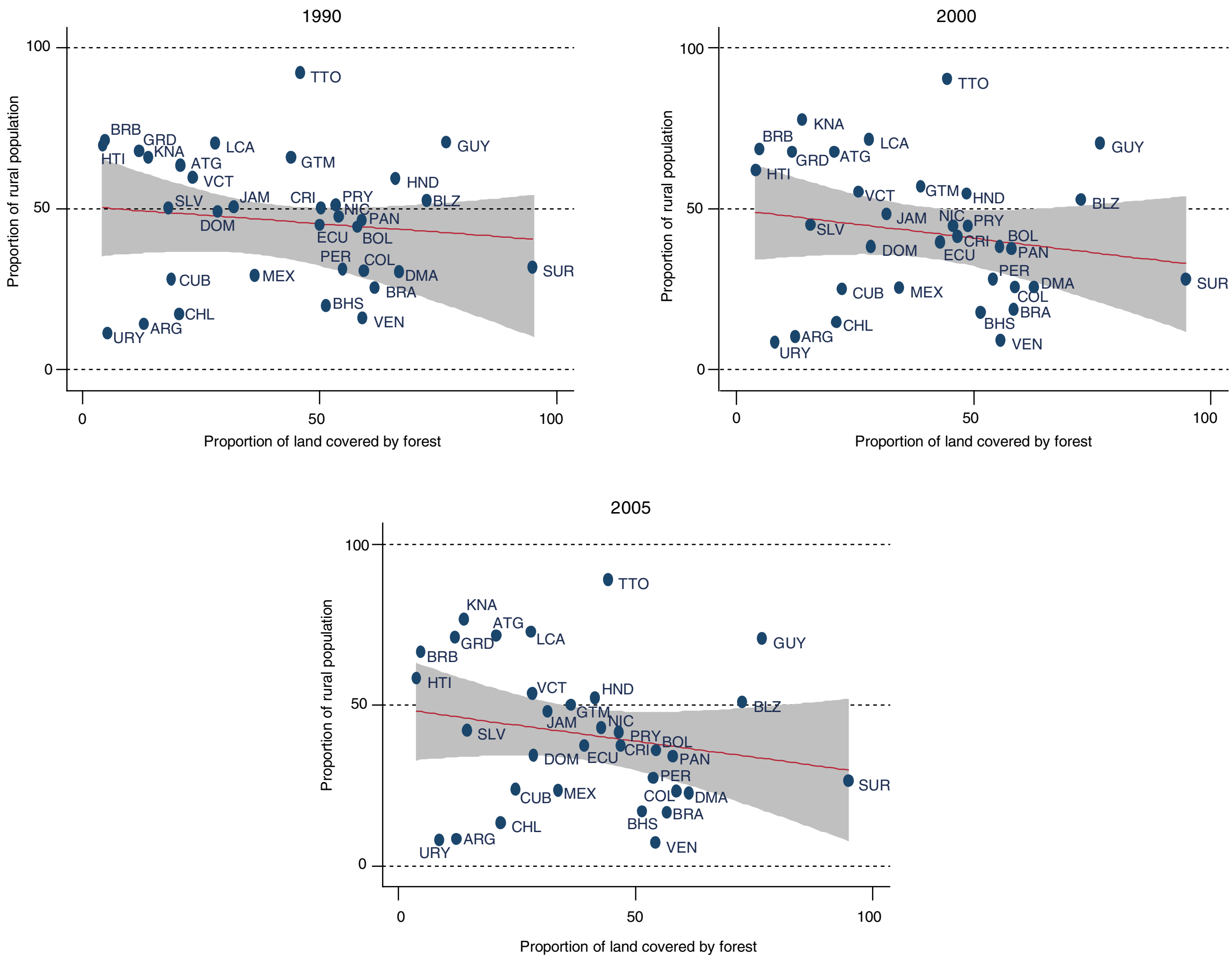
LATIN AMERICA AND THE CARIBBEAN: PROPORTIONS OF FORESTED AND AGRICULTURAL AREAS, 1990, 2000 AND 2005

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of statistics from the Food and Agriculture Organization of the United Nations (FAO).

Figure VII.24
LATIN AMERICA AND THE CARIBBEAN: PROPORTIONS OF FORESTED AREA AND OF RURAL POPULATION, 1990, 2000 AND 2005



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of statistics from the Food and Agriculture Organization of the United Nations (FAO) and Social Indicators Statistics Database (BADEINSO) for population data.

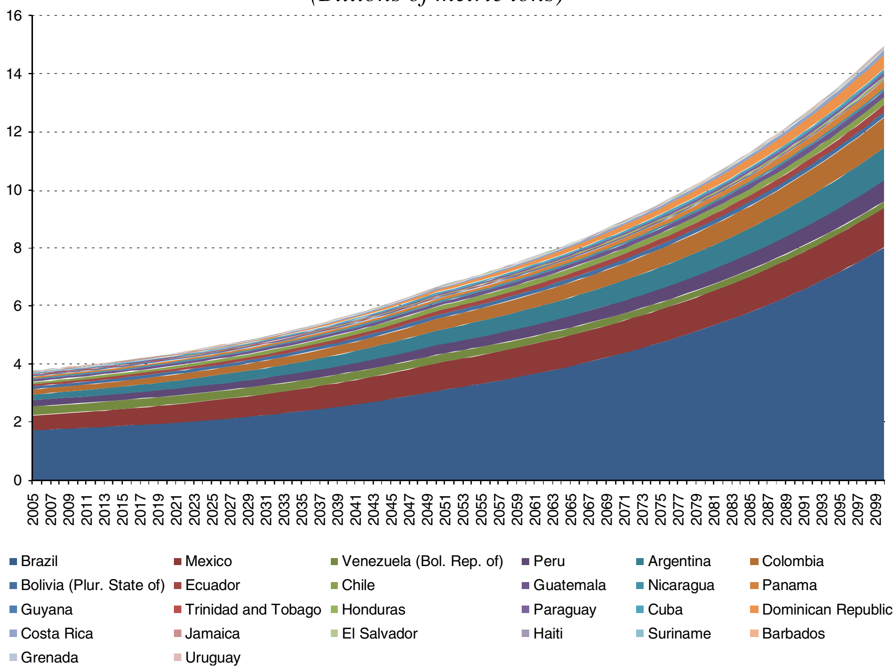
6. Total CO_2 emissions in Latin America

Under the BAU scenario and assuming constant LUC emissions, total CO_2 emissions, including energy consumption, cement production and LUC, increase by an average of 1.5% for 2005-2100, though with differences from one country to another (see figure VII.25). This means that CO_2 emissions will grow slightly below the average per capita GDP growth rate for Latin America.

Figure VII.25

LATIN AMERICA AND THE CARIBBEAN: PROJECTED TOTAL CO_2 EMISSIONS, 2005-2100 [a]

(Billions of metric tons)



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

[a] The countries are ordered by the magnitude of their emissions in 2005.

7. Mitigation in Central America

The Central American countries as a group contribute less than 0.5% of all GHG emissions at the global level. However, different mitigation options could be beneficial for the region since, for example, there are major gains to be made from making an early start on decarbonization in terms of the availability of international financing and access to cleaner technologies. Some of these measures also offer significant co-benefits.[4]

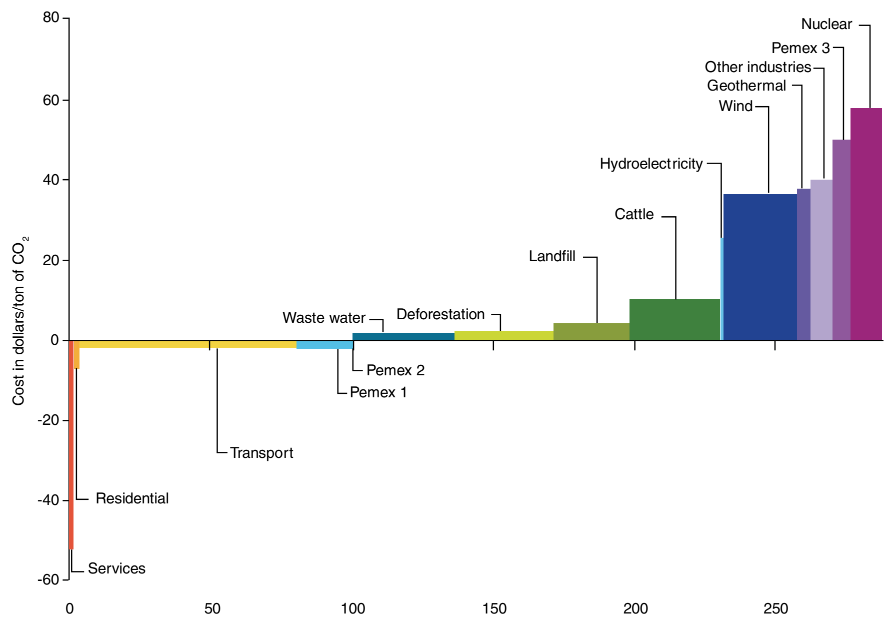
Using inventories of sectoral emissions, it is possible to carry out projections assuming specific growth rates in each of the relevant sectors in the different countries. In the baseline estimate, growth rates are assumed for sectors of the economy in accordance with the macroeconomic scenarios (Cuevas and Lennox, 2009) for the cut-off years 2010, 2020 and 2030. Projection of the baseline scenario to 2030 gives total annual emissions of over 300 million tons of CO_2e.[5] Based on the average cost scenarios per ton of CO_2e reduction in each of the sectors examined, an incremental or marginal cost horizon can be constructed combining these scenarios with the differences in sectoral emissions between the BAU scenario and the proposed emissions reduction scenario. These costs take no account of potential co-

[4] This section is based on Cuevas and Lennox (2009). The database used is not the same as that used for the comparative analysis for Latin America and Central America overall. Hence, particular figures may not coincide. In addition, the sectoral growth assumptions used are different to those used in the previous section.

[5] In this exercise the emissions factors were calculated using the IPCC methodology for clean development mechanism projects, which gives an average for Central America of 627 tons CO_2/Gwh.

benefits such as the conservation of biodiversity and water capture areas, the reduction of local-impact pollutant emissions, poverty reduction and the development of sustainable economic alternatives. Based on information from one of the cost curves for Mexico, figure VII.26 gives a graphic representation of the sequential relationship between average costs and potential emissions reduction up to 2020, which, could be inter preted as a marginal cost curve of emissions reduction for the region overall.

Figure VII.26
MEXICO: MARGINAL COST CURVE OF MITIGATION, 2030
(Millions of tons of CO_2 per year)



Source: L.M. Galindo, *La economía del cambio climático en México*, Mexico city, Secretariat of the Environment and Natural Resources (SEMARNAT), 2009.

8. Mitigation costs: preliminary aggregate estimates using international data

For purely illustrative purposes, an initial aggregate economic assessment of the potential costs of mitigation can be conducted assuming a cost of between US$ 10 and US$ 30 per ton of carbon and that this value is equivalent to the opportunity cost of emissions. Table VII.2 summarizes the potential costs of mitigation by country, supposing an emissions reduction of 30% with respect to BAU emissions up to 2100. These results show that the costs of mitigation processes are certainly significant for the region and can be covered only with additional international financing.

Table VII.2
LATIN AMERICA AND THE CARIBBEAN: CURRENT VALUE OF THE COSTS OF MITIGATING CLIMATE CHANGE UP TO 2100 AS A PERCENTAGE OF 2007 GDP [a]

	Price per ton: US$ 10			Price per ton: US$ 30		
	Discount rate			Discount rate		
	0.5%	**2%**	**4%**	**0.5%**	**2%**	**4%**
Argentina	0.64	0.31	0.15	1.93	0.92	0.44
Barbados	0.31	0.16	0.09	0.92	0.49	0.27
Bolivia (Plurinational State of)	1.98	0.95	0.45	5.95	2.84	1.36
Brazil	1.89	0.81	0.34	5.67	2.44	1.02
Chile	0.49	0.25	0.13	1.46	0.74	0.39
Colombia	1.62	0.72	0.31	4.86	2.16	0.94
Costa Rica	1.56	0.66	0.27	4.68	1.97	0.80
Cuba	0.50	0.25	0.13	1.51	0.75	0.39
Ecuador	1.96	0.94	0.45	5.89	2.81	1.35
El Salvador	0.45	0.22	0.11	1.35	0.67	0.34
Grenada	8.67	3.33	1.15	26.02	9.99	3.45
Guatemala	1.74	0.77	0.34	5.23	2.32	1.01
Guyana	0.31	0.18	0.11	0.94	0.54	0.32
Haiti	0.39	0.20	0.10	1.17	0.60	0.31
Honduras	0.67	0.34	0.18	2.02	1.02	0.53
Jamaica	0.03	0.02	0.01	0.08	0.05	0.03
Mexico	0.30	0.16	0.09	0.90	0.48	0.26
Nicaragua	2.10	0.97	0.44	6.31	2.90	1.33
Panama	3.05	1.23	0.47	9.16	3.70	1.40
Paraguay	3.38	1.38	0.53	10.13	4.14	1.59
Peru	1.67	0.73	0.31	5.02	2.18	0.92
Dominican Republic	3.40	1.41	0.56	10.20	4.23	1.68
Suriname	3.91	1.83	0.87	11.72	5.48	2.60
Trinidad and Tobago	-	-	-	-	-	-
Uruguay	0.59	0.27	0.12	1.76	0.80	0.36
Venezuela (Bolivarian Republic of)	-	-	-	-	-	-

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Resources Institute (WRI), "Climate Analysis Indicators Tool (CAIT) Version 6.0" [online] www.cait.wri.org, 2009.

[a] In scenario II the target is to reduce CO_2 emissions by 30% by 2100.

9. Main messages

The empirical evidence available for Latin America and the Caribbean shows that the usual relations exist between GHG emissions and their main determining factors. It also shows that these relations support a number of inferences and simulations based on alternative emissions scenarios.

The simulations carried out show that, in general, emissions may be expected to increase throughout this century by an average of up to 1.5%, although with major differences between countries and sources. Emissions from land-use change may be expected to decrease or stand still, while those from fossil fuel burning and cement production will increase. The increase of emissions from energy consumption has a number of particular features:

- Energy consumption tracks output and is fairly insensitive to changes in relative energy prices. However, energy intensity decreases as per capita GDP increases. There is, therefore, a gradual decline in energy intensity, or energy decoupling.

- Emissions are increasing at a lower rate than energy consumption, which reflects a process of decarbonization. In addition, the ratio of emissions to GDP varies in inverse proportion to the growth rate of per capita GDP.

- Emissions are rising at a faster rate than population growth, so that per capita emissions are increasing. The evidence also points to a process of absolute convergence in per capita emissions in the region. Accordingly, emissions in the countries with lower per capita emissions will increase more quickly than those of countries with higher per capita emissions.

- The evidence overall suggests that the emissions of the Latin American and Caribbean region will continue to rise, albeit more slowly than in the past.

The evidence available shows that the region has significant options for mitigation. Some of them are already being deployed, but at the aggregate level the costs of mitigation are significant. However, ratios of energy to per capita GDP and of emissions to energy fall as per capita GDP rises. This suggests that economic growth is compatible with energy decoupling and decarbonization, which also offers major co-benefits.

VIII. ECONOMIC VALUATION AND OBSERVATIONS ON PUBLIC POLICY

Climate change is one of the major challenges of this century. Its impacts on economic activities and current production, distribution and consumption patterns, on population, on ecosystems and, in general, on living conditions on the planet make it one of the most daunting issues for humankind. It is therefore crucial to identify the channels of transmission and the most significant economic costs of climate change. This is no easy task since a wide range of highly uncertain factors and various ethical considerations must be taken into account and be reflected in the adoption of an optimum risk-management strategy.

The international empirical evidence available on the economic costs and benefits of climate change is highly varied and mixed (Nordhaus and Boyer, 2000; Nordhaus, 2008; Fankhauser, 1995; Mendelsohn, 2002; and Stern, 2007), given the wide range of methodologies and time periods, analytical models and economic assumptions (for example, the inclusion of adaptation processes and the application of new technologies), as well as different climate projections, differential analysis of sectors, regions or countries and even varying discount rates and proposed mitigation targets. The evidence presented must be examined with caution since it is merely indicative of the scenarios that may emerge in the future.

At the aggregate level, the economic impacts of climate change calculated so far in the countries of Latin America and the Caribbean present various characteristics as indicated below:[1]

- The economic costs associated with climate change are significant and non-linear and they have been increasing over time. In other words the economic consequences of climate change have a discernible and significant impact across the range of economic activities.

- The economic costs are heterogeneous and climate change may translate into short-term gains for some sectors and activities and, at the same time, into significant losses in other geographical areas or sectors.

- In many cases, the impacts, such as loss of biodiversity or human life, are irreversible.

- Some endogenous adaptation actions correspond to the intrinsic response capacity of the economic actors, whose costs have not been calculated, but could be reduced by designing public policies aimed at adaptation.

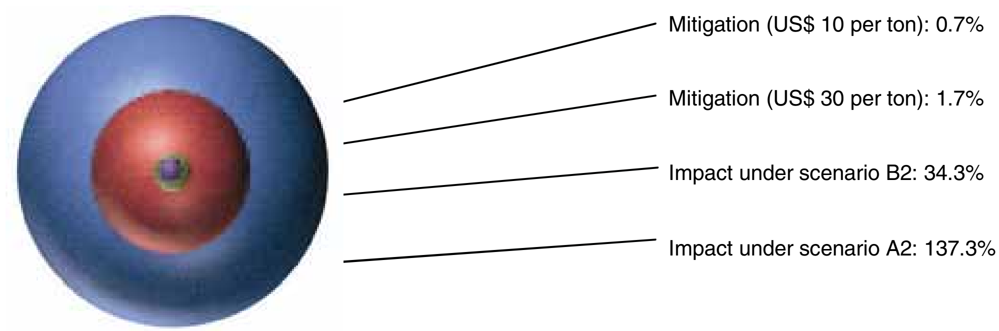
- Figures VIII.1 and VIII.2 sum up the valuation of total economic costs and benefits for Latin America and the Caribbean using currently available information. These estimates are preliminary, indicative and incomplete, but show that the costs of the impacts usually exceed those estimated in developed countries. This is not necessarily so for all countries, however.

[1] It should be borne in mind that the results do not include the impacts of climate change in all economic sectors, although probably in the largest ones, and there are fiscal, labour, social and other implications which should be studied in greater depth in order to gain a comprehensive vision.

Figure VIII.1

LATIN AMERICA (15 COUNTRIES): AVERAGE PRELIMINARY ECONOMIC COSTS OF THE CUMULATIVE IMPACT OF CLIMATE CHANGE AND MITIGATION, UP TO 2100 [a]

(Percentages of 2007 GDP)



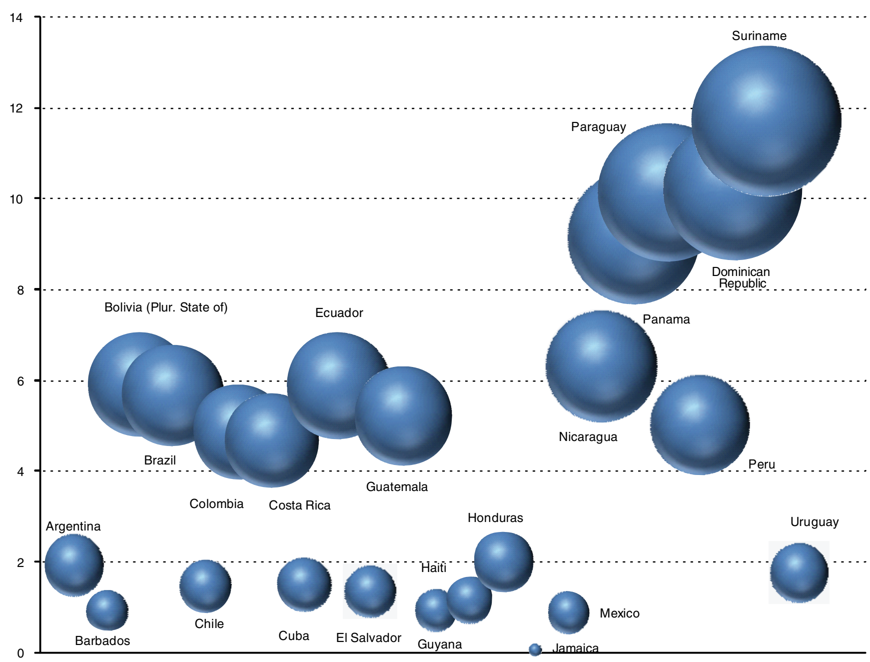
Source: Economic Commission for Latin America and the Caribbean.

[a] The mitigation target used is equivalent to 30% of the levels projected for 2100. Includes: Argentina, Belize, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Plurinational State of Bolivia and Uruguay. A discount rate of 0.5% was applied. The impact and costs correspond to the average of the values recorded in the countries under consideration.

Figure VIII.2

LATIN AMERICA AND THE CARIBBEAN (23 COUNTRIES): PRELIMINARY CUMULATIVE ECONOMIC COSTS OF MITIGATION UP TO 2100

(Percentages of 2007 GDP)



Source: Economic Commission for Latin America and the Caribbean.

[a] The mitigation target used is equivalent to 30% of the levels projected for 2100. A discount rate of 0.5% was applied.

- For all the countries of Latin America and the Caribbean, the economic costs associated with the impacts of climate change are higher than those of participating in a mitigation agreement that recognizes historical responsibility and imposes differential targets by region in accordance with the principles of equity and co-responsibility.

- The simultaneous implementation of efficient adaptation and mitigation actions means that current patterns of production, distribution and consumption will have to be changed substantially.

When drawing up an international agreement, negotiators must recognize that those countries that have contributed most to climate change are not necessarily those that are suffering the worst impacts and, indeed, many countries with only a marginal contribution to emissions may be bearing the brunt of these impacts. Thus, any international agreement on climate change must take into account the need for developing countries to maintain a good rate of economic growth and obtain additional international financing in order to make the transition to low-carbon economies. Unilateral solutions may lead to the imposition of adjustment processes that are inequitable from the perspective of developing countries, that is, the externalization of mitigation to those countries without reducing their vulnerability (and the resulting costs of adaptation) to climate change.

Given the magnitude of the economic costs associated with climate change, a public-policy strategy must be designed and implemented in which society as a whole can participate in order to help reduce the adverse effects of this phenomenon, facilitate adaptation processes and develop options for reducing mitigation costs. This will mean preparing a strategy for effective risk management. This is an extremely complex task, however, and one that must be based not only on technical factors, but also on ethical considerations. Nevertheless, beyond the climate scenarios or the public policy adopted, there are a few general points that seem to be common to any strategy:

- "Taking out insurance" against the most extreme climate risks and the severest damage expected.

- Preserving biodiversity and natural resources for future generations and avoiding irreparable losses.

- Realigning relative prices in a manner compatible with sustainable development.

- Recognizing the need to review lifestyles and promote a cultural change in that regard.

- Promoting a technological innovation process in the context of sustainable development.

- Ensuring the transition to low-carbon economies. Modern economies are fossil fuel-intensive. It must be recognized that the era of cheap, almost limitless fossil energy is coming to an end and that relative energy prices must fully reflect the negative externalities generated.

Generally speaking, the evidence on the economic consequences of climate change points to the need to take into account the following considerations when formulating relevant public policies:

- Climate change policy must be at the heart of macroeconomic policy and policies on development and technological innovation. It must be directed towards changing attitudes and patterns of behaviour in order to put in place procedures for making decisions that are sustainable in the long term.

- Prices and markets are important mechanisms that can contribute to sustainable economic development, although they are insufficient and have major limitations bearing in mind the low price elasticities currently observed in the region and other market characteristics. Here, other mechanisms that complement price measures such as regulatory interventions, promotion of technological innovation and changes in consumption, distribution and production patterns must also be taken into account. Thus, the aim must be to apply a policy on relative prices based on a ramp trajectory which gradually reflects the negative externalities and allows time for adjustments, and this policy should be complemented with the necessary regulations. Climate change, understood as a negative externality, can be reduced by charging for CO_2 emissions (Stern, 2007), and the price must be equitable, agreed internationally and provide for specific conditions; furthermore all the policies implemented must be oriented in the same direction.

Regulations must be aimed at:

- Reducing the energy and carbon content per unit of output and per capita and promoting new technologies at affordable costs.
- Conserving natural resources and biodiversity.
- Moderating and compensating for the economic impacts attributable to climate change.

When implementing adaptation measures, decision-makers must prioritize those that are robust under any climate or economic scenario, that generate significant collateral benefits, such as reducing other environmental impacts or poverty, and that are consistent with mitigation strategies. They must also bear in mind that the adaptation measures applied can generate new negative externalities such as environmental degradation due to expansion of the agricultural frontier in marginal areas (which must be avoided) or overexploitation of hydrographic resources.

A set of regular patterns must be considered when designing mitigation processes. In particular, attention should be paid to the following:

- Per capita GDP, energy consumption and CO_2 emissions have been trending upwards over time, albeit at different rates and with different intensities. In general, the tendency is towards decoupling of energy from output and of CO_2 emissions from energy although, again, at different rates which are insufficient to curtail the absolute increase in emissions or energy consumption.

- Thus, a higher economic level is reflected in a higher level of energy consumption although the increases are not proportional. Thus, any drastic cutback in energy consumption will result in a contraction in output. Sustained economic growth with steady emissions reduction, or at least some degree of stabilization, is a desirable goal but remains difficult to fulfil.

- There is an inverse correlation between per capita income and energy intensity. This energy decoupling is still insufficient, however, to halt the increase in energy consumption. Moreover, energy decoupling is more common than decarbonization, which seems to indicate that the pattern of GHG emissions is not yet being treated as a major concern in the region. The reduction in the energy/GDP ratio and in the emissions/energy consumption ratio merely helps to slow growth in emissions, but is insufficient to bring it to a halt.

- All this translates into a gradual decrease in the ratio between emissions and per capita GDP. Moreover, the emissions intensity of GDP is tending to decrease faster in countries with higher per capita GDP growth.

- In practically all cases, however, there has been a gradual increase in per capita emissions. The rate of population growth is lower than the rate of growth in CO_2 emissions. Moreover, the region shows a gradual absolute convergence in per capita emissions; in other words, emissions are increasing faster in those countries where per capita emissions are lowest than in those where they are highest.

- Simulations point to the likelihood that GHG emissions associated with fossil fuels and cement production will continue to increase if the BAU pattern is maintained. The historical trend of energy decoupling and decarbonization is insufficient to control the growth in emissions if business is allowed to continue as usual. Accordingly, active public policies are required.

Any mitigation strategy defined for Latin America and the Caribbean must take into account the fact that this region has a common but clearly differentiated responsibility in the mitigation process. The region should engage in an equitable international agreement that recognizes the following:

- The low contribution of the energy sector in Latin America and the Caribbean to global climate change.
- The need for the region to continue to develop whether on the basis of current growth patterns or others that are more sustainable.
- The importance of complying with the provisions of the United Nations Framework Convention on Climate Change (UNFCCC) in terms of making available additional international resources to achieve ambitious mitigation targets.
- The fact that mitigation actions in the region will not in themselves diminish its vulnerability to climate change and that, therefore, international resources are indispensable for facilitating adaptation to the effects that this global phenomenon will have on development and for reducing poverty in the least developed countries in the region.
- The implementation of unilateral mitigation processes in the developed countries could make mitigation in Latin America and the Caribbean more costly than it would have been if conducted under an international agreement.

In any event, in this century, climate change will require a change in patterns of growth and development. In the context of an international agreement, this will also mean the establishment of an institutional framework capable of mobilizing vast quantities of resources and verifying their use and the specific fulfilment of targets.

Over the coming years, the Latin American and Caribbean region should demonstrate its capacity to define its future with full knowledge of the facts, modifying its production, consumption and distribution patterns but also adapting to the new circumstances and consequences of a world with a different climate.