Overview for 2014

The economics of climate change in Latin America and the Caribbean

Paradoxes and challenges

United Nations

ECLAC

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Foreword

Climate change poses one of the most formidable challenges of the twenty-first century. It has planet-wide causes and consequences, but its impacts are asymmetrical among regions, countries, sectors and socioeconomic groups, with those that have contributed the least to global warming being the hardest-hit. As part of this picture, Latin America and the Caribbean has made a minor contribution to climate change, given the region's low levels of greenhouse gas emissions, but is particularly vulnerable to its negative impacts.

The challenge posed by climate change is associated with unsustainable production and consumption patterns that are largely based on the use of carbon-intensive fossil fuels. Climate change has ushered in a number of constraints that make it imperative to rework these production paradigms and consumption patterns. The multi-faceted challenge of adapting to new climate conditions and implementing mitigation measures while, at the same time, recognizing the existence of common but differentiated responsibilities and differing capacities is clearly a formidable one that will shape the development process of the twenty-first century.

The robust growth of Latin American and Caribbean economies in recent years has led to an improvement in economic and social conditions in the region. It has also had negative effects, such as more air pollution in urban areas and a serious deterioration of various natural assets, including non-renewable resources, water resources and forests. There are economies, societies and specific socioeconomic groups within the region whose production structures and consumption patterns leave a large carbon footprint and others that are highly vulnerable to all sorts of adverse impacts of climate change. This situation is undermining the foundations of the region's economic buoyancy and social cohesion. The Latin American and Caribbean region therefore needs to make the transition in the years to come towards a more sustainable form of development that will preserve its economic, social and natural assets for future generations and leave them with a legacy of a more equal, more socially inclusive, low-carbon form of economic growth. Viewed from this standpoint, the climate change challenge is also a sustainable development challenge, and if this issue is to be addressed successfully, a global consensus that takes into account the asymmetries and paradoxes that it involves will have to be reached.

Alicia Bárcena
Executive Secretary of the Economic Commission
for Latin America and the Caribbean (ECLAC)

Executive summary

The current global development style is not sustainable considering its simultaneous impact on economic, social and environmental conditions, as reflected fully in the climate change challenge.

Climate change, which is being brought about essentially by anthropogenic greenhouse gas emissions, is already discernible in such phenomena as a rise in average global temperatures, alterations in precipitation patterns, rising sea levels, the shrinking cryosphere and changes in the pattern of extreme weather events (IPCC, 2013). There is evidence that the mean global temperature rose by 0.85°C over the period from 1880 to 2012 and, in the most probable scenarios, the average is projected to climb by between 1°C and 3.7°C during this century, with the increase amounting to between 1°C and 2°C by 2050. Some extreme regional scenarios predict even higher temperature rises. To date insufficient progress has been made in reducing greenhouse gas emissions in order to stabilize climate conditions, and the effects of climate change that are expected to arise during this century therefore appear to be increasingly unavoidable. The only possible solution to climate change entails a global agreement in which all countries take part.

The implications of climate change for economic activities, social conditions and the world's ecosystems are significant indeed. The multi-faceted challenge of adapting to new climate conditions, intensifying mitigation efforts and, at the same time, recognizing the existence of common but differentiated responsibilities and differing capacities is clearly a formidable one that will shape the development process of the twenty-first century. Climate change also poses a paradox in the sense that, while it is a long-term phenomenon whose effects will be stronger in the second half of this century than in the first, urgent action will have to be taken immediately if it is to be dealt with.

The Latin American and Caribbean region is in an asymmetrical position, since its contribution to total greenhouse gas emissions is quite limited yet it is highly vulnerable to the effects of climate change. The economic costs of climate change are estimated —albeit with a high degree of uncertainty— at between 1.5% and 5% of the region's GDP. These estimates (which are probably conservative and could be raised in the future) reflect a range of differing figures for different sectors and time periods. For example, agricultural activities are especially sensitive to weather conditions and, hence, to climate change. The available evidence for Latin America and the Caribbean indicates that climate change will result in a net aggregate loss for agricultural activities over the long run, but may also bring some short-run gains for some regions or products. The projected losses in the agricultural sector will also have multiple effects, such as slowing progress towards poverty-reduction and food-security goals.

There is a great deal of evidence that climate change adaptation processes are already under way, and many options for reducing climate-related impacts have been identified. There are, nonetheless, inevitable —and, in many cases, irreversible— residual costs and significant barriers that block or diminish the effectiveness of adaptation processes. In addition, many of the proposals that are on the table are still very general in nature. Flexible and efficient adaptation strategies that do not require a global consensus at the very outset need to be designed and implemented in order to manage the risks involved and reduce the economic costs of climate change.

Meeting the climate change challenge will entail making major structural changes in existing development styles. Transport is a striking case in point. At present, Latin America is witnessing rapid growth in gasoline consumption and in its vehicle fleet, generating greater greenhouse gas emissions, rising costs in terms of traffic congestion, road accidents and air pollution, and the collateral consequences for the health of the population, which are intensified by climate change. The close correlation between the demand for gasoline and income levels, the low price elasticity of the demand for gasoline and the high concentration of expenditure on gasoline and private motor vehicle ownership in the higher income quintiles highlight the segmentation of the modes of transportation that are available to the different sectors of the population. Because a modern, safe, quality mass transit system is not in place, private modes of transportation take on a predominant position in the structure of expenditure for the upper and mid-level quintiles, and private modes of transportation gradually displace public transport as people's income levels rise. A new public/private matrix therefore needs to be created that will meet the mobility needs of emerging income groups in Latin America and the Caribbean in a way that is in keeping with a sustainable and inclusive development path.

The region's current development style is exhibiting a degree of inertia that is undermining its sustainability in the face of the planet-wide negative externalities of climate change, which are heightening the problems and paradoxes confronting the region (Stern, 2007, 2008). The existing production structure and type of infrastructure, the predominant low-innovation technological paradigm, the political economy framework of economic incentives and subsidies, and current trends in the public/private services and goods matrix all feed into an environmentally unsustainable and uneqal growth path (ECLAC, 2014).

Altering these factors and trends will involve making thorough-going changes in the existing development paradigm. If the world's population is to succeed in adapting to these new climatic conditions and in implementing the mitigation processes that will be necessary in order to meet climate-related goals, a global agreement on how to transition to a sustainable form of development will have to be forged. Sustainable development can usher in greater equality and social cohesion, together with a public/private matrix that is in line with this new paradigm. And all of this will, in turn, reduce the degree of vulnerability to adverse impacts and will increase the feasibility of mitigation and reduce its costs. The climate change challenge and the sustainable development challenge are thus one and the same.

I. Introduction

Given the global nature of climate change and its planet-wide, asymmetrical causes and implications, climate change is one of the most formidable challenges of the twenty-first century. The available evidence indicates that the negative impacts of climate change are significant and are, in all likelihood, more intense in some areas of Latin America and the Caribbean than other regions of the world (IPCC, 2014a; Stern, 2013, 2007). The current trend in levels of emissions suggests that many of the effects of climate change foreseen for this century will be virtually inevitable. Thus, adaptation processes are imperative and need to begin immediately so as to minimize their financial costs and, in some cases, irreversible residual effects. The evidence suggests that a determined effort to reduce the current global level of per capita emissions from approximately 7 tons to 2 tons by 2050 will have to be made in order to stabilize climate conditions. The economic and social challenge of devising ways to deal with the economic, social and environmental losses and costs associated with climate change while at the same time mitigating the effects of greenhouse gas emissions will shape the development style of the twenty-first century.

This climate change challenge can only be met if a global consensus is built on the basis of an acknowledgement of common but historically differentiated responsibilities. And this agreement will only be viable and have real effects if it proposes a sustainable development path that will make it possible to preserve the world's economic, social and environmental assets for future generations (ECLAC, 2014). When viewed from an economic vantage point, climate change is a global negative externality (Stern, 2007), since economic activities release the greenhouse gases that drive climate change into the atmosphere at no cost to those activities. Climate change thus manifests and intensifies the economic, social, and environmental consequences and pressures associated with the current development style. This is why the challenges posed by climate change can be dealt with only by transitioning to a sustainable form of development with more egalitarian and more socially cohesive societies, which will be less vulnerable to climate-related and other shocks and will be in a better position to meet mitigation targets.

Achieving a sustainable style of development is, however, a complex, comprehensive process that calls for major structural changes and for the creation of a targeted public policy package and a new public/private matrix. This conceptual overview is therefore intended to place the analysis of the implications of climate change for Latin America and the Caribbean within the context of the effort to put the region on a sustainable development path.

This study is divided into six sections. The first is this introduction. The second presents the available evidence regarding global warming and estimates of the potential impacts on the region. The third reviews adaptation measures and their potential costs. The fourth section looks at global and regional greenhouse gas emissions. The fifth discusses the importance of moving towards a more balanced public/private matrix in order to improve quality of life and combat climate change, looking in particular at trends in consumption patterns with a focus on transportation needs. The sixth section presents the conclusions.

II. Climate change: concepts and the basic numbers

Climate change poses one of the most formidable challenges of the twenty-first century. It has planet-wide causes and consequences, but its impacts are asymmetrical among regions, countries, sectors and socioeconomic groups. The available evidence indicates that climate change, which is being brought about essentially by human-induced greenhouse gas emissions, is driving a gradual rise in global temperatures, alterations in precipitation patterns, a shrinking of the cryosphere, rising sea levels and changes in the pattern of extreme weather events.

Land mass and ocean temperatures rose by 0.85°C (0.65°C to 1.06°C) between 1880 and 2012,[1] while the difference between the mean temperature for 1850-1900 and the mean temperature for 2003-2012 is 0.78°C (0.72°C to 0.85°C) (IPCC, 2013). The records also show that each of the last three decades has been hotter than the one before, posting the highest temperatures since records began in 1850. For the northern hemisphere, paleoclimatic reconstructions indicate that the period from 1983 to 2012 has probably been the hottest in the last 1,400 years. However, specific regions experienced differences relative to these overall averages.

Temperature records and scenarios, as summed up in figure 1, project a rise in temperature between now and 2100 of between 1°C and 3.7°C, with a high probability that the increase will be greater than 1.5°C. There are extreme projections of up to a 4.8°C increase. Climate models also

1 Calculated on the basis of a linear trend.

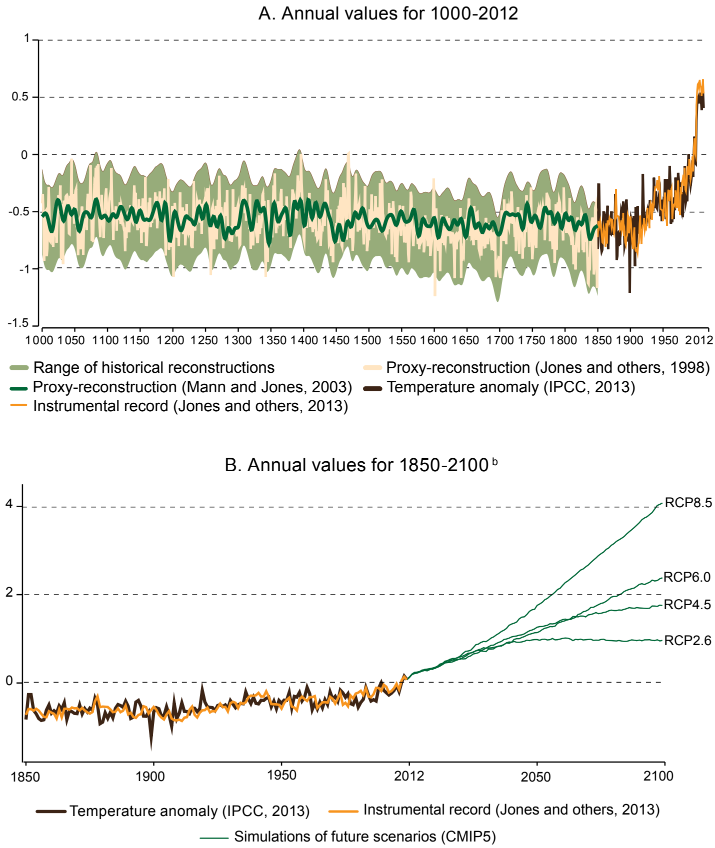
indicate that sea levels will continue to rise and may even do so at a faster pace than in 1971-2010 owing to the thermal expansion of the oceans caused by global warming and the shrinkage of glaciers and ice caps. Consequently, a rise of between 24 cm and 30 cm is expected by mid-century and one of between 40 cm and 63 cm is projected to occur by the end of the twenty-first century (IPCC, 2013).

Discernible trends and alterations in temperature and precipitation patterns in Central and South America include a temperature increase of between 0.7°C and 1°C since the mid-1970s, with the exception of coastal areas of Chile, which saw a 1°C reduction. At the same time, annual levels of precipitation rose in the south-eastern part of South America, but have been trending downward in most of Central America and the southern central area of Chile. The region has also experienced changes in the degree of weather variability and has been hit by numerous extreme weather events (IPCC, 2013). Climate projections suggest (at a mid-range confidence interval) that temperatures will rise by between 1.6°C and 4°C in Central America and South America and possibly even by between 1.7°C and 6.7°C in some areas of South America. Changes in precipitation levels are projected at between -22% and 7% for Central America by the end of the twenty-first century, while, for South America, projections differ from one location to another, with estimates at a low confidence interval ranging from a reduction of 22% for north-eastern Brazil to an increase of 25% in south-eastern South America (IPCC, 2013).

Changes in the climate have major implications for economic activities, the well-being of the population and ecosystems (Stern, 2007; IPCC, 2014b). What is more, there is a risk that the impending changes in the climate system may be even more dramatic than is indicated by projections calculated on the basis of inertial scenarios. In addition, the negative impacts in different sectors will most likely generate a complex feedback loop between various economic and social activities and the climate that could result in even greater —and, in some cases, perhaps irreversible— losses (Stern, 2013; IPCC, 2014b).

Figure 1

Global surface temperatures (ºC): annual temperature anomalies relative to the mean value for the reference period 1986-2005 [a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2013: The Physical Science Basis*, Cambridge University Press, 2013; P.D. Jones and others, "High-resolution paleoclimatic records for the last millennium: Interpretation, integration and comparison with general circulation model control-run temperatures", *The Holocene*, No. 8; M.E. Mann and P.D. Jones, "Global surface temperatures over the past two millennia", *Geophysical Research Letters*, vol. 30, No. 15, 2003; P.D. Jones and others, "Global and hemispheric temperature anomalies land and marine instrumental records", *Trends: A Compendium of Data on Global Change*, Oak Ridge, Tennessee, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory (ORNL), Department of Energy of the United States, 2013.

[a] A temperature anomaly is measured with reference to the 1986-2005 average.

[b] The Representative Concentration Pathways (RCPs) are a new set of scenarios calculated under the framework of the Coupled Model Intercomparison Project Phase 5 (CMIP5) of the World Climate Research Programme. These scenarios simulate changes based on a set of anthropogenic forcings scenarios.

Climate change also poses a paradox in terms of the necessary human response because of the delay between our emissions and their accumulating effects. So while it is a long-term phenomenon whose effects will be stronger in the second half of this century than in the first, urgent action will have to be taken immediately if it is to be dealt with. Climate models indicate that concentrations of 450 parts per million (ppm) of CO_2-equivalent are consistent with an increase in the mean global temperature[2] of 2°C relative to the pre-industrial era (at an 80% degree of probability). In order to stabilize concentrations of greenhouse gases in the atmosphere at levels consistent with an increase of no more than 2°C, annual greenhouse gas emissions will have to be reduced gradually from a total of 46.6 gigatons of CO_2-equivalent ($GtCO_2$-eq) and around 7 tons per capita[3] per year to 20 $GtCO_2$-eq and approximately 2 tons per capita by 2050; and to 10 $GtCO_2$-eq and approximately 1 ton per capita by the end of the century (UNEP, 2013; Vergara and others, 2013; Stern, 2008). In short, in order to stabilize the climate, emissions will have to be cut from approximately 7 tons to 2 tons per capita in the next 40 years. If, however, the world's economies continue to develop types of infrastructure that generate high emissions of CO_2 and if they retain a matrix of subsidies, relative prices and regulations that underpin a high-carbon-emissions economy, they will be tied to a style of economic growth that will be difficult to reverse in the short or medium term and will fail to meet the climate-change targets set for 2050 (see table 1).

The evidence suggests that the impact of climate change in Latin America and the Caribbean is already significant and is very likely to be even greater in the future (IPCC, 2013; IPCC, 2014b). The effects in the region are mostly negative, unevenly distributed and non-linear, but some are actually positive in some areas and for some periods. For example, there is evidence of major impacts on agricultural activities, water resources,

2 Studies (IPCC, 2013) that have modelled the trend in temperatures on the planet's surface over the last two millennia have drawn upon empirically based reconstructions using indirect climate data, proxy reconstructions of temperature patterns in past centuries, experiments dealing with natural and human-induced forces, and models for the analysis of data series on atmospheric circulation, precipitation and droughts. These assessments confirm that there was a more or less constant adjustment in global temperatures up until 1870. These studies have also looked at the chief determinants of changes in surface temperatures and have found that, while natural factors provide a fairly satisfactory explanation of the main changes occurring up to the start of the twentieth century, human-induced pressures on the climate are the likely explanation for the anomalous global warming witnessed in the twentieth century.

3 World Resources Institute (WRI), CAIT 2.0. 2013 [online] http://cait2.wri.org.

biodiversity, sea levels, forests, tourism, the population's health and the region's cities (IPCC, 2014b). However, this evidence is still fragmented and surrounded by a great deal of uncertainty, which makes it difficult to aggregate or to make comparisons. Nonetheless, there are a number of studies (see figure 2) that estimate some of the major aggregate economic costs of an increase in temperature in the region, for example, the projected cost of a 2.5°C increase in temperature is a loss of between 1.5% and 5% of GDP. These are conservative estimates that are limited to certain sectors and regions and are subject to a variety of methodological limitations, but they nonetheless provide some idea of the magnitude of the impacts of climate change on economic activities; it is also highly probable that additional costs will be identified in the years to come (Stern, 2013).

Table 1
Likelihood of exceeding a temperature increase at equilibrium relative to pre-industrial levels
(Percentages of likelihood)

Stabilization level (in ppm CO_2-eq)	2°C	3°C	4°C	5°C	6°C	7°C
450	78	18	3	1	0	0
500	96	44	11	3	1	0
550	99	69	24	7	2	1
650	100	94	58	24	9	4
750	100	99	82	47	22	9

Source: N. Stern, "The economics of climate change", *American Economic Review*, vol. 98, No. 2, 2008.
Note: Equilibrium climate sensitivity refers to the equilibrium change in the annual mean global surface termperature following a doubling of the atmospheric equivalent carbon dioxide concentration. Current CO_2-eq concentration is 446 ppm. With aerosols it is 416 ppm. Abbreviations: ppm CO_2-eq: parts per million of CO_2-equivalent.

These aggregate estimates consider many different types of impacts at the sectoral and regional levels and cover only some of the potential effects, as may be seen from table 2.

These economic impacts will generate greater potential losses of other sorts, given their various multiplier and "downstream" effects on other economic activities, and the possibility of even more extreme weather-related events and climate change scenarios. This can be illustrated by an examination of the agricultural sector, which is of great importance for Latin America and the Caribbean. In 2012, the agricultural sector in Latin America accounted for around 5% of GDP,[4] employed 16% of the working

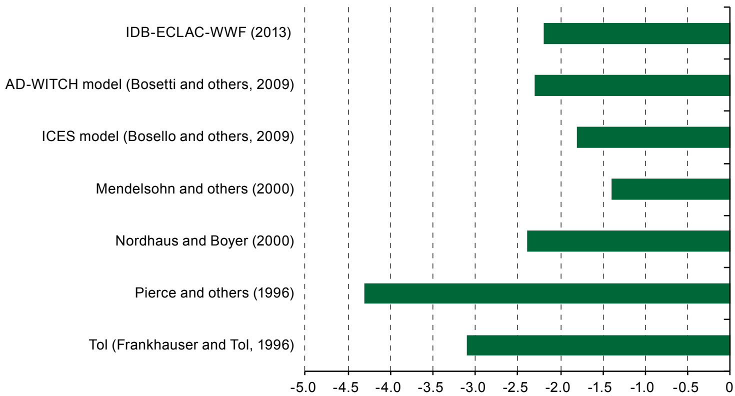
[4] Share of annual GDP, by economic activity, at current prices.

population[5] and produced approximately 23% of the region's exports.[6] Agricultural activities are also of key importance for the region's food security, help to drive its economy, bolster the trade balance, play a significant role in poverty reduction and are a main source of livelihood for the rural population, which represents 22% of the total population in the region.[7]

Figure 2

Impacts of climate change on the Latin American and Caribbean region assuming a 2.5°C temperature increase in the second half of this century

(Percentages of regional GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of F. Bosello, C. Carraro and E. De Cian, "Market- and policy-driven adaptation", *Smart Solutions to Climate Change: Comparing Costs and Benefits*, Bjørn Lomborg (ed.), Cambridge University Press, 2010, pp. 222-277.

Note: Figures on the impacts of climate change for Latin America given an increase in temperature of 2.5°C are taken from Bosello, Carraro and De Cian (2010), pp. 222-277. The data shown for IDB-ECLAC-WWF (2013) are for the year 2050.

Farming and livestock activities are influenced by a wide range of socioeconomic and technological factors, as well as by land quality, but they are especially vulnerable to the climate. In addressing the potential effects of climate change on this sector, a complex web of factors must be borne in mind, including multi-faceted socioeconomic conditions, a striking degree of structural heterogeneity, its overall low levels of

5 18 countries (Argentina, 2012; Bolivarian Republic of Venezuela, 2012; Brazil, 2012; Chile, 2011; Colombia, 2012; Costa Rica, 2012; Dominican Republic, 2012; Ecuador, 2012; El Salvador, 2012; Guatemala, 2006; Honduras, 2010; Mexico, 2012; Nicaragua, 2009; Panama, 2011; Peru, 2012; Paraguay, 2011; Plurinational State of Bolivia, 2011; and Uruguay, 2012).

6 Exports of food and agricultural raw materials.

7 Data from CEPALSTAT [online] http://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/Portada.asp.

productivity, limited access to credit, insurance and infrastructure, including irrigation, and the limited supply of funding for adaptation to new climatic conditions. In addition, climate change losses are being incurred at a time when the agricultural sector is striving to meet a growing demand for food and other agricultural products at the national and global levels, to help combat poverty and to ensure the region's food and energy (bio-fuels) security (Vergara and others, 2013).

Table 2
Potential impacts and risks associated with climate change in Latin America

Impacts	Key risks	Climatic drivers
Agriculture	Decreases in food production, food quality and revenues, rising prices, dependency on imports and pressure on ecosystems.	– Temperature rise and extremes – Precipitation volatility and extremes – CO_2 concentration – Changes in precipitation patterns and volumes
Water	Decreased fresh water availability in semi-arid, glacier-melt-dependent and coastal regions, flooding and landslides in urban and rural areas due to extreme precipitation, decreased availability of water for human consumption and key production activities such as agriculture and hydroelectricity.	– Upward trend in temperature and vaporation – Increased droughts – Reduced snow cover and glacier formation
Biodiversity and forests	Land-use changes, reduction of forests, changes in types of forests adapted to new conditions, coral reef bleaching, decoupling of ecosystems, loss of biodiversity and of ecosystem services.	– Increased deforestation – CO_2 concentration – Upward trend in temperature and extreme weather events – Temperature increase and acidification of oceans
Health	Changes in geographical distribution and incidence of of vector-borne diseases for humans, livestock and crops.	– Upward trend in temperature – Temperature extremes – Precipitation extremes – Changes in inter-annual precipitation patterns
Tourism	Loss of infrastructure and ecosystem services (forests, beaches, reefs, water), rising temperatures, sea levels and extreme events in coastal areas	– Rising sea levels – Temperature and rainfall extremes and changing patterns
Poverty	Reduction in livelihoods and incomes of vulnerable groups, especially in the agricultural sector, and increased nutritional and income inequality	– All of the above.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Intergovernmental Panel on Climate Change (IPCC), "Chapter 27. Central and South America", *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, V.R. Barros and others (eds.), Cambridge, Cambridge University Press, 2014.

The evidence concerning the impacts of climate change on agriculture indicates a concave, non-linear (inverted U) relationship between the net yields and revenues of farming (and, in many cases, livestock activities) relative to temperature and precipitation, with the tipping points varying from product to product and between regions. The degree of uncertainty associated with the specific scale of the expected impacts remains very high (see table 3). A negative correlation is also observed between extreme weather events (such as days of extreme heat or extremely high levels of precipitation, droughts and floods) and agricultural yields. The intensification of desertification and soil degradation processes as a result of, or together with, climate change is also a cause of growing concern (IPCC, 2014c).

The available evidence indicates that in Latin America and the Caribbean, as elsewhere in the world, the impacts of climate change on agriculture are already observable and will increase in the future.[8] Figure 3 presents an overall picture of potential losses in agriculture, which highlights the heterogeneity of the situation across countries. These results suggest, in general terms, that an increase in temperature will cause significant losses in the farm sector between now and the end of this century (see figure 3). Only Ricardian models are used for ease of comparison, although this approach is subject to considerable limitations; other methods can produce significant additional evidence, such as production functions.

These estimates are still conservative ones, since they generally do not include the negative impacts of extreme weather events (Stern, 2013). In addition, lower net yields and revenues will have major collateral effects that will impact economic performance. For example, climate change can be expected to bring about changes in national and regional agricultural production patterns, have a particularly strong impact on subsistence farming (Margulis and Dubeux, 2010), drive up food prices (with the implications that this will have for nutrition levels), impact public finances as a consequence of food subsidies, harm trade balances owing to additional imports, and lead to what may be an increased over-use of water resources in agriculture as farmers strive to adapt to climate change.

[8] Recent estimates (Vergara and others, 2013; Fernández and others, 2013) point to significant potential losses in the Latin American and Caribbean agricultural sector by 2020.

Table 3

Changes in agricultural net revenues associated with rising temperatures based on ricardian models

Author	Country	Increase in temperature (°C)	Revenue change *(percentages)*
Sanghi (1998)[a]	Brazil	2.0	-5 to -11
		3.5	-7 to -14
Mendelsohn, and others (2000)[b]	South America	2.0	0.18 to 0.46
Lozanoff and Cap (2006)[c]	Argentina	2.0 to 3.0	-20 to -50
Timmins (2006)	Brazil	2.0	-0.621
González and Velasco (2008)	Chile	2.5 and 5.0	0.74 and 1.48
Seo and Mendelsohn (2007)[d]	South America	1.9, 3.3 and 5	-64, -38 and -20 (small farms)
			-42, -88 and -8 (large farms)
Mendelsohn and Seo (2007a)[e]	South America	1.4 to 5.1	-9.3 to -18.9
		1.3 to 3.2	-5.0 to -19.1
		0.6 to 2.0	41.5 to 49.5
Mendelsohn and Seo (2007b)[f]	South America	1.4 to 5.1	Exogenous: -6.9 to -32.9 Endogenous: -5.4 to -28.0
		1.3 to 3.2	Exogenous: -5.7 to -17.6 Endogenous: -4.2 to -19.0
		0.6 to 2.0	Exogenous: 4.7 to 0.1 Endogenous: 9.7 to -1.1
Mendelsohn, and others (2007b)	Brazil	10[g]	-33
Seo and Mendelsohn (2008b)	South America	5.1 to 2.0	-23 to -43
Seo and Mendelsohn (2008c)	South America	1.9, 3.3 and 5	-14.2 to -53.0
			-14.8 to -30.2
			2.3 to -12.4
Sanghi and Mendelsohn (2008)[h]	Brazil	1.0 to 3.5	-1.3 to -38.5
Mendelsohn, and others (2010)[i]	Mexico	2.3 to 5.1	-42.6 to -54.1
Cunha, and others (2010)[j]	Brazil	2.0	-14
Seo (2011)[k]	South America	1.2, 2.0 and 2.6	-26 to 17 (private irrigation)
			-12 to -25 (public irrigation)
			-17 to -29 (dry farming)

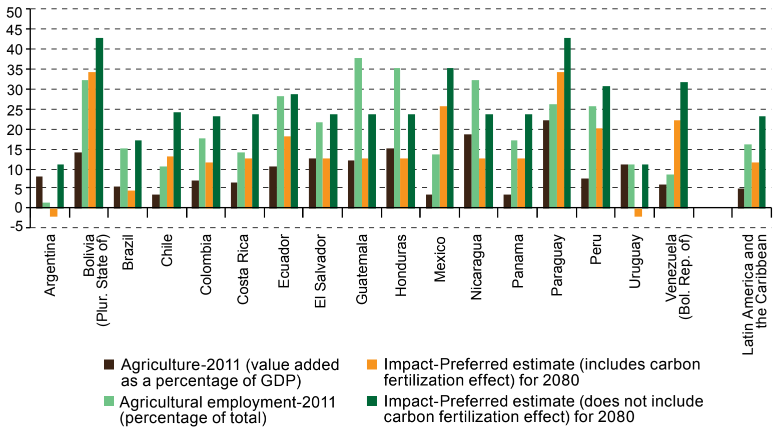
Source: Economic Commission for Latin America and the Caribbean (ECLAC).
Note: Estimates do not take the CO_2 fertilization effect into account. Positive values denote benefits and negative ones denote damage.

[a] The climate scenario is based on a 7% increase in precipitation.
[b] Impacts as a percentage of GDP.
[c] The climate scenario is based on a -5% to 10% change in precipitation levels.
[d] Mean precipitation levels could increase (decrease) in some countries, but there will be a reduction (increase) in rainfall.
[e] Precipitation increases and diminishes over time, with no apparent pattern being observed.
[f] The exogenous model predicts more serious damage and fewer benefits than the endogenous model for all scenarios. The differential increases over time.
[g] Percentages.
[h] The climate scenario is based on a change of between -8% and 14% in precipitation levels.
[i] A series of climate change scenarios include projections or increases and decreases in annual precipitation levels.
[j] Farmers' revenues tend to rise for those with irrigated farmland but tend to fall for those practising dry farming.
[k] Predictions based on the climate scenario include overall increases and decreases in precipitation levels. South America: Argentina, Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Ecuador and Uruguay.

Figure 3

Latin America and the Caribbean: impact of climate change and agriculture on regional GDP

(Percentages)

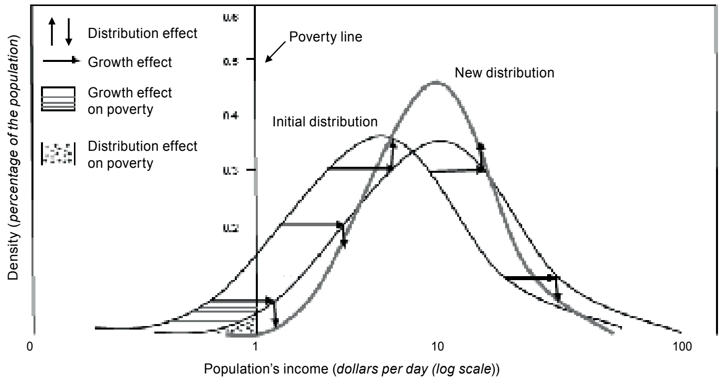


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Bank, World Development Indicators, and William R. Cline, *Global Warming and Agriculture: Impact Estimates by Country*, Peterson Institute, 2007.

Note: The figure depicts the share of total GDP represented by agricultural value added which is lost. The impact of climate change on the agricultural sector was calculated as a linear function of the preferred impact estimate for 2080 given in Cline (2007). The impact shown for the Latin American and Caribbean region is a simple average. It is assumed that the impact given for Paraguay is the same as that shown under the heading "Other South American countries"; the impact for Uruguay is the same as it is for Argentina.

The impact of climate change on farming is a major transmission channel between climate change and poverty. This is because climate change influences the rate of economic growth, particularly in the agricultural sector, which is highly sensitive to weather conditions. In turn, the pace of economic growth influences poverty levels (Bourguignon, 2003; Ravallion, 2004; OECD, 2007). In effect, changes in poverty levels are the logical outgrowth of changes either in mean personal income (economic growth effect) or in income distribution (income distribution effect) (Bourguignon and Morrisson, 2002; Epaulard, 2003; ECLAC, 2012a). Thus, an increase in the population's average income will translate into a reduction in poverty under an assumption of a lognormal income distribution at constant prices (see diagram 1) (Bourguignon, 2003, 2004; Datt and Ravallion, 1992; OECD, 2010).

Diagram 1
Breakdown of changes in poverty levels: income effect and distribution effect



Source: F. Bourguignon, "The growth elasticity of poverty reduction: Explaining heterogeneity across countries and time periods", *Inequality and Growth: Theory and Policy Implications*, T. S. Eicher and S. J. Turnovsky (eds.), CESIfo Seminar Series, 2002.

The available evidence indicates that rural poverty in Latin America declined during the period stretching from the late 1990s to the end of the first decade of the twenty-first century, although the trends differed significantly from country to country. It is estimated that the percentage of the rural population living below the indigence (extreme poverty) line in Latin America and the Caribbean fell from 38% to 31%, while the percentage of the total rural population living below the poverty line slid from 64% to 54% during this period. These figures represent a decrease of approximately 15 million and 11 million people living in extreme poverty and poverty, respectively, during this period (ECLAC, ILO and FAO, 2010).

The evidence for Latin America[9] clearly points to the presence of this negative correlation between per capita economic growth rates and poverty levels (see figure 4). For example, estimates for Latin America (Galindo and others, 2014b) yield an elasticity for economic growth relative to changes in poverty levels of between -1.5 and -1.7 for the indigence line and of between -0.94 and -1.76 for the poverty line (depending on the poverty indicator that is used). The elasticity of income distribution is positive and statistically significant in all cases. This suggests that a greater degree of economic inequality has a negative influence on poverty indicators, that is,

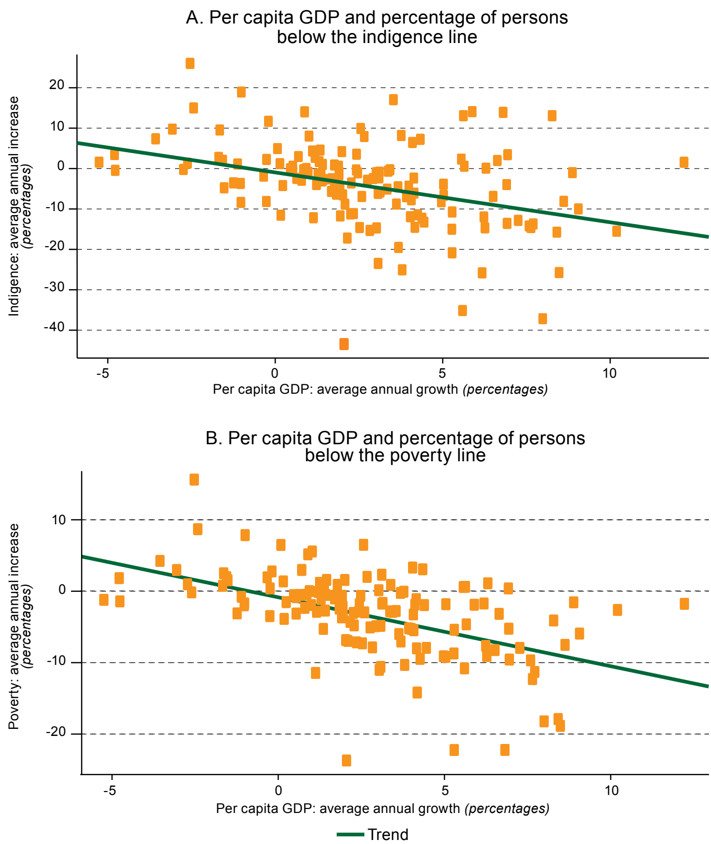
9 See also ECLAC (2009).

greater inequality is associated with higher poverty levels. These results can be used to build forward-looking scenarios that can be used to gauge the potential impact of climate change in terms of poverty based on its impact on the farm sector's growth rate. This demonstrates that climate change is a factor to be taken into account when drawing up social policy agendas.

Figure 4

Latin America and the Caribbean: per capita GDP growth and poverty

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC) based on data from CEPALSTAT.

Note: The left-hand figure depicts observations for the average annual per capita GDP growth rate in 2000 dollars and indigence indices for 17 countries of the region for 1989-2011. Each point shown in the figure denotes an observation for a specific point in time and country. The right-hand figure contains the same information, but in reference to the poverty line rather than the indigence line.

III. Adapting to climate change: from the unavoidable to the sustainable

The mitigation measures which the Member States of the United Nations have committed to undertake are not enough to achieve the reduction in greenhouse gases necessary for climate stabilization (UNEP, 2013). The Latin American and Caribbean region is highly vulnerable to climate change as a consequence of various factors, including its geography, the way in which its population and infrastructure are distributed, its dependence on natural resources, the scale of its agricultural activities, the size of its forests and its biodiversity. Other factors that add to its vulnerability include its limited capacity to fund additional adaptive processes and the large number of people who live in socioeconomic conditions that expose them to greater levels of risk (ECLAC, 2012a, 2010a; Cecchini and others, 2012; Vergara and others, 2013). This all underscores the importance of incorporating suitable adaptation measures into national sustainable development strategies.

The concept of climate change adaptation encompasses any deliberate adjustment made in response to actual or expected changes in climatic conditions. From an economic perspective, adaptation processes are defined as the additional economic costs associated with human activities and ecosystems that are incurred in order to adjust to changed climatic conditions. These additional efforts and costs are not initially taken into consideration in the business-as-usual baseline and may include a vast range of changes, including social, cultural, administrative and processal changes, behavioural modifications, new infrastructure or technologies, updates to products, inputs or services, and changes at the structural public policy level (IPCC, 2001, 2007; IPCC, 2014c; World Bank, 2010a; OECD, 2012).

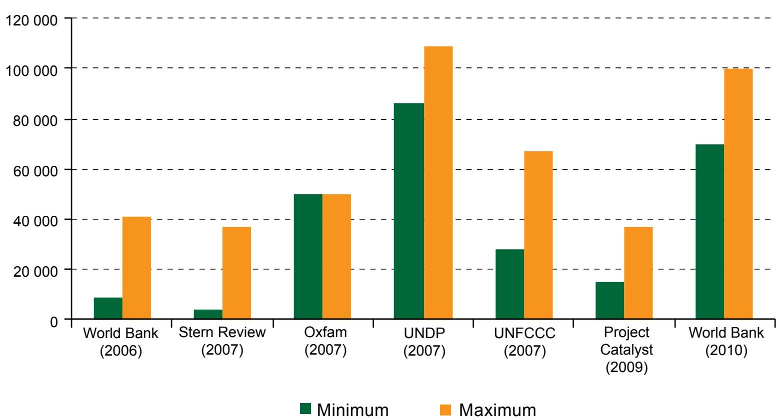
Despite the importance of adaptation, there is still a lack of knowledge and a great deal of uncertainty about adaptive processes, their costs and their economic benefits. This is a consequence of the difficulties involved in defining a baseline and in distinguishing, for example, between the business-as-usual processes that drive economic growth and the more efficient and effective risk-management systems and measures which are specifically aimed at adapting to climate change.

Currently, the evidence gleaned from a number of different adaptation processes shows that any adaptation process is bound to generate certain inevitable —and, in many cases, irreversible— residual effects and that significant inefficiencies and barriers of various sorts will be encountered. For example, a sustained change in mean temperatures that is treated as if it were temporary may lead to the over-use of water resources that will increase losses and vulnerability in the future.

Various estimates of the actual and potential costs of adaptation processes are presented in figure 5, which shows that the global economic cost of adaptation may vary from US$ 4 billion to US$ 100 billion as a yearly average. In general, the estimated global costs of adaptation represent less than 0.5% of GDP and the World Bank estimates that these costs will represent 0.2% of the projected GDP for developing countries for this decade. These costs are expected to fall to 0.12% for the period 2040-2049, while, for South-East Asia, they are projected at over 0.5% for 2020-2029 (World Bank, 2010b). As these are conservative estimates, in all probability the final costs will be higher (Parry and others, 2009), especially in Latin American and the Caribean.

The annual adaptation costs for the Latin American and Caribbean region are estimated at about 0.5% of the region's current GDP, although these estimates cover a limited set of responses, entail a high level of uncertainty and will very probably increase (World Bank, 2010b; Vergara and others, 2013) (see figure 6). The World Bank (2010a) estimates that the region's adaptation costs in agriculture, water resources, infrastructure, coastal zones, health, extreme weather events and fisheries will be below 0.3% of the region's GDP (between US$ 16.8 trillion and US$ 21.5 trillion per year up to 2050 (World Bank, 2010a). Agrawala and others (2010) estimate the region's adaptation costs for irrigation, water resource infrastructure, coastal protection, early warning systems, investments in climate-resistant housing, cooling and refrigeration costs, the treatment of illnesses and adaptation R&D to be around 0.24% of regional GDP (Agrawala and others, 2010). UNFCCC (2007) estimates that the investments and financial flows necessary to mitigate the impacts of climate change in the region between now and 2030 will amount to approximately US$ 23 billion for the water resources sector, while it estimates the amount needed for additional infrastructure at between US$ 405 million and US$ 1.726 billion and the cost of coastal zone protection measures at between US$ 570 and US$ 680 million (see figure 6). The estimates that have been prepared so far for adaptation costs in Latin America are thus largely based on the costs involved in "hard adaptation measures", such as protection for coastal zones, agricultural activities and water resources. However, there are many other types of costs that have yet to be identified. Nonetheless, the available evidence suggests that implementing adaptation processes makes economic sense where they can help to reduce some of the other higher —and in some cases irreversible— economic costs of climate change.

Figure 5
Estimated range of adaptation costs for developing countries
(Millions of dollars per year)

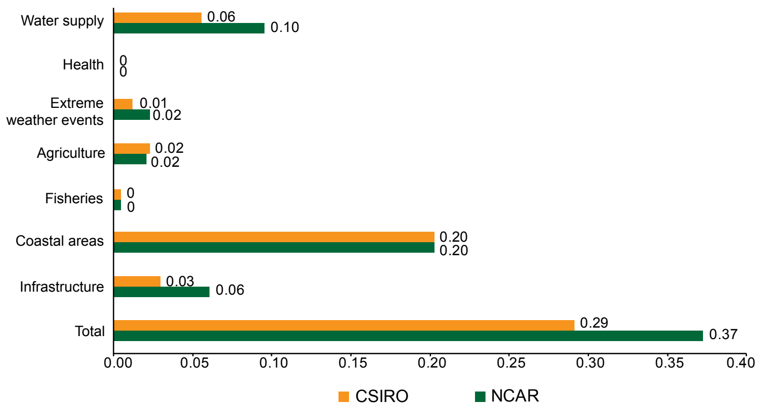


Source: Economic Commission for Latin America and the Caribbean (ECLAC).
Note: The estimated costs cited in the World Bank studies (2006), Stern Review (2007) and Oxfam (2007) are present values. The costs estimated in UNDP (2007) are costs for 2015. The costs estimated in UNFCCC (2007) and Project Catalyst (2009) are costs for 2030, and those estimated by the World Bank (2010a) are annual costs projected through to 2050.

Figure 6

Latin America and the Caribbean: annual costs of adaptation

(Percentages of regional GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Bank, "The cost to developing countries of adapting to climate change. New methods and estimates", Washington, D.C., The World Bank Group, June 2010.

Note: NCAR: National Centre for Atmospheric Research, wettest scenario. CSIRO: Commonwealth Scientific and Industrial Research Organization, driest scenario. Fishery sector: average range (0.18 to 0.36 and 0.18 to 0.35 for the NCAR and CSIRO models, respectively). The estimated health costs are still not fully considered and therefore do not reflect a significant share of the GDP.

A summary of some of the main adaptive measures proposed in the region is shown in table 4. There is uncertainty about what the results of these processes will be and more work needs to be done on the potential benefits and costs, but many could be important for more sustainable and equitable development and could help to reduce the economic costs of climate change and even generate additional economic and social benefits (Agrawala and others, 2010; Tan and Shibasaki, 2003; Bosello, Carraro and Cian, 2009; Rosenzweig and Parry, 1994).

The agriculture sector has demonstrated its capacity for adaptation through its long tradition of adapting to changing weather and climate conditions. For example, there is evidence that some South American farms have responded to more recent climate pressures by switching from growing maize, wheat and potatoes to cultivating fruits and vegetables, from crop farming to livestock-raising or a mixture of the two and have adjusted their irrigation decisions (Seo and Mendelsohn, 2008a, 2008b; Mendelsohn and Dinar, 2009).

Table 4
Selection of proposed adaptation measures

Agriculture	Coastal areas
• Diversified mixture of crops and livestock and forests in production systems such as agroforestry and shade systems • Efficient management of irrigation water and retention of humidity in soil, integrated rural landscape management, including watersheds • Climate monitoring and forecasting • Crop development and use, including at the local/producer level with genetically diverse local varieties • Production systems to increase soil organic matter and fertility and resistance to pests and climate, such as multiple or mixed cropping, terracing and slope-run-off management, use of local organic matter • Development of post-harvest infrastructure to reduce losses and increase producers' opportunities to manage sales or on-farm consumption • Changes in production and farming practices: implementation of diversification strategies such as alternating or changing crops or livestock, and adjustments to sowing and harvesting dates • Expansion of arable land, reforestation of other lands, changes in the spatial distribution of agricultural land and land-use management • Improve land use based on land type, capacity and topographical characteristics • Intensification of the management of inputs and diverse technologies that contribute to sustainable and climate resilient production Public programmes with producers to increase their access to a basic package of services in credit, technology, inputs and insurance • Diversification of revenue sources and agricultural activities through a reactivation of the rural sector and improved value chains with agro-industry and services, including support for protection of ecoservices	• Integrated management, regulation and planning of coastal areas • Integrated management of watersheds and coastal areas • Protection of coastal wetlands and education on ecosystem services • Climate-resilient building codes • Dykes, defences and barriers along coasts and wharves, including the use of "green" infrastructure • Land-use planning and designation of high-risk zones • Land-use regulation • Planned reassignment and prohibitions, hard defences • Restoration/management of sediments • Restoration of coastal dunes and beaches • Construction limits • Seawater intrusion barriers • More efficient water use • Injection of freshwater • Modernize drainage systems and improvements of urban drainage systems • Polders • Change of land use and land zoning • Flood, wave, tidal and storm alert systems • Community-based disaster risk reduction • Balanced conservation of marine fishing grounds, coral reefs and mangrove swamps • Improvements in the livelihoods and protection of traditional settlements • Management of non-climatic stress factors
Health sector	**Water sector**
• Preventive and sanitation measures • Training programmes on public health, emergency response systems and disaster prevention and control programmes • Improvement of the adaptive capacity of different social groups • Social security networks • Construction standards • Improvement of public health infrastructure • Prevention of waterborne diseases • Supply of drinking water • Early warning systems for the identification of infectious diseases • Monitoring networks and system for alerting communities to upcoming heat waves • Design of natural disaster alert and prevention systems • Public health improvements • Anti-vector programmes • Disease eradication programmes • Health education programmes • Research • Vector control R&D • Vaccines • Disease eradication • Implementation of local anti-pollution measures along with other co-benefits	• Water conservation and demand management (water permits, prices and taxes) • Watershed management • Land-use management • Efficient water use and adjustments in use patterns • Recycling of water and water treatment systems • Efficient irrigation • Water management infrastructure • Importation of water-intensive products • Increase in adaptative capacities of rain-fed agriculture • Institutional and governance improvements to ensure the effective implementation of adaptation measures • Sources of ongoing improvements: • Water storage and conservation techniques • Exploration for and sustainable extraction of groundwater • Reduction of losses in water and irrigation systems • Elimination of invasive species in reservoirs • Rainwater collection • Water transfers • Risk management to cope with rainfall variability • Water allocation (for example, municipal use versus agriculture) • Desalination

Table 4 (concluded)

Biodiversity and ecosystems	Retreat of glaciers
• Increase the number of protected areas and corridors based on climate risks and measures to facilitate adaptation • Improve representation and replication across networks of protected areas • Improve the management and restoration of existing protected areas in order to increase their recovery capacity • Design of new natural areas and restoration sites • Incorporate foreseen impacts of climate change into management plans, programmes and activities • Manage and restore ecosystem functions • Incorporate best practices into the fisheries industry • Land-use regulation • Focus the use of conservation resources on endangered species or on overall sustainability of ecosystems and their functions • Relocate endangered species • Conserve populations of species in captivity • Reduce non-climate-related pressures on flora and fauna • Improve existing laws, regulations and policies • Protect biological corridors, sanctuaries and wildlife crossings • Improve monitoring programmes • Develop dynamic land conservation plans • Safeguard wildlife and biodiversity • Management of multiple forest use • Evidence ecosystem services and their economic, social and cultural value	• High-altitude reservoir design • Use of drought-resistant varieties in high-altitude agriculture • Demand management measures • Expansion and design of water catchment systems • Glacial basin planning • Compilation of statistical and other data on glacier dynamics

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of W. Vergara and others, *The Climate and Development Challenge for Latin America and the Caribbean: Options for Climate-Resilient, Low-Carbon Development*, Inter-American Development Bank (IDB), 2013; Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, V.R. Barros and others (eds.), Cambridge, Cambridge University Press, 2014.

Note: The co-benefits and overall costs of these measures were not necessarily considered.

The available evidence indicates that adaptation is a complex, heterogeneous process that is difficult to gauge accurately, since it involves non-linear patterns and generates unequal and uncertain costs from one region to the next. There is already a wide range of cost-effective adaptive options that can significantly reduce the economic, social and environmental costs of climate change and that bring considerable side-benefits, such as the promotion of energy efficiency, improvements in the population's health status, reduced deforestation and less air pollution. The fact remains, however, that these adaptive measures do have limitations and can therefore not resolve some of the residual —and irreversible— damage associated with climate change. In addition, some of the available options will prove to be inefficient because they will do significant damage. Furthermore, there are institutional, technological and resource barriers that will hinder the implementation of some suitable adaptive measures. The market may not be able to “read” some of these measures properly and some of the proposed measures need to be made more specific and relevant to particular regions and populations.

This evidence points to the importance and the economic advantages of implementing and planning adaptive processes as part of a sustainable and inclusive development process. This kind of adaptive strategy for reducing the most negative and irreversible impacts of climate change can be implemented by individual countries without waiting for a global climate change agreement to be concluded (Bosello, Carraro and Cian, 2009). It is thus an intrinsic part of a risk management strategy that includes a range of flexible adaptive measures. A portfolio of adaptive measures should include both precautionary and remedial measures for forestalling extreme, irreversible types of damage in order to protect the most vulnerable sectors of the population and the region’s natural assets, along with measures that will generate co-benefits, such as improvements in health, social security, energy efficiency, and reductions in air pollution and in deforestation, while avoiding inefficient forms of adaptation. All of this will entail a transition to a sustainable form of development (World Bank, 2008).

Thus, sustainable development processes directed along a low-carbon, egalitarian growth path will need to be based on the concurrent implementation of interconnected processes for supporting adaptation to, and the mitigation of, climate change (IPCC, 2014c). This is because the end results of adaptation processes will hinge upon the outcome of mitigation processes while, at the same time, adaptation processes can contribute to mitigation especially when carried out within a sustainable development environment.

IV. Sustainable development and mitigation strategies in the global economy

From an economic point of view, climate change is a global negative externality and the geographical source of greenhouse gas emissions is irrelevant (Stern, 2007, 2008). Given this fact, resolving climate change necessarily entails changes in this existing economic system based on a global agreement that is embraced by all countries. This agreement should involve the design and application of new institutional arrangements and regulations, economic incentives and instruments, technologies and structural changes aimed at the construction of a more egalitarian and inclusive society that provides a stronger and more resilient social protection network able to withstand climatic and other shocks.

Greenhouse gas emissions amounted to 46 gigatons of CO_2 equivalent ($GtCO_2$-eq) in 2011,[10] with a mean annual growth rate of 1.5% between 1990 and 2011. The emissions of the Latin American and Caribbean region represented 9% of the global total (4 $GtCO_2$-eq), with a mean annual growth rate of 0.6% for the same period. As may be seen from figure 7, the breakdown of emissions by regions and countries reflects striking differences.

In Latin America and the Caribbean, the main source of emissions is the energy sector, which accounts for 42% of the region's total emissions. The second and third sectors by emissions are agriculture (28%) and changes in soil use and forestry activities (21%). The region's sectoral emissions pattern differs significantly from the global pattern, in which the energy sector accounts for just slightly less than three quarters of the total, while the farming sector and changes in land use account for

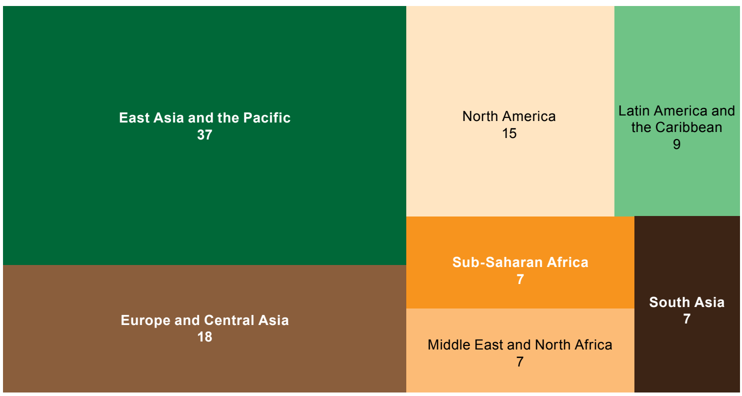
[10] Climate Analysis Indicators Tool (CAIT) 2.0., Washington, D.C., World Resources Institute ©2014 [online] http://cait2.wri.org.

far less(see figure 8). In terms of trends, the region's energy-sector and agricultural emissions continue to climb, while those associated with deforestation and land-use change are declining (see figure 9).

Figure 7

Regional shares of total greenhouse gas emissions, 2011

(Percentages)



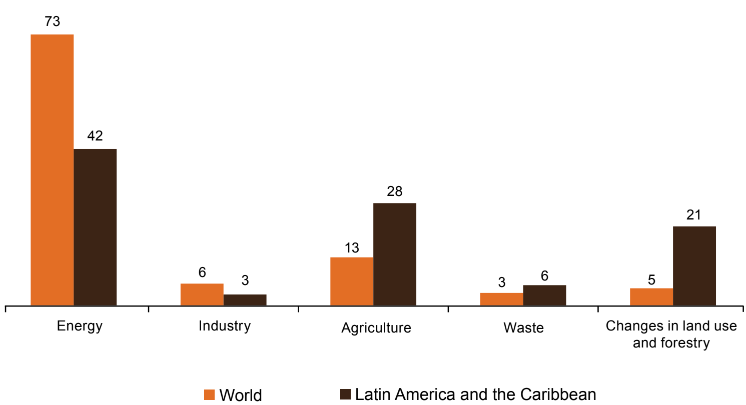
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Climate Analysis Indicators Tool (CAIT) 2.0. ©2014, Washington, D.C., World Resources Institute [online] http://cait2.wri.org.

Note: Mexico is included in Latin America and the Caribbean.

Figure 8

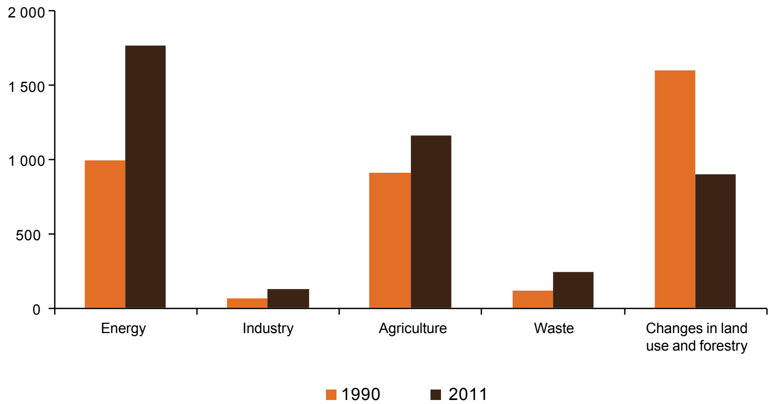
The world's and the Latin American and Caribbean region's shares of greenhouse gas emissions, by sector, 2011

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from the Climate Analysis Indicators Tool (CAIT) 2.0. ©2014, Washington, D.C., World Resources Institute [online] at: http://cait2.wri.org.

Figure 9
Latin America and the Caribbean: greenhouse gas emissions, by sector, 2011
(Megatons of CO_2-eq)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from the Climate Analysis Indicators Tool (CAIT) 2.0. ©2014, Washington, D.C., World Resources Institute [online] http://cait2.wri.org.

Per capita emissions[11] in 2011 in Latin America and the Caribbean amounted to 7 tons of CO_2-eq, as compared to a world average of 6.6 tons, with emission levels in the region varying widely from country to country (see figure 10). Average per capita emissions for the energy sector in the region amounted to 3 tons of CO_2-eq, which compares favourably with the world average of 4.8 tons of CO_2-eq, although there are also considerable variations between the countries (see figure 11).

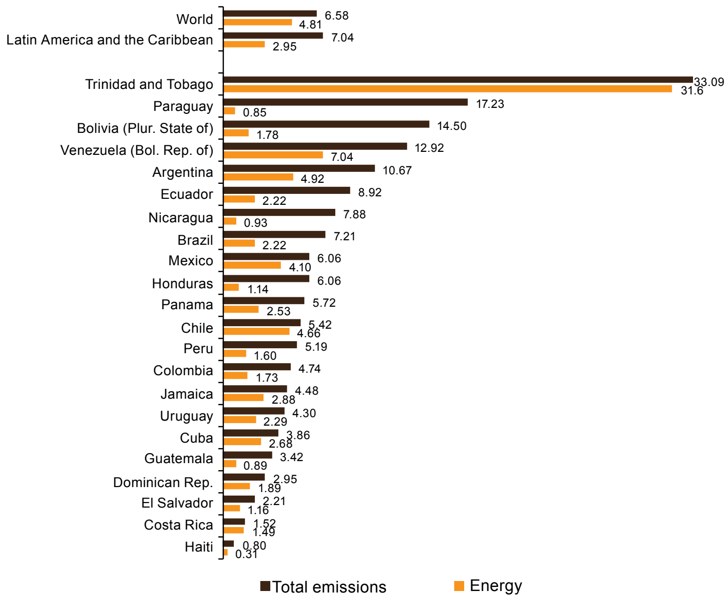
In the discussion on policy options, it is important to note the strong correlation between per capita emissions, per capita energy use, per capita income and demographic trends in the region, as in other modern economies (ECLAC, 2010b) (see figure 11). Under an inertial scenario, the region's per capita emissions for 2050 would be above the climate-stabilization targets, even if only energy consumption related emissions were counted (Vergara and others, 2013).

11 Data on emissions are taken from WRI, CAIT 2.0. 2014 [online] http://cait2.wri.org. In a departure from earlier versions that used Houghton (2003a, b; 2008) as a source for data on land-use-related emissions, CAIT 2.0 uses the new FAO database. The figures used by CAIT 2.0 are therefore not, strictly speaking, comparable with those provided in earlier versions.

Figure 10

Latin America and the Caribbean: per capita greenhouse gas emissions, 2011

(Tons of CO_2-eq)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from Climate Analysis Indicators Tool (CAIT) 2.0. ©2014, Washington, D.C., World Resources Institute [online] http://cait2.wri.org.

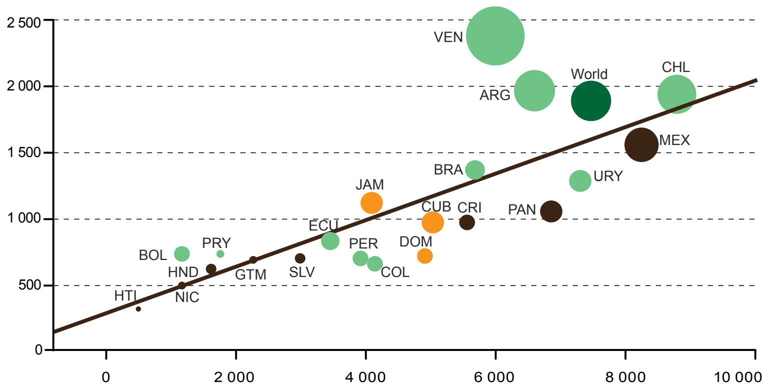
Note: Only those countries that have data on energy-sector emissions have been included in this table.

The Latin American and Caribbean region faces an asymmetrical challenge in the sense that its contribution to total greenhouse gas emissions is quite limited, yet it is highly vulnerable to the effects of climate change. But a planet-wide problem such as climate change must be addressed within the context of the global economy by means of a global climate change framework agreement, and this type of agreement will inevitably have worldwide consequences. In other words, the scale of the changes required to adapt to new climatic conditions and to put global mitigation processes in place will spur sweeping structural changes and the creation of a new structure for the world economy that will deeply affect the region. It is therefore in the region's best interests to proactively explore opportunities and not remain on the sidelines as a new sustainable development agenda is drawn up and implemented.

Figure 11

Latin America and the Caribbean: per capita GDP and per capita energy consumption, 2011

(Dollars at constant 2005 prices and kilograms of petroleum equivalent)



Source: Economic Commission for Latin America and the Caribbean (ECLAC). The data on energy use are from the World Bank, World Development Indicators (WDI) database. Per capita GDP data are from CEPALSTAT. Data on the energy sector's emissions are from Climate Analysis Indicators Tool (CAIT) 2.0. ©2014, Washington, D.C., World Resources Institute [online] http://cait2.wri.org.

Note: The size of the circles represents the level of the energy sector's per capita emissions of greenhouse gases. The colours denote the different subregions: green for South America; black for Central America; and orange for the Caribbean.

V. The transition to an egalitarian, low-carbon economic growth path: the public/private matrix

The region as a whole has displayed greater economic dynamism over the last decade thanks, in part, to booming exports of renewable and non-renewable natural resources. And this increased dynamism has been coupled with upswings in employment, consumption and investment, a reduction in poverty and an improvement in income distribution (ECLAC, 2014). However, this heightened economic buoyancy and the social advances that have gone along with it also pose certain risks and involve certain paradoxes that suggest that the current development style is unlikely to be sustainable in the long run and that its underpinnings are already fragile and are perhaps being eroded (Galindo and others, 2014a).

This is illustrated by current consumption patterns in the region, which invariably reflect a high degree of heterogeneity in its income distribution patterns and poverty levels, trends in income and relative prices, sociodemographic characteristics and education levels. Other factors include a general pattern of conspicuous consumption, the available technologies and infrastructure, the provision and quality of public goods and services, and various "aspirational" and cultural factors (Lluch and others, 1977; Sunkel and Gligo, 1980; Filgueira, 1981; ECLAC, 2014). These consumption patterns have a strong influence on economic dynamics and are associated with significant negative externalities, such as the generation of waste, air pollution, environmental deterioration or destruction, increased use of renewable and non-renewable resources, and emissions of the greenhouse gases that are driving climate change.

The expansion of consumption deriving from rapid economic growth has also been associated with groups of low- and middle-income consumers who have only recently risen above the poverty line and who have new, genuine consumption aspirations, but who also retain particular vulnerabilities to various types of shocks. Meeting the consumer demand of these groups is, of course, important and must be done, but this will be possible only within the context of a sustainable development pattern coupled with a new public/private matrix that is capable of reducing their exposure to a variety of risks.

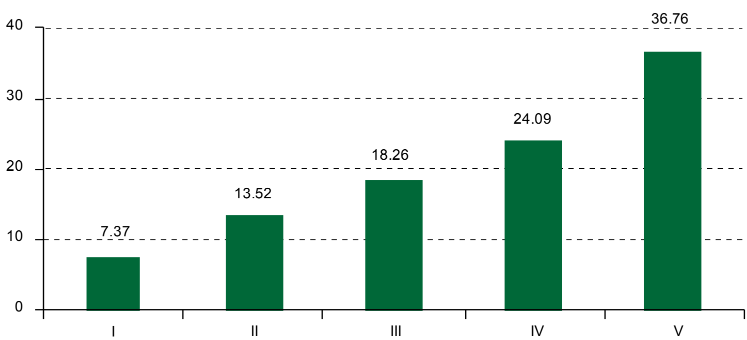
The available evidence[12] shows that expenditure on food is one of the main items of expenditure of all income groups and that the largest share of spending on food is accounted for by middle- and high-income groups (see figure 12) (Gamaletsos, 1973; Lluch and others, 1977). Nonetheless, the proportion of total expenditure devoted to the purchase of food diminishes as income levels (measured by quintile) rise, in line with Engel's law (Chai and Moneta, 2010; Lewbel, 2012) (see figure 13). In other words, as income rises, the proportion of income spent on food falls, even if actual expenditure on food is higher. This behaviour pattern is, however, highly volatile.

Figure 12

Proportion of total expenditure on food and beverages represented by household expenditure on food and beverages, by income quintile

(Percentages)

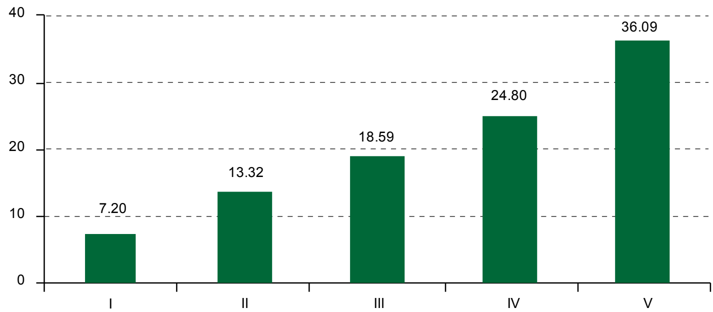
A. Argentina



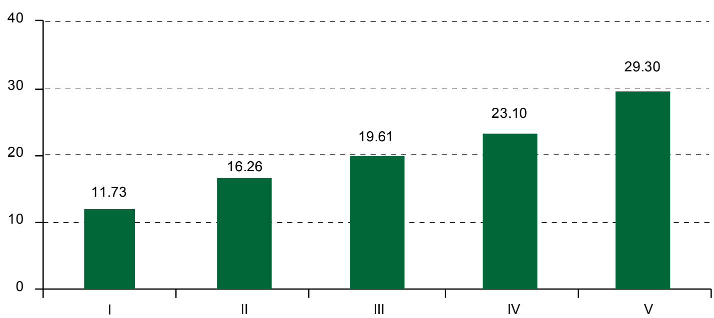
[12] The data include cases of non-consumption.

Figure 12 (continued)

B. Brazil



C. Chile



D. Colombia

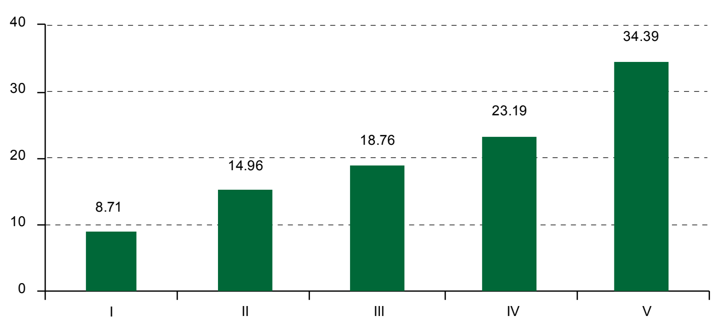


Figure 12 (continued)

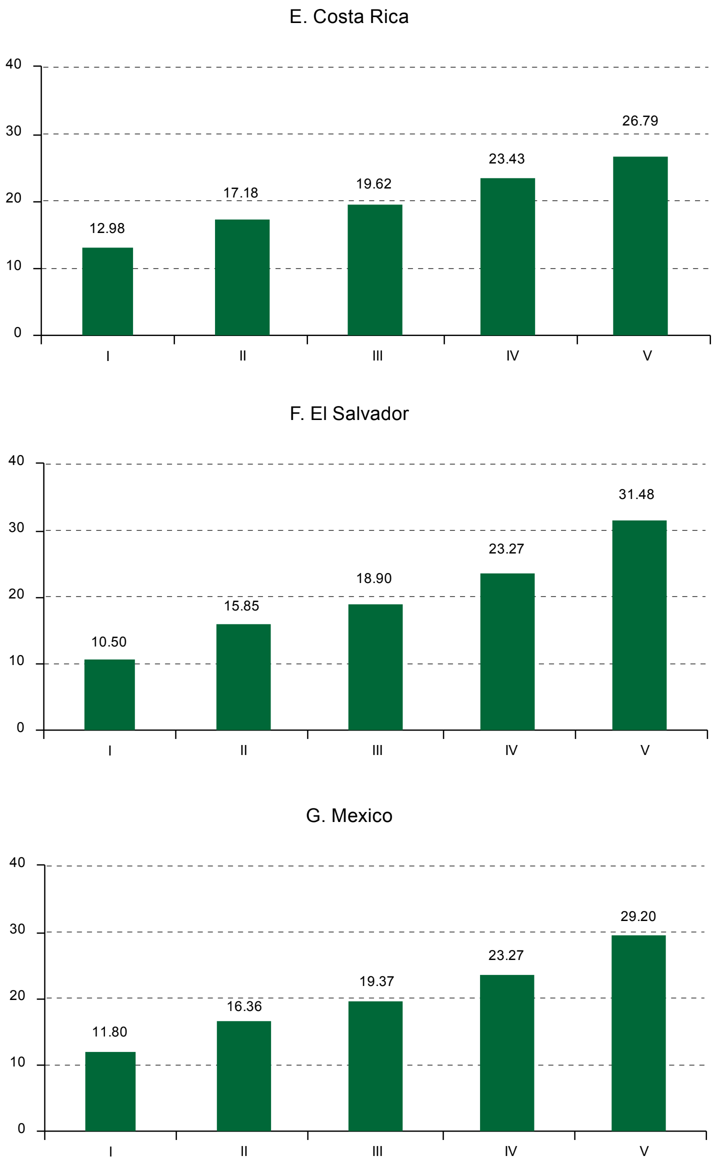
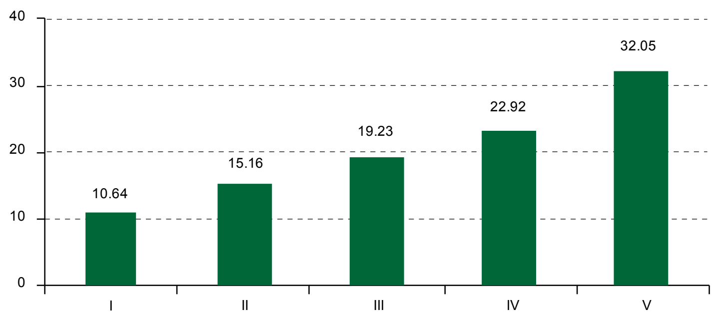
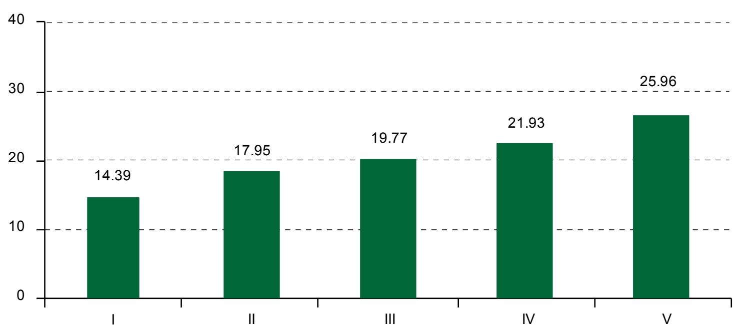


Figure 12 (concluded)

H. Nicaragua



I. Uruguay



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of following surveys: Argentina: National Household Expenditure Survey, 2004-2005; Chile: Family Budget Survey, 2007; Colombia: National Income and Expenditure Survey, 2006-2007; Costa Rica: National Household Income and Expenditure Survey; El Salvador: Household Income and Expenditure Survey, 2005-2006; Mexico: National Household Income and Expenditure Survey, 2012; Nicaragua: Household Living Standards Survey, 2009; Uruguay: National Household Income and Expenditure Survey, 2005-2006.

Thus, rising incomes are coupled with an upward trend in food demand, but they also open up opportunities for the consumption of new types of goods and services (see diagram 2). The type of new consumption patterns that take shape will play a decisive role in defining sustainable consumption options.

Figure 13
Proportion of total household expenditure represented by expenditure on food and beverages, by income quintile
(Percentages)

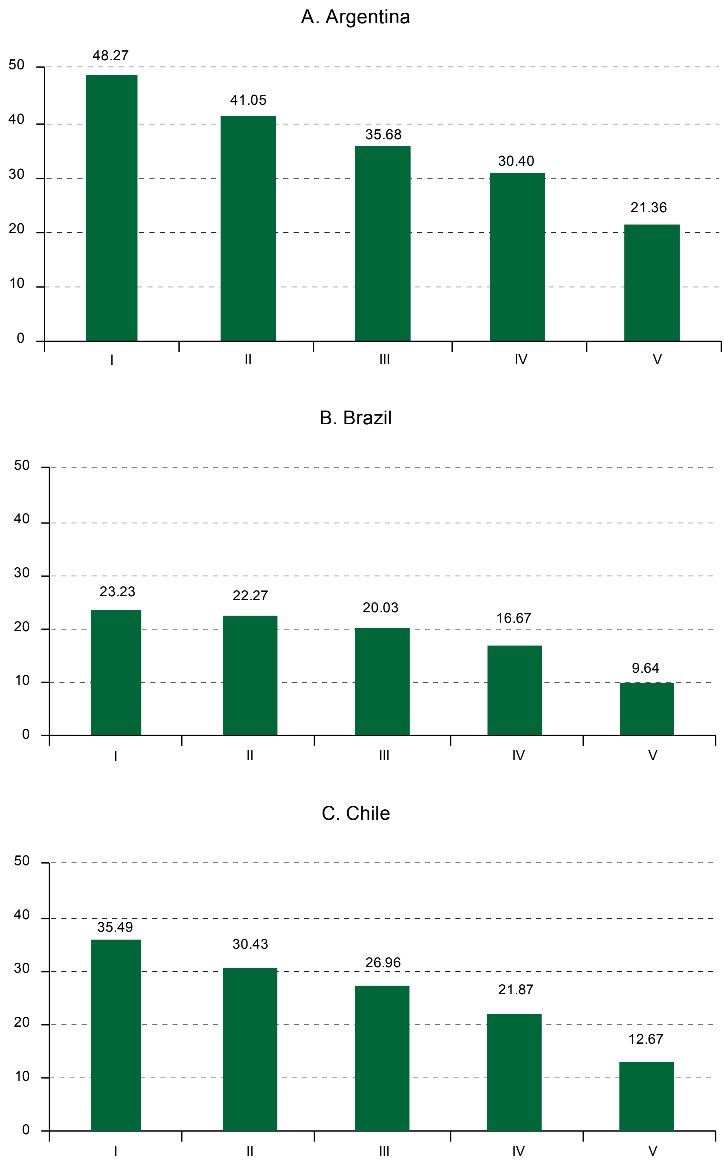
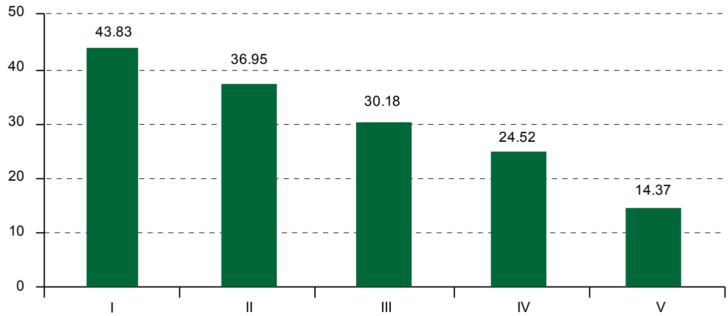
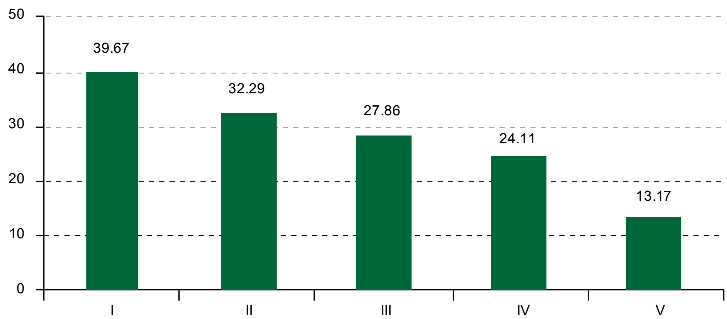


Figure 13 (continued)

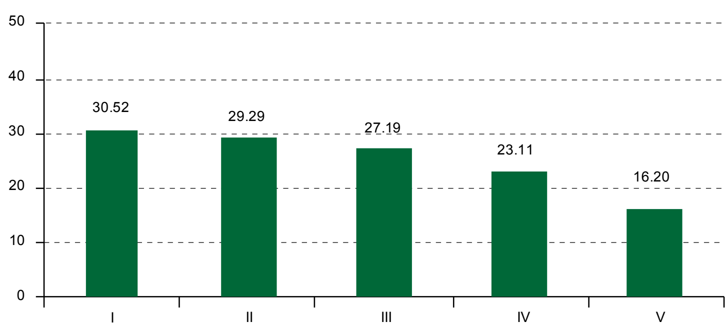
D. Colombia



E. Costa Rica



F. El Salvador



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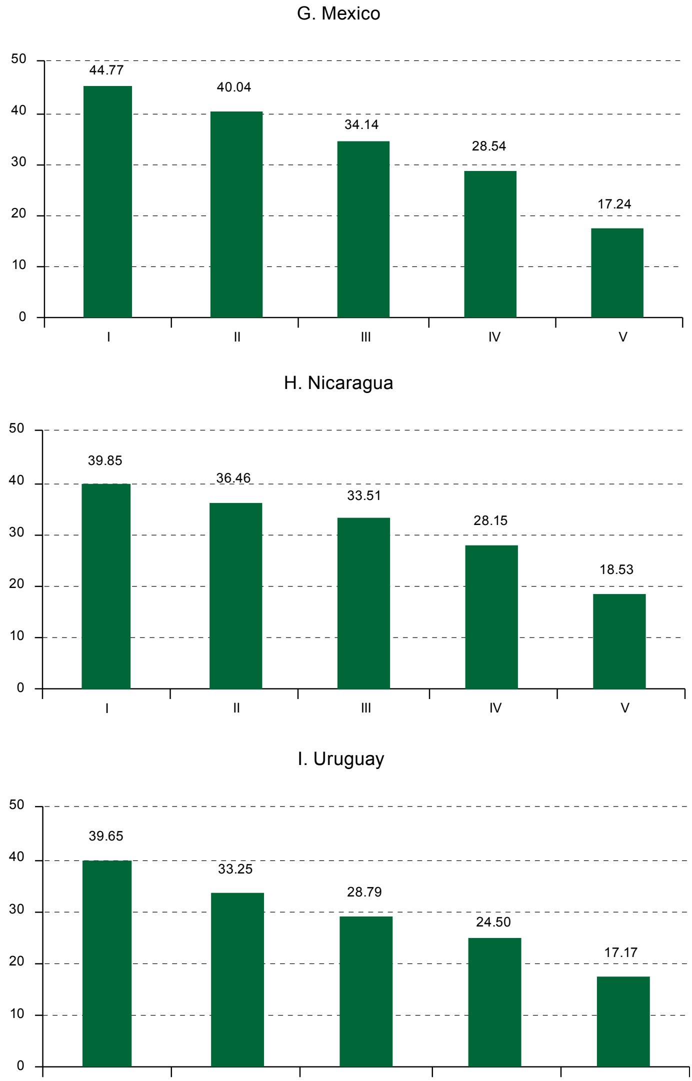
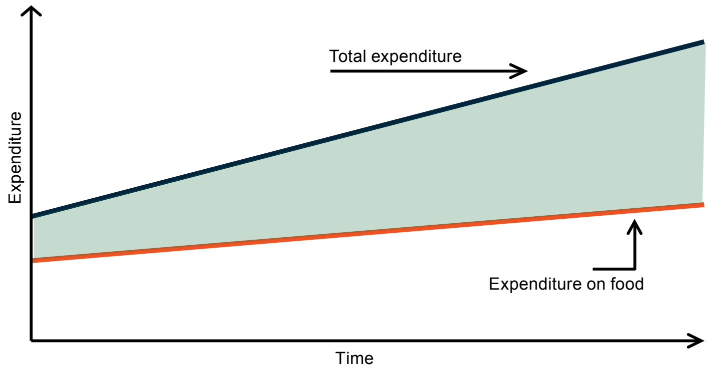


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of following surveys: Argentina: National Household Expenditure Survey, 2004-2005; Chile: Family Budget Survey, 2007; Colombia: National Income and Expenditure Survey, 2006-2007; Costa Rica: National Household Income and Expenditure Survey; El Salvador: Household Income and Expenditure Survey, 2005-2006; Mexico: National Household Income and Expenditure Survey, 2012; Nicaragua: Household Living Standards Survey, 2009; Uruguay: National Household Income and Expenditure Survey, 2005-2006.

Diagram 2
Expenditure trends



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

The evidence shows that current consumption patterns and their corresponding public/private matrix are not in keeping with a sustainable form of development (Ferrer-i-Carbonell and Bergh, 2004). This can be illustrated by the trend in gasoline consumption. The pattern of gasoline consumption in Latin America indicates that the amount of gasoline that is being used is on the rise for all income quintiles in most cases, despite the fact that it is a relatively homogenous good in terms of quality and price. Furthermore, an especially large share of total expenditure is accounted for by gasoline use in the top income quintile (see figure 14). Trends in this item of expenditure, divided by quintile, vary across countries, but, generally speaking, are moving upward (see figure 15). The concentration of expenditure on gasoline in middle- and high-income groups becomes even more evident when expenditure by quintile is weighted by the percentage of people who actually consume gasoline in each quintile (Antón and Hernández, 2014; Porteba, 1991). This concentration of expenditure on gasoline is in line with the concentration of private automobile ownership in middle- and high-income groups (see figure 16). In many Latin American cities, the rapid expansion of the vehicle fleet is associated with sharply rising rates of motor vehicle use (ECLAC, 2014). Although these rates are still lower in Latin American cities than they are in other regions of the world, the overall rate has already topped 250 vehicles per 1,000 persons, and it is extremely likely that it will continue to rise in the future (see figure 17 and figure 18). This ongoing shift from public to private transportation as income levels rise suggests that public transit systems are not meeting the mobility demands of the region's emerging income groups.

A meta-analysis of the rapid growth of gasoline consumption in the region yields income elasticities for gasoline demand for some countries and periods that are very close to 1 and some that are even greater than 1. These elasticities are higher in Latin America than they are in the countries of the Organization for Economic Cooperation and Development (OECD) (excluding Chile and Mexico), which means that a similar growth rate in the OECD countries and in Latin America will lead to a sharper increase in gasoline consumption in Latin America than in the OECD countries (see figures 19A and 19B).

Figure 14

Proportion of total expenditure on transport fuels represented by household expenditure on transport fuels (gasoline, diesel, biodiesel), by income quintile

(Percentages)

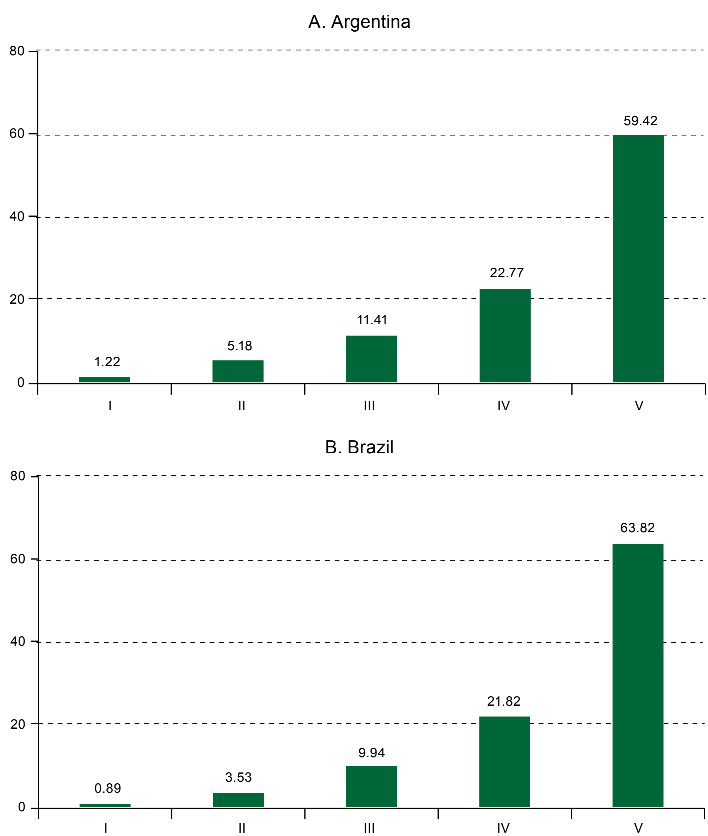
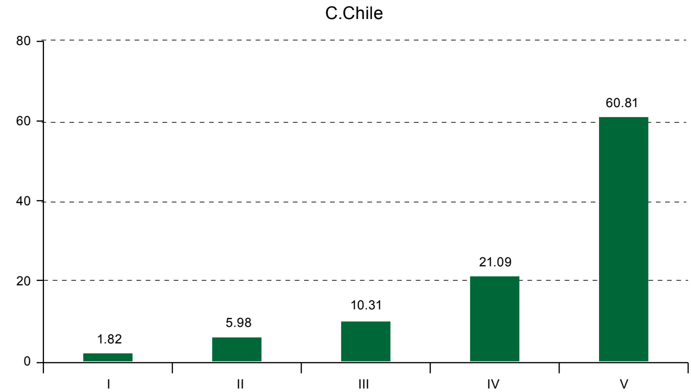
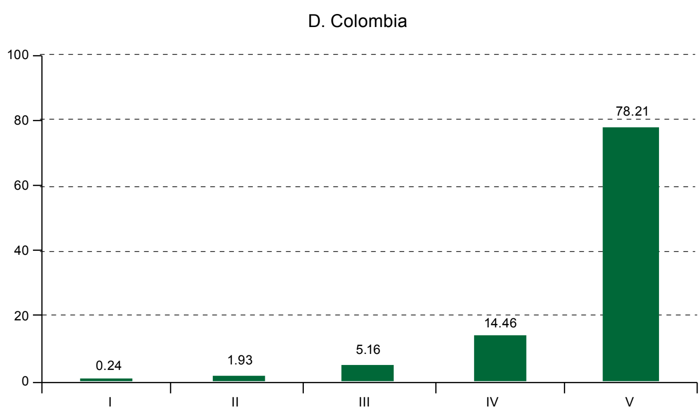


Figure 14 (continued)





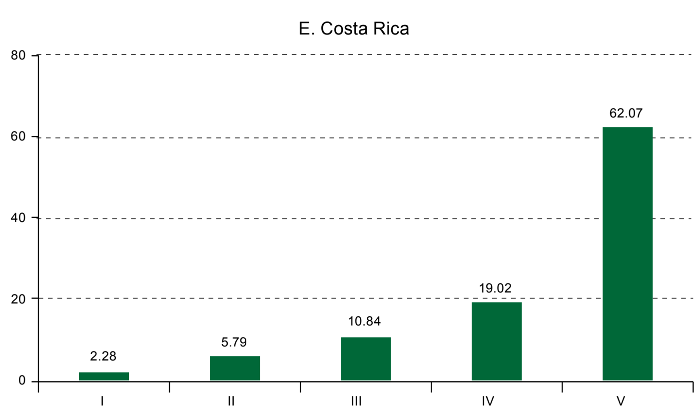
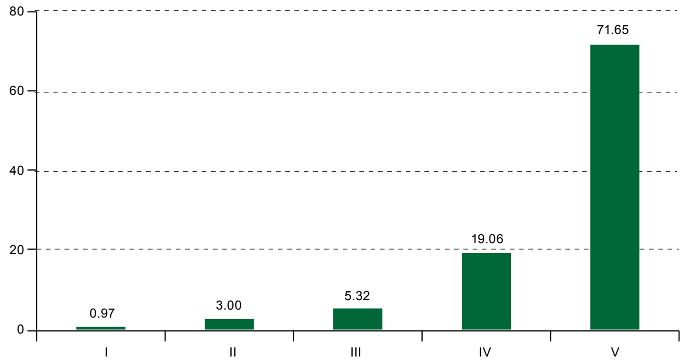
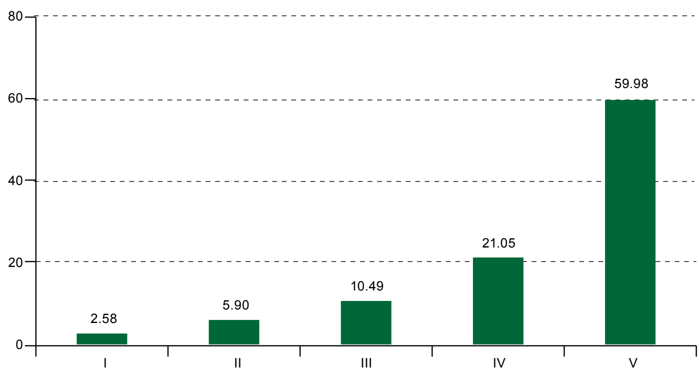


Figure 14 (continued)

F. El Salvador



G. Mexico



H. Nicaragua

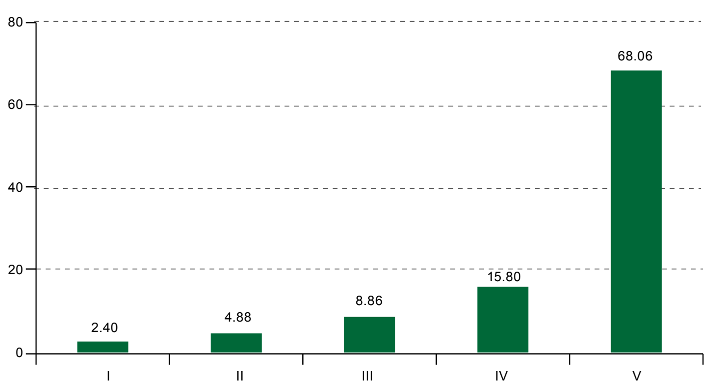
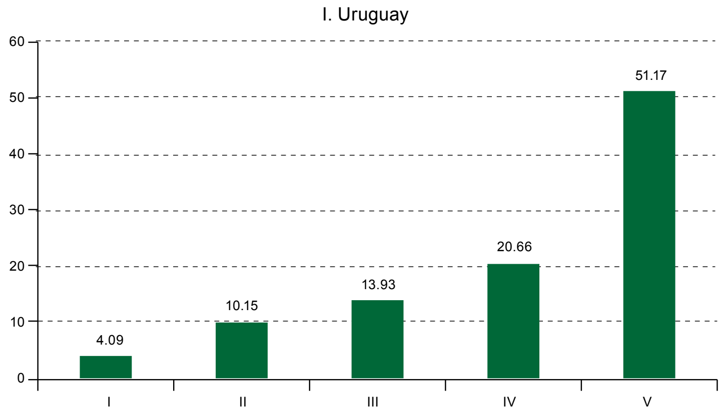


Figure 14 (concluded)

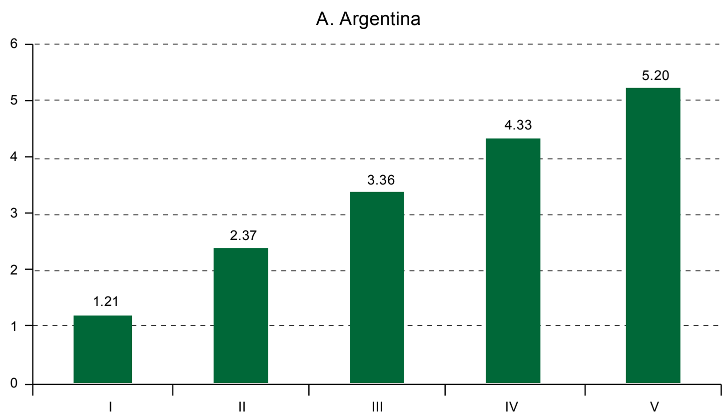


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of following surveys: Argentina: National Household Expenditure Survey, 2004-2005; Chile: Family Budget Survey, 2007; Colombia: National Income and Expenditure Survey, 2006-2007; Costa Rica: National Household Income and Expenditure Survey; El Salvador: Household Income and Expenditure Survey, 2005-2006; Mexico: National Household Income and Expenditure Survey, 2012; Nicaragua: Household Living Standards Survey, 2009; Uruguay: National Household Income and Expenditure Survey, 2005-2006.

Figure 15

Proportion of total household expenditure represented by expenditure on transport fuels (gasoline, diesel, biodiesel), by income quintile

(Percentages)



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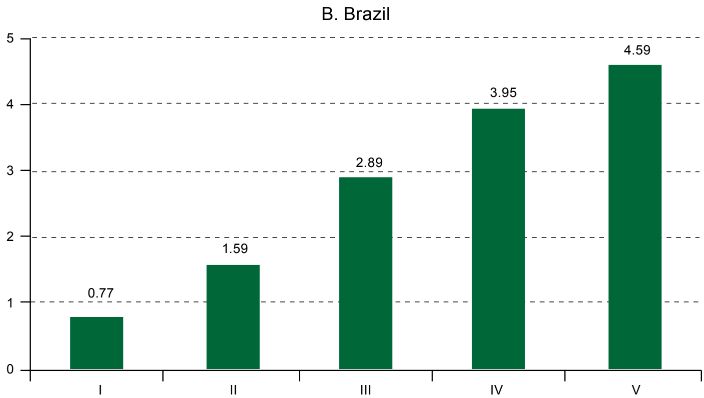
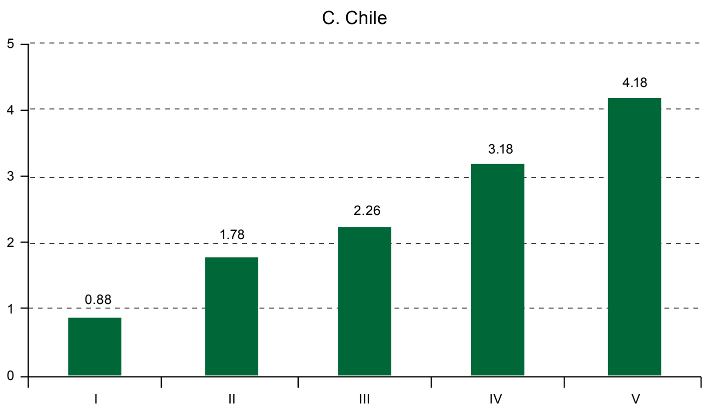




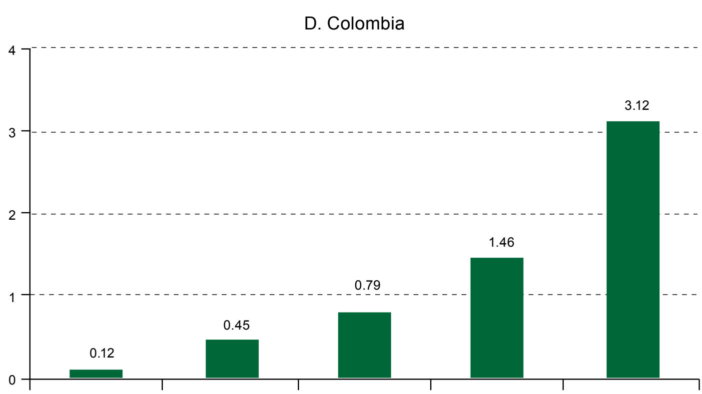
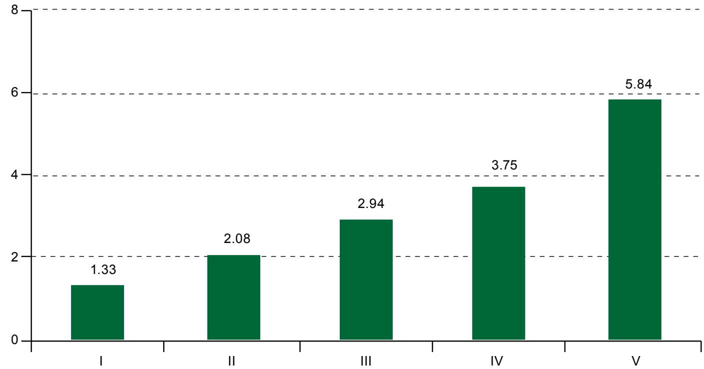
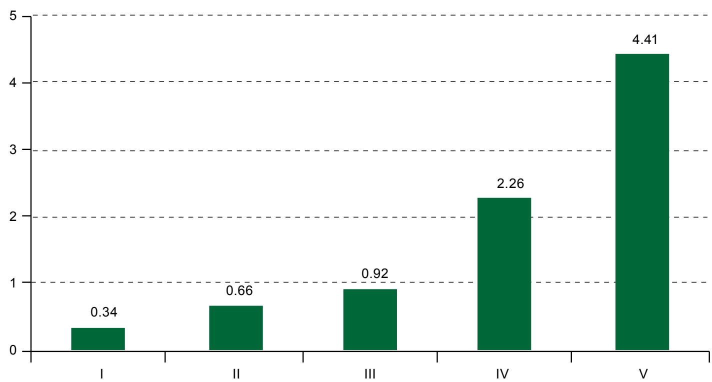


Figure 15 (continued)

E. Costa Rica



F. El Salvador



G. Mexico

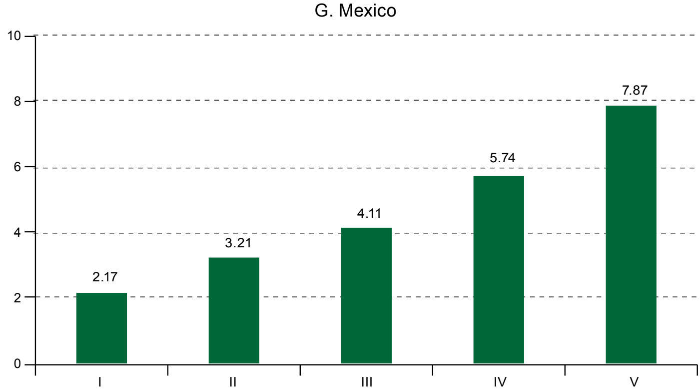
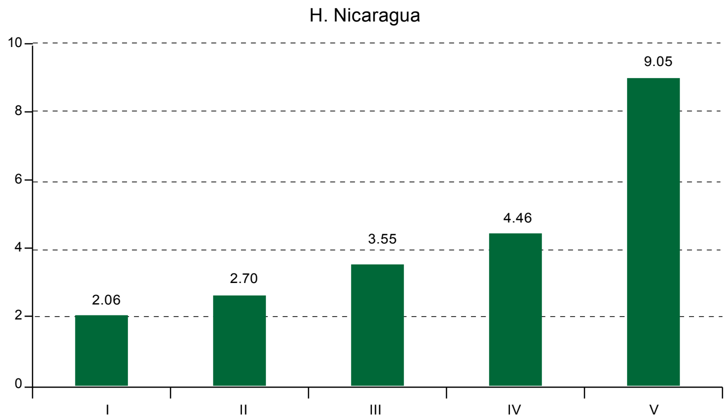
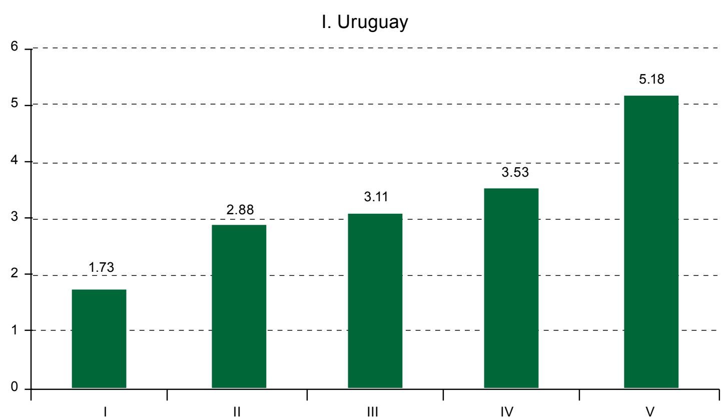


Figure 15 (concluded)





Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of following surveys: Argentina: National Household Expenditure Survey, 2004-2005; Chile: Family Budget Survey, 2007; Colombia: National Income and Expenditure Survey, 2006-2007; Costa Rica: National Household Income and Expenditure Survey; El Salvador: Household Income and Expenditure Survey, 2005-2006; Mexico: National Household Income and Expenditure Survey, 2012; Nicaragua: Household Living Standards Survey, 2009; Uruguay: National Household Income and Expenditure Survey, 2005-2006.

Figure 16

Automobile ownership, by income quintile

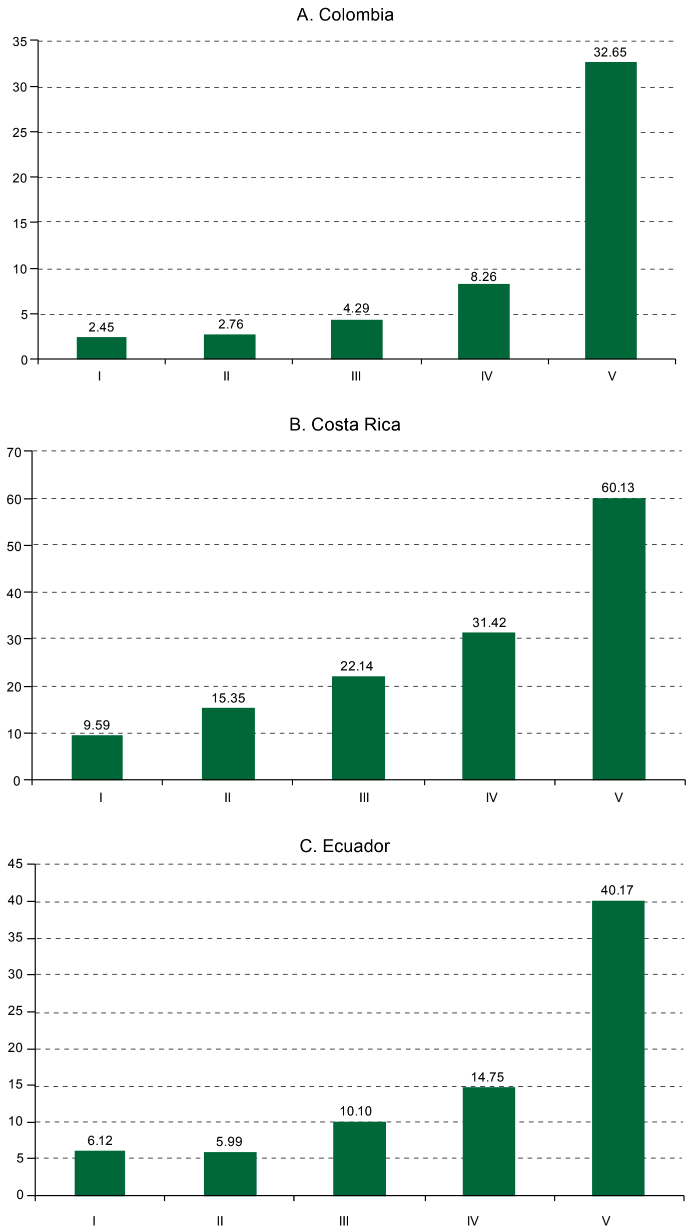
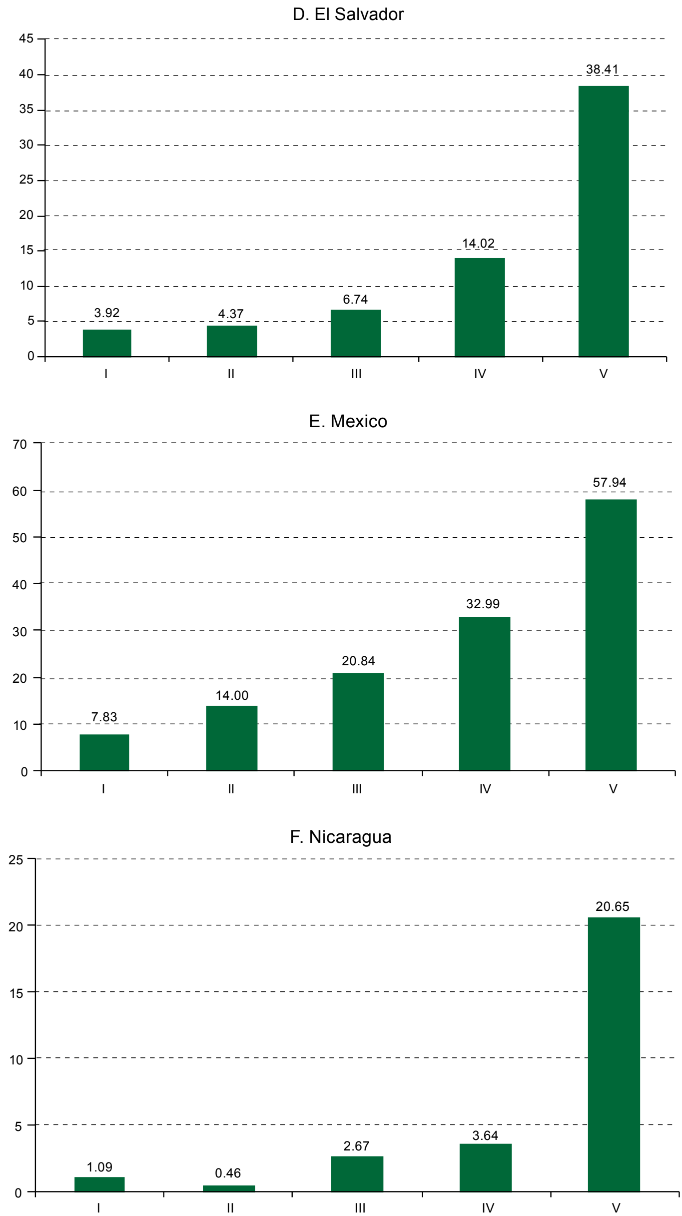


Figure 16 (concluded)

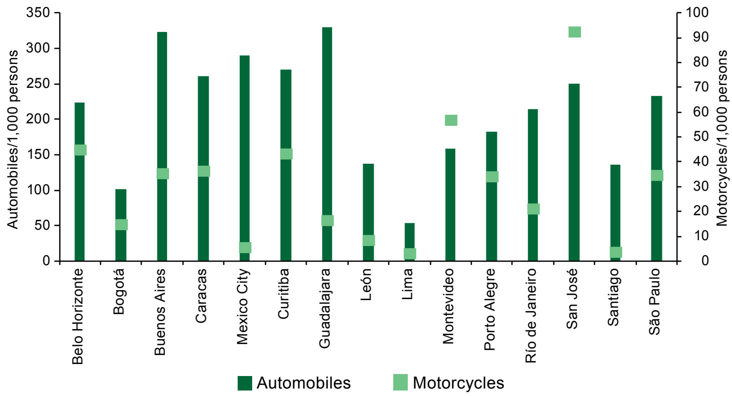


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Centre for Distributive, Labour and Social Studies (CEDLAS) and the World Bank

Figure 17

Rate of motor vehicle use in selected Latin American cities, 2007

(Automobiles and motorcycles per 1,000 persons)

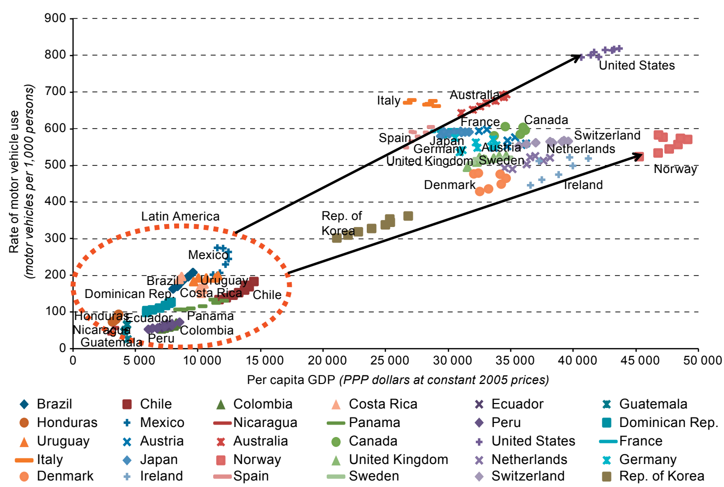


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Andean Development Corporation (CAF), Urban Mobility Observatory database, 2009.

Figure 18

Relationship between the rate of motor vehicle use and per capita GDP in developed countries and Latin America, 2003-2010

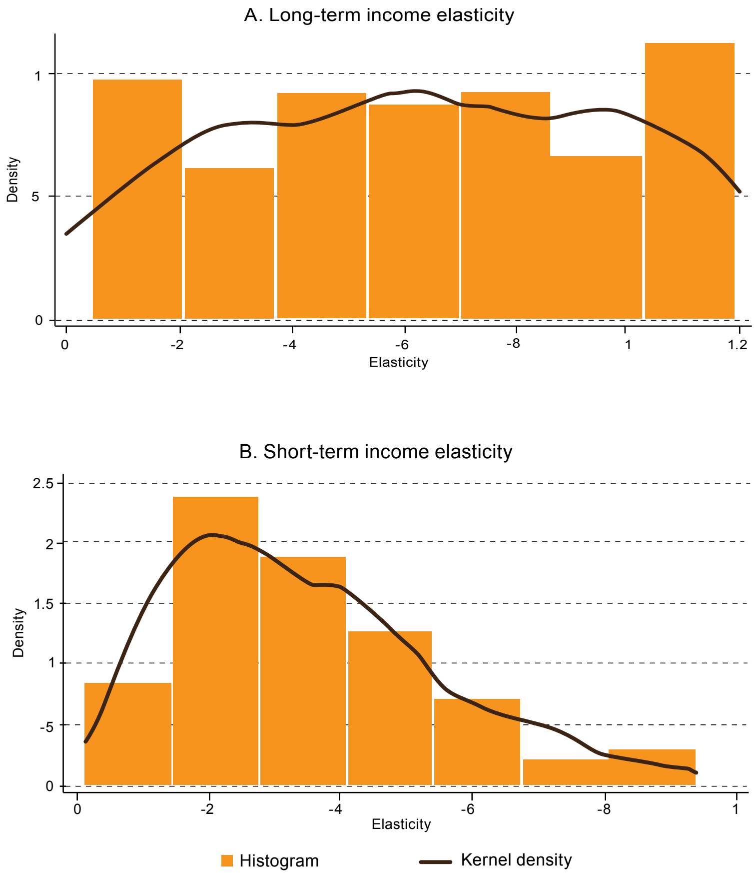
(Motor vehicles per 1,000 persons and PPP dollars at constant 2005 prices)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the bais of World Bank, World Development Indicators.

Note: The upper line corresponds to such countries as the United States, Australia, Spain and Italy. The lower line corresponds to Norway, the Netherlands and Denmark. These two solid lines do not denote projections but rather possible trends that will depend on the types of growth styles adopted by the region.

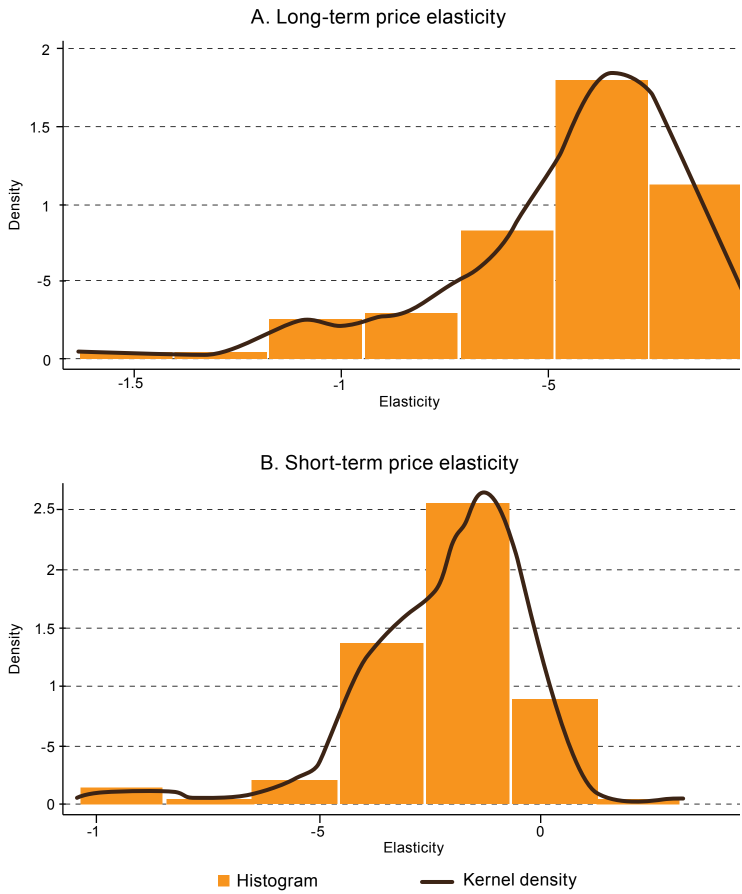
Figure 19A
Distribution of estimates of the income elasticity of gasoline demand



Source: Economic Commission for Latin America and the Caribbean (ECLAC) based on a review of the statistical data reported in international studies.
Note: The histograms show the distribution of 227 estimates of the income elasticity of gasoline demand reported in the international literature.

Figure 19B

Distribution of estimates of the price elasticity of gasoline demand



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of a review of statistical data reported in international studies.

Note: The histograms show the distribution of 343 estimates of the price elasticity of gasoline demand reported in the international literature.

In addition, the meta-analysis also shows that the price elasticities of gasoline demand are lower in Latin America than they are in the OECD countries, which reflects the scarcity of suitable substitutes for private means of transportation. Differing patterns in different income and socioeconomic groups also reflect this gradual shift from public to private modes of transportation. For example, the income elasticities of gasoline demand are normally higher in lower-income groups than in middle- and higher-income groups, which reflects this gradual move away from public transit and towards private means of transportation. Price elasticities are lower in higher-income groups, which reflects a relative aversion to the use of public transportation and a "lock-in" effect once a vehicle has been acquired (Galindo and others, 2014c). This indicates that price mechanisms alone will not be enough to reduce gasoline consumption in the region, especially during times of rapid economic growth. Thus, market mechanisms will therefore have to be coupled with regulatory instruments to bolster these economic incentives (see table 5).

Table 5

Meta-analysis: income and price elasticity of gasoline demand, by region

	OECD countries	Latin America
	Income elasticity	
Long-term elasticity	0.55	0.69
Short-term elasticity	0.24	0.26
	Price elasticity	
Long-term elasticity	-0.41	-0.31
Short-term elasticity	-0.22	-0.17

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

Note: The estimate of elasticity, weighted by the standard deviation, was calculated using the random effects model. In all cases, the *Q* test rejected the null hypothesis of homogeneity of the estimates. By the same token, for the long- and short-term income and price elasticities, the I^2 statistic indicates that the proportion of the variation observed in the size of the effects that is attributable to the heterogeneity of the studies is greater than 85%. "OECD countries" refers to the member countries of the Organization for Economic Cooperation and Development (except Mexico and Chile). These results correct for potential biases in the individual estimates.

This analysis provides evidence of a development pattern that favours private transportation over public transportation and in which private automobiles are the mode of transportation of choice for the middle and upper classes and, increasingly, for lower-income strata. This pattern exhibits a public service matrix that provides incentives for unsustainable consumption patterns, in which middle- and high-income groups prefer private modes of transportation and low-income groups have to face the risks and costs associated with the lack of modern, safe, high-quality public transit systems. As a result, a gradual shift from public to private modes of transportation is seen as people's incomes rise.

This phenomenon will be difficult to alter in the short run given its strong inertial component. Existing infrastructure and technologies normally remain in use in the region for between 30 and 50 years, which means that the carbon-intensive road networks and transport infrastructure which are built in the next few years will still be in use in 2050. In addition, continuing to develop this type of transportation system will, in terms of climate change, favour a lock-in to carbon concentrations of at least 450 ppm (IEA, 2013). The political economy of the current income distribution also makes it difficult to do away with fossil fuel subsidies. The shift from public to private transportation is also mirrored in the patterns associated with other public goods, such as the shift from the use of public health and education services to private services.

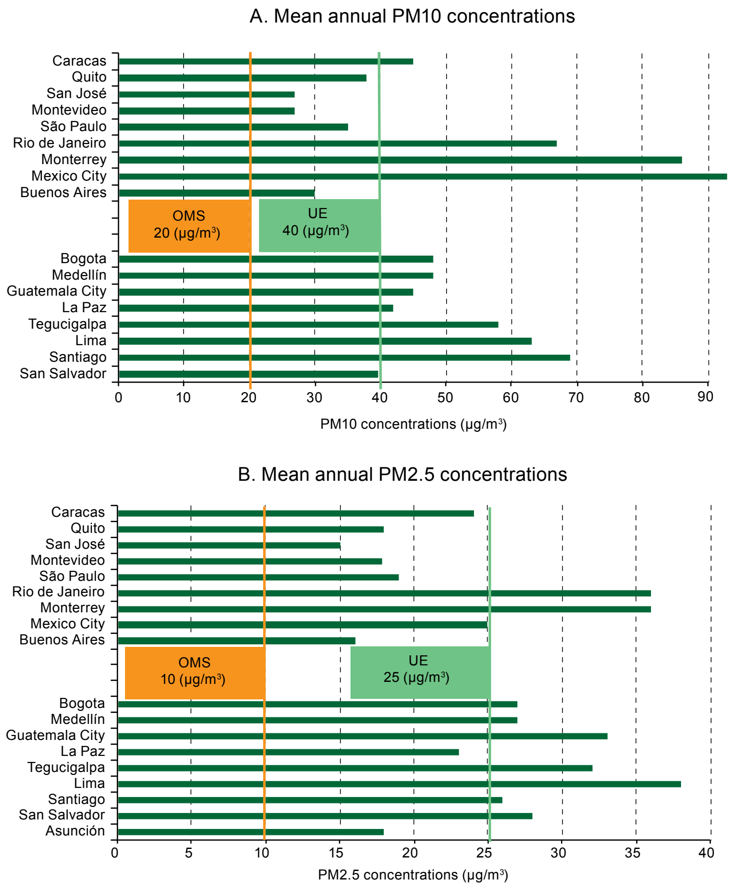
The increasing reliance on private modes of transportation in Latin America's urban areas, along with the increasing consumption of gasoline that is its corollary, is giving shape to a complex network of negative externalities, such as the costs associated with traffic accidents, congestion, extended travel times and reduced worker productivity, and the construction of types of infrastructure that will tend to drive up CO_2 emissions and increase air pollution (see figure 20), which will also have significant health impacts on the population. For example, there is a clear-cut relationship between ozone and PM10 pollution and respiratory ailments such as asthma, bronchitis and others that can push up respiratory mortality and morbidity rates, especially among children and persons over 65 years of age (Cifuentes and others, 2005; Bell and others, 2006; Antón and Hernández, 2014; Newberry, 2005; Moolgavkar, 2000; Ballester and others, 2002; Borja-Aburto and others, 1998; Rosales-Castillo and others, 2001).

There is also evidence that the greenhouse gas emissions that are driving climate change exacerbate the damage that air pollution does to people's health. This is because the higher local surface temperatures in polluted areas trigger chemical reactions and emissions feedback loops that will cause peak levels of ozone and PM2.5 particles to rise

(IPCC, 2013). This interaction between urban development, economic productivity, local air pollution, health and climate change is particularly worrisome in Latin America in view of the high levels of air pollution in the region's cities, which in many cases exceed the recommended limits (see figure 20).

Figure 20

PM10 and PM2.5 concentrations in selected Latin American cities, 2011



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Health Organization (WHO), Ambient Air Pollution Database, May 2014.

Note: The data on these concentrations for La Paz, Medellín and Rio de Janeiro are for 2010; those given for San Salvador, Santiago, Lima, Mexico City, Monterrey, San José and Caracas refer to 2011; those shown for Guatemala City, Bogota, Buenos Aires, Sao Paulo, Montevideo and Quito are for 2012; and the figures for Tegucigalpa correspond to 2013.

These interlinked externalities and the potential co-benefits of a more sustainable approach highlight the importance of combining an urban development strategy with public policy measures to reduce not only overall emissions of greenhouse gases, but also of these and other pollutants at the local level that are harmful to the health of the population.

The case of rapid, affordable, safe and clean public urban transportation illustrates how meeting the climate change challenge necessarily entails building a more egalitarian, inclusive society based on a public/private matrix that will meet the needs of emerging income groups within a growing population and improve the quality of urban living for all groups. This type of development style will be better able to withstand climate shocks and will pave the way for the implementation of mitigation processes. In summary, there are close links between climate change adaptation and mitigation processes that can be taken advantage of within a sustainable development environment: "Social equality, environmental sustainability and economic growth with innovation do not have to be mutually exclusive. The great challenge is to identify synergies among them." (ECLAC, 2014).

In order for the region to issue a suitable climate risk reduction response, it will need to identify synergies that will enable it to implement adaptation and mitigation processes within a sustainable development context on the basis of a global climate change agreement that acknowledges the existence of common but differentiated responsibilities and differing capacities.

VI. Conclusions

Climate change generated by anthropogenic greenhouse gas emissions is already discernible in a rise in average global temperatures, alterations in precipitation patterns, rising sea levels, the shrinking cryosphere and extreme weather events (IPCC, 2013). There is, for example, evidence that the mean global temperature rose by 0.85°C between 1880 and 2012, and the average is projected to climb by between 1°C and 3.7°C during this century, and by between 1°C and 2°C by 2050. Not enough progress has been made in mitigating greenhouse gas emissions in order to stabilize the climate and keep temperature increases under 2°C, which will require a reduction of greenhouse gas emissions from approximately 7 tons to 2 tons per capita by 2050 and to 1 ton per capita by 2100. And this task must be undertaken against the backdrop of a continuing close correlation between per capita emissions, per capita energy consumption and per capita income in all of today's modern economies.

Climate change has enormous implications for economic activities, social conditions and ecosystems. The types of effects and the diverse channels through which they are being transmitted through the economy, society and nature are, in all likelihood, going to multiply and intensify in the years to come. The multi-faceted challenge of adapting to new climate conditions and implementing mitigation measures and, at the same time, recognizing the existence of common but differentiated responsibilities and differing capacities is clearly a formidable one that will shape the development process of the twenty-first century.

The Latin American and Caribbean region is facing an asymmetrical dual challenge, since its contribution to total greenhouse gas emissions is limited yet it is highly vulnerable to the effects of climate change. For example, agricultural activities are particularly sensitive to weather conditions and, thus, to climate change. The agricultural sector makes a major contribution to the region's GDP and to employment, has an impact on social conditions, and influences trends in national food security and poverty, especially among the rural population. The available evidence indicates that climate change will occasion an aggregate net loss for agricultural activities in the region, which may also slow progress towards poverty-reduction goals.

Given the existing difficulties that will have to be overcome in order to achieve climate-related goals, it is imperative for Latin America and the Caribbean to implement a variety of adaptive strategies in order to significantly reduce the costs of climate change. There is a great deal of information regarding adaptation processes and a wide range of options proposed for reducing climate-related impacts. There will, nonetheless, be inevitable —and, in many cases, irreversible— residual costs, and formidable barriers to the implementation of adaptation processes; in addition, some of those adaptation processes will no doubt turn out to be inefficient and may generate additional costs in the future.

Meeting the challenge posed by climate change will call for major structural modifications in the current development style. The transport sector is a telling example of the kinds of changes that will have to be made. At present, gasoline consumption and the vehicle fleet are growing rapidly in Latin America. These trends generate higher greenhouse gas emissions, increasing costs in terms of traffic congestion, time lost, road accidents and air pollution, along with their impacts on the health and productivity of the population. The close association among the demand for gasoline and income trends, the low price elasticity of gasoline demand and the high concentration of expenditure on gasoline and private motor vehicle ownership in the middle- and higher-income quintiles is a sign of the segmentation of modes of passenger transport. In the absence of modern, safe, high-quality mass transit systems, there is an increasing demand for private modes of transportation, especially in the upper- and middle-income quintiles and, increasingly, even in lower-income groups.

The region's development style displays a degree of inertia that is eroding the very factors that serve as its foundation, and the global negative externalities generated by climate change are heightening these problems and deepening these paradoxes (Stern, 2007, 2008). The production structure, specific types of infrastructure, the predominant low-innovation technological paradigm, the political economy of economic incentives and subsidies, and the public/private matrix of goods consumption are both fostering and consolidating an environmentally unsustainable and inequitable development path (ECLAC, 2014).

In order to turn these trends around, thorough-going changes will have to be made in the development paradigm. And in order to adapt to new climate conditions and implement the mitigation processes that will be necessary in order to meet climate-related goals, a global climate agreement will have to be reached that plots out the directions to be taken in order to move towards a sustainable development path. Sustainable development entails greater equality, more social cohesion and a public/private matrix that is in keeping with that new paradigm. All these factors will reduce the level of vulnerability to adverse impacts and will make the costs of mitigation less onerous and more affordable. Thus, the climate change challenge and the sustainable development challenge are one and the same.

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