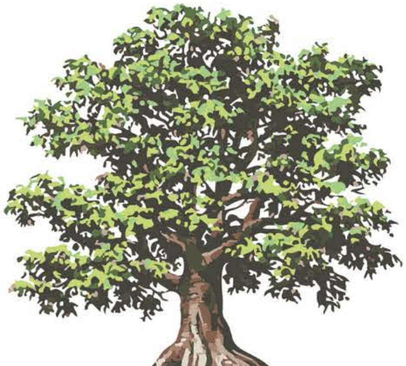
CLIMATE CHANGE IN CENTRAL AMERICA

POTENTIAL IMPACTS AND PUBLIC POLICY OPTIONS



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Climate Change in Central America:
Potential Impacts and Public Policy Options

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This publication was based on analysis between 2008 and 2015 within the framework of "The Economics of Climate Change in Central America Initiative", coordinated between the Ministries of Environment, Treasury or Finance, their Ministerial Councils and Executive Secretariats of the Central American Commission for Environment and Development (CCAD) and the Council of Ministers of Finance/Treasury of Central America and Dominic Republic (COSEFIN), and the Secretariat for Central American Economic Integration (SIECA), as bodies of the Central American Integration System (SICA) and the ECLAC Subregional Headquarters in Mexico; with financial support from UKAID/DFID and DANIDA. The agricultural series was coordinated with the Ministries of Agriculture of SICA, their Ministerial Council (CAC), its Executive Secretariat and Technical Group on Climate Change and Integrated Risk Management (GTCCGIR). The publication on health was prepared with the Ministries of Health, their Ministerial Council (COMISCA), its Executive Secretariat and its Committee of the Technical Commission on Surveillance in Health and Information System (COTEVISI). In addition, it includes analyses prepared by the Climate Change Unit DDSAH ECLAC, and SIECA.

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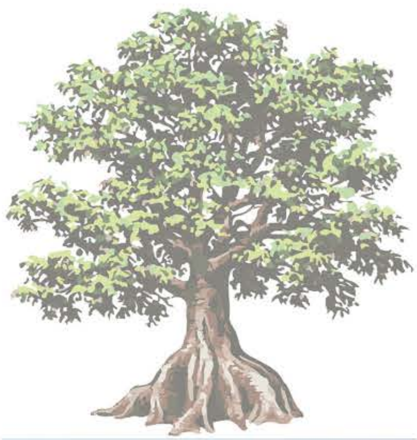

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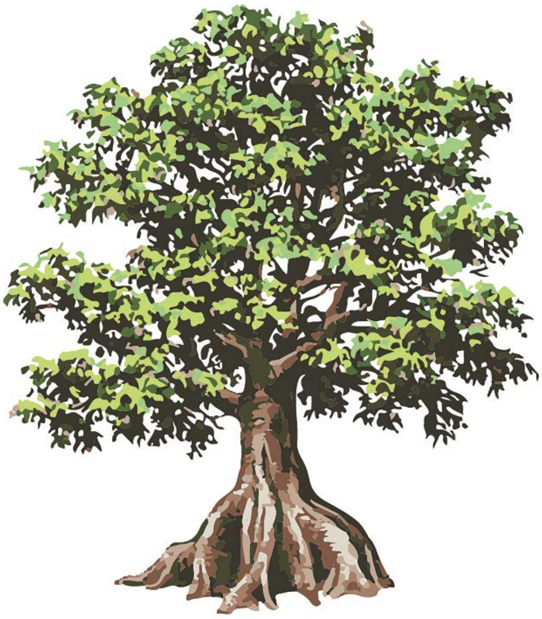
Our Grateful Thanks

To the rivers that crisscross Central America,
from the smallest springs to the
longest and mightiest rivers

To the trees that raise their branches and leaves
to the sky and bury their roots deep in the soil

We give thanks for the home you have given us
and for your teachings. We hope to have
sufficient wisdom to understand



«And the Great Mother Ceiba rose up
[Yaax Imix Che, “Green Ceiba”],
in the midst of the memory
of the destruction of Earth.
She settled herself and raised her treetop
asking for eternal leaves»

From the Chilam Balam of Chumayel

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FOREWORD

Since 2008 we have supported the collaborative initiative "Economics of Climate Change in Central America" aimed at demonstrating the impacts of climate variability and change and fostering a discussion on public policies in key sectors. The initiative has been led by the Ministries of Environment and Treasury or Finance of Central America, with the support of their ministerial councils, CCAD, COSEFIN, and Economic Integration Secretariat, SIECA. The Ministries of Agriculture and of Health, with their councils, CAC and COMISCA, have also joined the effort; and the Dominican Republic came on board in 2015.

These policy discussions have generated a proposal to give priority to adaptation that explicitly favours sustainability and inclusion and integrated with programmes to reduce poverty and vulnerability. Within this framework, it is proposed to support a transition to environmentally sustainable economies that are low in greenhouse gas (GHG) emissions. Climate change should be seen as a warning to pay greater attention to common public and intergenerational goods and services, including the climate, but also water resources, ecosystems, food and energy security, and public transport. For this reason, the Sustainable Development Goals (SDGs) provide us with a useful framework for recognizing the right of all people to sustainable development.

During these years, we have witnessed the development of regional strategies and national policies aimed at responding to climate change. The countries of the region have also contributed to the international agenda, especially in the creation the adaptation framework, the mechanism for losses and damages associated with the effects of climate change and the Green Climate Fund, all within the framework of the UNFCCC. We have appreciated their innovative proposals, such as the approaches based on landscapes and Mitigation based on Adaptation (MbA) for Reducing Emissions from Deforestation and forest Degradation plus (REDD+), the call to give a "human face" to the challenge of climate change, the alliance to harness education, and their early measures to reduce emissions through the Clean Development Mechanism (CDM) and Nationally Appropriate Mitigation Actions (NAMA) projects, including the first such project in the world in the agricultural sector, and many other initiatives.

Now, the challenge for the region lies in implementation, in coordinating actions between sectors and involving all stakeholders in society. And at the global level, the challenge is to close the gap of required emissions reductions and ensure the international support needed for the successful implementation of a response focused on inclusive and sustainable adaptation in developing countries, especially in those that are particularly vulnerable, such as Central America. We face a shortening window of opportunity, both regionally and globally. As this challenge requires a redoubling of efforts, we reaffirm our commitment to continue working with our Central America partners.

Hugo Eduardo Beteta
Director, ECLAC Subregional Headquarters in Mexico

KEY MESSAGES

Central America is one of the regions of the world most exposed to climate phenomenon, and its societies and ecosystems are particularly vulnerable to the adverse effects of climate change. They exhibit several of the characteristics of vulnerability identified in the United Nations Framework Convention on Climate Change. As an isthmus bridging two continents and found between the Pacific and Atlantic oceans, it has long coastlines with lowland areas. The region is repeatedly affected by drought, intense rains, cyclones and the El Niño Southern Oscillation (ENSO). Central America is home to forests and ecosystems with high levels of biodiversity, including in mountainous regions. These ecosystems face not only degradation and deforestation, but also the effects of temperature increases and hydro-meteorological extremes.

In its Fifth Report, the IPCC reported a wide range of climatic effects on Central America, including changes in temperature and sea level, coral bleaching, delays in the start of the rainy season and greater irregularity in, and intensity of, rainfall. In its regional chapter, the Report also considered scenarios involving changes in hydrological conditions, temperature increases, food production and security, hydroelectricity and health (Magrin and others, 2014). In its previous report on extreme events, the IPCC had reported that there was medium confidence that anthropogenic influences had contributed to the intensification of extreme precipitation at the global scale, and to drought in some regions, including Central America, due to decreases in rainfall and/or increases in evapotranspiration (IPCC, 2011).

The global climate risk index created by the organization German Watch reports Honduras as the country in the world most affected by climate risk between 1994-2013; Nicaragua is the fourth; Dominica Republic is the eighth; Guatemala is the ninth; El Salvador is the twelfth; Belize, the twenty-first, Costa Rica, the sixtieth; and Panama, the ninetieth. Considering the 2004-2013 period, that the countries of the region often find themselves in the top ten places in the index: the Dominican Republic was second in 2004; Guatemala, first and Honduras, seventh in 2005; Nicaragua, third in 2007; Belize, ninth in 2008; El Salvador, first in 2009; Guatemala, second and Honduras, fifth in 2010; El Salvador, fourth and Guatemala ninth in 2011 (Harmeling, 2012; Kreft and others, 2015).

DARA's Climate Vulnerability Monitor (2012) has five levels of vulnerability: acute (most vulnerable), severe, high, moderate and low (least vulnerable). Levels of vulnerability for Central American countries for 2010 were: moderate for Costa Rica, Guatemala, Nicaragua and Panama; high for the Dominican Republic; severe for El Salvador and Honduras; and acute for Belize. The Monitor predicts an increase in vulnerability toward 2030, reaching the following levels: high for Costa Rica, Guatemala and Nicaragua; severe for Panama; and acute for Belize, El Salvador, Honduras and the Dominican Republic.

However, the region is not only characterized by this vulnerability; it also has valuable natural and cultural assets that need to be preserved and valued for their contribution to the development of current and future generations. The ecosystems of Central America are home to approximately 7% of the world's biodiversity (INBio, 2004) and are part of the "megadiverse hotspot" of Mesoamerica (Ramírez, 2003). These ecosystems contain the wild variants of important crops and provide multiple environmental services, including pollination, pest control and regulation of humidity, the water cycle and local climate. However, they are deteriorating due to unsustainable development. The population of the region is relatively young and boasts great diversity in terms of culture, ethnicity and lifestyles. It is a valuable asset that can contribute to the response to climate change. Nevertheless, it requires greater recognition and investment in order to do so, as it is extremely vulnerable to the effects of climate change.

Climate change is exacerbating socioeconomic vulnerabilities in Central America and will increasingly affect its economic progress, given that factors that depend on the climate are very important to a broad range of production activities, such as agriculture and generation of hydroelectric power. At the same time, it is estimated that Central America produces only a minimal portion of global greenhouse gas (GHG) emissions: less than 0.3% of emissions without land-use change, and less than 0.8% of net total emissions (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

Climate change could be considered a phenomenon that will only have an effect in the distant future. The pressure of existing social and economic issues as well as public budget constraints could be wielded as arguments for postponing the implementation of much-needed measures. However, the growing impacts of extreme events, such as Tropical Depression 12-E in 2011 and the intensified cycle of drought in recent years, demonstrate that the vicious cycle of the cumulative effect of losses and damages and of reconstruction measures that reproduce vulnerabilities to climate events, needs to be broken. Significant measures are required to ensure that post-disaster reconstruction and public investment be undertaken very differently than in the past. There need to be incentives and requirements related to vulnerability reduction and adaption to both the current climate variability and changes forecast for the future.

Various initiatives are being made to analyze and demonstrate the significant increases in temperature, tropical storms, hurricanes, floods and drought in the region. They include the regional Climate Forum, its related Forum for Food and Nutritional Security Applications, the International Disaster Database (EMDAT), The Famine Early Warning Systems Network (FEWSNET) and the Economics of Climate Change in Central America Initiative (ECC CA, and now called ECC CARD due to the entry of the Dominican Republic). The region has already produced various estimates of the potential impacts of climate change on sectors such as water resources, agriculture, biodiversity, forests and hydroelectricity. The initial economic valuation carried out by the ECC CA initiative shows that the impacts and costs of climate change, in a scenario of growing emissions and global inaction (such as scenario A2), would be significant and grow over time. The impacts and costs would be higher than in a scenario in which the rate of emissions growth were reduce (such as scenario B2) or in which emissions would be stabilized and reduced significantly, the aspiration for the international negotiations. Therefore, the cost of inaction in the face of extreme events combined with the present day costing of the future impacts of climate change will be too high if immediate, ambitious measures are not taken to reduce emissions, especially by the countries that have been the largest emitters and, therefore, responsible for the accumulation of emissions in the atmosphere. (ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA, 2012d; ECLAC, UKAID and CCAD/SICA, 2010).

Since climate change is a market failure, it cannot be treated as the exclusive responsibility of environmental institutions. Rather, it should be seen as a central and transversal economic problem that has serious fiscal implications. In financial terms, climate change is a contingent public liability that will increasingly affect public finances, which are already facing greater pressure in the region due to the impact of a growing number of extreme weather events such as droughts, hurricanes, intense rains and floods. Therefore, proactively addressing the challenge of extreme events, climate variability and climate change is of utmost importance. If it is not addressed, the current generation will suffer greater losses and damages due to extreme events, and future generations will bear a very high cost of a difficult adaptation to climate change and will have a late and chaotic transition to more sustainable, low-GHG emission economies.

Given the circumstances and priorities of the region, it is proposed to give priority to measures and policies that contribute to and provide incentives for adaptation strategies that are explicitly designed to improve inclusion and sustainability and that are integrated with actions to reduce poverty and vulnerability to extreme events and climate change. This priority framework should guide the transition toward economies and societies that are environmentally sustainable and low in GHG emissions. In addition, these policies should be an integral part of plans for national development and poverty reduction.

Climate change presents a series of multisectoral challenges that need to be tackled with sectoral specific measures and with intersectoral coordination which facilitates the contributions of diverse stakeholders, including the public and private sectors, citizens and civil society organizations, academia, integration institutions and the international community.

Structural changes in the global economy and the risks of climate change could be used as opportunities to carry out an in-depth review of the productive specialization of these economies, including their form of insertion in global markets, intraregional production and trade value chains, the growing dependence on hydrocarbon consumption for energy—with the associated costs of importation, pollution, and harm to public health—and the degradation of forests and other ecosystems that provide a multitude of products and services.

In terms of public policy, these challenges will require society-level pacts regarding agreements on the investments and incentives needed for structural changes in production and consumption that reduce climate risk and promote the transition to environmentally sustainable economies; fiscal policies that create a better equilibrium between private and public goods and services in the constellation of measures aimed at the well-being of the population; a more robust management of natural resources and environmental protection that creates incentives for a more diversified and "green" production matrix, and finally; a social and labour agreement which strengthens the redistributive capacity of the State and creates a more inclusive labour institutions (ECLAC, 2010).

This effort requires a series of measures ranging for changes in infrastructure standards, protection of river basins and natural coastal barriers (e.g. mangroves), improved water management, and changes in the design and location of homes, communities and social infrastructure. At the same time, there needs to be a strategic vision and coordination to maximize the benefits and minimize the costs of measures with cross-sectoral implications and of adaptation vis-a-vis mitigation measures, and by integrating them in the national and regional development agenda. Ultimately, this implies special attention to inclusion and sustainability in its many forms, and greater attention to shared public and intergenerational goods and services, such as the climate, water resources, ecosystems, food and energy security, and public transport.

The progress in reaching an international consensus on the necessity of transitioning to a path of sustainable development is another significant opportunity in an adequate response to climate change. Following a decades-long effort, with milestones such as the 1992 Earth Summit and the Río+20 Conference on Sustainable Development in 2012, the Sustainable Development Goals (SDGs) were established. The SDGs should guide the development efforts of the international community for the next 15 years. The SDGs include the goal of "taking urgent action to fight climate change and its impacts" and achieving many of its other goals will depend on a rapid, ambitious, sustainable and inclusive response to climate change.

Given that almost half of the population of Central America lives in conditions of poverty, it is crucial to link the responses to climate change to poverty reduction programs, and to improve the quality of life and opportunities for this population. As the economist Nicholas Stern has stated, the two unresolved problems that will define this century are climate change and poverty. They are intimately linked: if one is not resolved, the other will not be resolved either. It is worth mentioning that the United Nations Framework Convention on Climate Change (UNFCCC) often acknowledges the relationship between the response to climate change, sustainable development and the eradication of poverty.

In international negotiations, the governments of the Central American Integration System have prioritized adaptation and the reduction of vulnerability, considering the conditions in their region. They have participated actively in the creation of the United Nations Framework Convention on Climate Change (UNFCCC) institutional structures for adaptation and losses and damages, as well as the Green Climate Fund, for which they have insisted on equal treatment of adaptation with regard to mitigation. They have proposed and supported innovative and integrative proposals, such as the landscape and adaptation-based mitigation approaches for REDD+, the call to give a "human face" to the challenge of climate change, and the alliance to harness education in the response to this threat.

The governments have also insisted on the need to achieve a reduction in global GHG emissions that will limit the global temperature rise to 1.5°C relative to the preindustrial era. They have offered to contribute to GHG emission reduction in the framework of common but differentiated responsibilities and national conditions and capacities, and predictable and favourable international support, encompassing methods of implementation, financing, technology development and transfer and capacity building. However, it must be mentioned that the countries of the region have already contributed with early emission-reduction measures, in some cases through CDM and NAMAS projects, including the first NAMA in the world for the agricultural sector. In recent years, Central America has made significant efforts to develop regional strategies and national policies that integrate climate change. Now, the challenge for the region lies in implementation, coordinating actions between sectors and involving all stakeholders in society. And at the global level, the challenge is to close the required gap of emissions reductions, and ensure the international support needed for the successful implementation of a response that focuses on inclusive and sustainable adaptation in developing countries, especially in vulnerable ones, such as those in Central America.

INTRODUCTION

This publication presents a summary of the analyses and discussions of public policy options carried out within the framework of the Economics of Climate Change in Central America (ECC CA) initiative since 2008. During this time, these discussions have evolved toward a consensus that priority needs to be given to adaptation explicitly oriented towards greater sustainability and inclusion. Within this priority framework, the transition to environmentally sustainable economies that are low in greenhouse gas (GHG) emissions and other contaminants can be properly situated.

The initiative EEC CA was coordinated between the Ministries of Environment, Treasury or Finance, their Ministerial Councils and Executive Secretariats of the Central American Commission for Environment and Development (CCAD) and The Council of Ministers of Finance/Treasury of Central America and Dominic Republic (COSEFIN), and the Secretariat for Central American Economic Integration (SIECA), as bodies of the Central American Integration System (SICA); with the technical coordination of ECLAC. These institutions created a Regional Technical Committee (RTC) for the joint technical management of this initiative.

In 2012, a technical work programme was established between ECLAC and the Central American Agricultural Council (CAC) of the Ministries of Agriculture of the SICA countries, which has been executed with its Executive Secretary and its Technical Group on Climate Change and Comprehensive Risk Management (GTCCGIR). Also, in 2012, the Council of Ministers of Health of Central America (COMISCA) established a ministerial mandate regarding health and climate change, which led to the design and implementation of a project with the Council's Executive Secretariat and its Technical Group of Directors of Epidemiology and Technical Commission on Health Monitoring and Information Systems (COTEVISI).

In the first two chapters, this publication presents the proposal for sustainable and inclusive adaptation, as well as ample evidence of the vulnerability of the region to extreme events and climate change. The third chapter provides estimates of potential impacts and policy options broken down by key sector, with special attention to the analysis of basic grains, coffee and food security, that were not included in previously published summaries. Newly broadened proposals on fiscal and trade policies, developed with the Executive Secretariat of COSEFIN and SIECA respectively, are also provided. The document also includes a foreword, key messages and conclusions.

This initiative has had the financial support of the Assistance Programme of the Department for International Development of the British Government (UKAID-DFID) and the Danish International Development Agency (DANIDA). Currently, a third phase is being implemented, now with the participation of the Dominican Republic. This phase has been financed by the Inter-American Development Bank (IDB), the Nordic Development Fund (NDF) and ECLAC.

More than a dozen technical teams have participated in the preparation of the analyses and discussions with the technical groups that make up the management structure of the initiative, particularly the RTC of the ECC CA, the GTCCGIR of CAC, and the COTEVISI of COMISCA. For more information on the collaboration that has made this initiative possible, please see the ECC CA publications.

1. SUSTAINABLE AND INCLUSIVE ADAPTATION

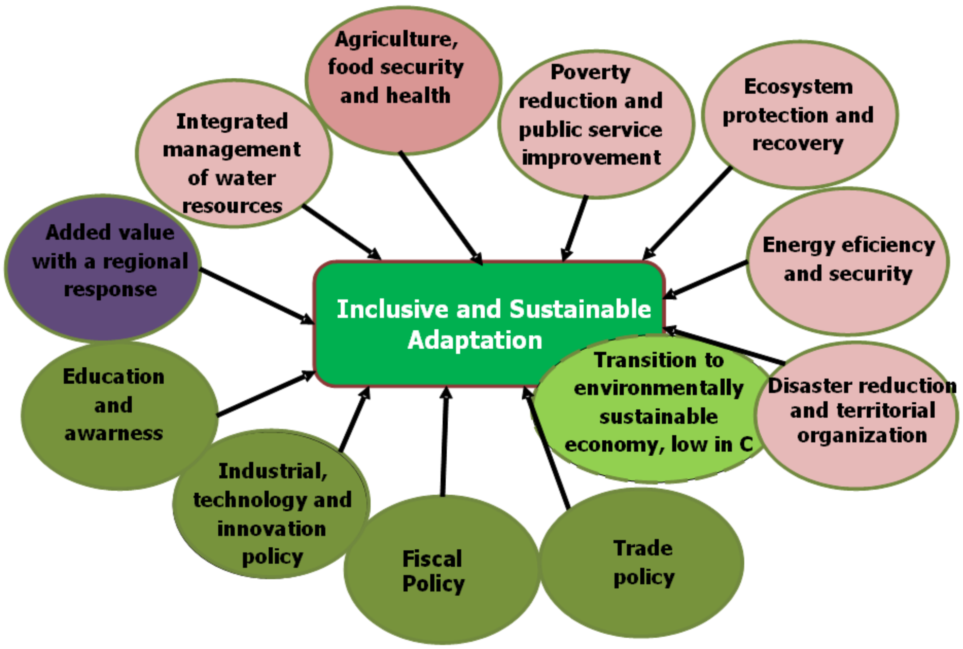
Climate change could be considered a phenomenon that will only have an effect in the distant future, and that cannot be addressed due to more urgent existing social and economic needs for the allocation of public budgets, whose existing constraints have been worsened by the current instability and transition of the global economy. However, the growing impacts of extreme events in the Central American region, such as the intense rains of Tropical Depression 12-E in 2011 and the droughts of 2010 and 2014-2015, demonstrate that urgent measures must be taken, which should not be conditioned by the discussion of their attribution to climate change.

The current reality requires that post-disaster reconstruction efforts be changed so that they contribute to risk reduction through improved infrastructure standards, more efficient water management, improved protection of forests, watersheds and natural coastal barriers such as mangroves, as well as changes in the design and location of homes, communities and infrastructure, among many other measures. Such investments should reduce currently vulnerability and the costs caused by upcoming extreme events, while improving the ability to cope with the expected impacts of climate change. For these reasons, SICA countries have prioritized the establishment of robust institutionalism for adaptation and the losses and damages associated with climate change in the international negotiations.

In this complex situation, it is recommended that national, regional and international agreements be reached in order to promote adaptation strategies that are explicitly designed to improve inclusion and sustainability and that are integrated with actions to reduce poverty and vulnerability to extreme events and climate change. Within this framework of priorities, it will be possible to transition to environmentally sustainable economies that are low in GHG emissions and other contaminants. A strategic vision is required to maximize potential co-benefits between sectors and, at the same time, minimized any costs for a given sector resulting from measures in other sectors. This same integrative approach needs to be applied so as to ensure co-benefits between actions focused on adaptation or on mitigation and so that the climate change response is part of national development agendas and the implementation of the Sustainable Development Goals for 2030, approved in September 2015.

Thereby, Central American societies could avoid *ad hoc* strategies involving an inertial logic that might respond to emergencies but heighten risks; solve problems in one sector at the cost of another, or address adaptation and sustainable development (including the mitigation of GHG emissions) separately. For example, making progress in energy efficiency and the protection and restoration of forests is a part of a sustainable development agenda that, if well-designed, could lead to co-benefits such as ecosystem adaptation, reduced emissions, and improved wellbeing and inclusion of populations living in poverty, including indigenous peoples (see Figure 1).

FIGURE 1
INCLUSIVE AND SUSTAINABLE ADAPTATION



Source: Own elaboration.

Public policies aimed at sustainable and inclusive adaptation could be designed to take into account intra- and inter-sectoral synergies by integrated groupings of policies, with explicit sectoral and territorial goals. The results of the ECC CA initiative suggest that it would be best to explore key policy options by grouping them as follows:

a) Inclusion and adaptation of human populations through policies aimed at reducing poverty and inequality, with a focus on food security, comprehensive management of water resources and reduction of extreme event impacts through land management and citizen participation.

b) Transition to environmentally sustainable, low-GHG emission economies that are efficient in their use of natural resources by introducing structural and technological changes related to energy security and efficiency, public transport, comprehensive water management, recycling and the reduction of deforestation and pollution.

c) Protection and restoration of natural ecosystems and rural landscapes, including forests, in order to improve their adaptation capacity and ensure the long-term provision of environmental services to human beings; this is a key component of adaptation and the transition to more sustainable economies, and should address both economic incentives and non-economic, cultural and intergenerational valuations.

d) Far-sighted and proactive fiscal, trade, technology and education policies with transversal effects, such as: climate change resilient criteria for public investments and appropriate incentives for risk reduction, adaptation and the transition toward more sustainable economies; institutional structures for climate financing, integration of climate change at various educational levels and on the technology development agenda, and insurance mechanisms.

e) Taking advantage of strategic opportunities for Central American integration, such as management of water resources, food and energy security, trade conditions and international negotiations.

It must be acknowledged that there will be limits to adaptation, and that irreparable damage and losses will occur, even with sufficient financing. The many direct and indirect impacts of climate change will exacerbate the different sources and forms of vulnerability for certain populations. Analysing these impacts requires taking into account the multiple dimensions of poverty and the ways in which it is experienced, using a method such as the "capability approach" approach taken by Amartya Sen (1999). This method requires an analysis of the ability of people to adapt to climate change, not only in terms of the financial, natural, educational and healthcare resources available to them, but also in terms of their ability to utilize these resources.

The IPCC highlights that both the problems resulting from climate change as well as their solutions are related to equity, as the countries that contribute least to GHG emissions are the most vulnerable due to their decreased capacity to adapt, and are therefore the ones that will suffer the greatest impacts of climate change (IPCC, OMM and UNEP, 2007). The Stern Report (2007) Stern states that "climate change is a great threat to the developing world and a major obstacle to the continued reduction of poverty in its many dimensions". Therefore, it is suggested that adaptation strategies be integrated with those aimed at reducing poverty and inequality (ECLAC, 2009; 2010; IPCC, 2007a; UNDP, 2007; AfDB and others, 2007).

Almost half of the population of Central America lives in poverty, and approximately third lives in extreme poverty, which is particularly prevalent in rural areas. High levels of socioeconomic, ethnic and gender inequality persist, as reflected by several indicators, including the relatively high Gini index [1] (0.53 in 2010); high rates of child and maternal mortality and morbidity; high levels of malnutrition and inadequate access to food, drinking water, health services, education, social security, capital and credit. A significant portion of the population that lives in poverty, especially in rural areas, depends directly on the environment for access to water, food, shelter, medicines and energy, among other needs. In some cases, the lack of capital and livelihood options leads to overexploitation of the environment by these populations. The general pattern of development and poor risk management has created a vicious cycle of human impoverishment and environmental degradation that will only worsen as climate change progresses.

Another segment of the population that lives in poverty—for example, those who live in marginal urban areas and/or those who are dependent on the informal economy—will be seriously disadvantaged when facing the economic instabilities that climate change could cause. This segment of the population accesses a large part of its goods and services through the market, and sectoral studies suggest that it could suffer various repercussions. A decrease and instability in availability of water and crop yields can affect labour markets, the supply and prices of basic goods, and migration to urban areas.

[1] Gini estimates based on household surveys range from 0.45 for El Salvador in 2013 and 0.59 for Guatemala in 2006.

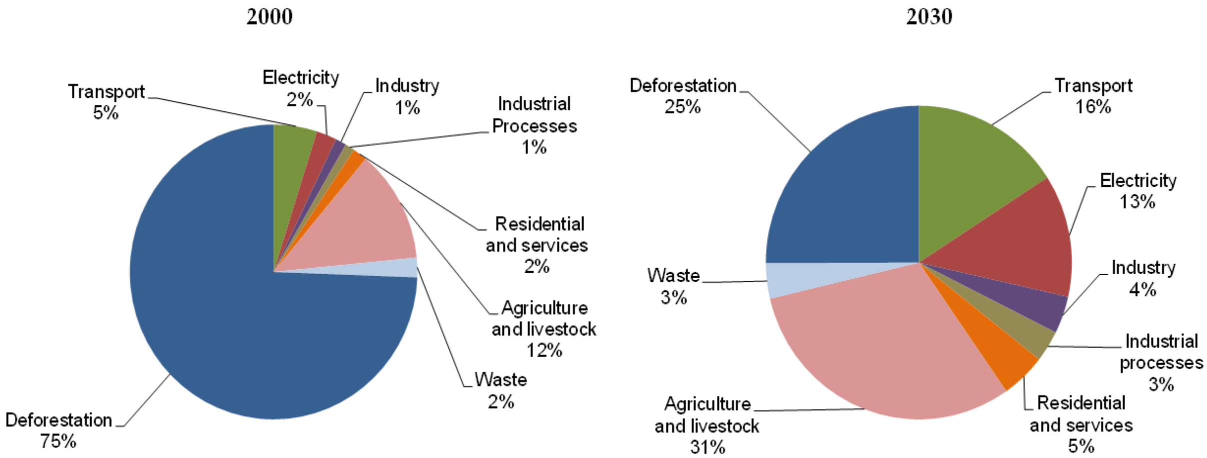
The challenge of social investment is related to the prevalence of informal work and the limited coverage of social protection in the majority of Central American countries. Only those employed in the formal sector have access to this coverage, which may include pensions, unemployment insurance and health services, among other services, although this is not true in all cases. Low per-capita social spending in Central American countries (with the exceptions of Panama and Costa Rica, where social spending is relatively high) limits resilience and the ability to adapt. Recent decades have seen the implementation of conditional cash transfer programs for poor families in several countries to supplement income and encourage the use of basic health and education services. These programs have the advantage of focusing their coverage on poor households with children, adolescents, female heads of households, and the unemployed and economically inactive population (ECLAC, 2012). Cecchini and Madriaga (2011) state: "Some countries facilitate access to social services for the sectors of the population that are most in need. However, one should not lose sight of the fact that these programs do not replace the roles of other policy instruments, and that their effectiveness depends largely on the presence of strong universal healthcare and educational systems." Strengthening the provision of these services remains a priority in the region and, in the current context, it is recommended that incentives for adaptation to extreme events and climate change be included in these programmes. The "human face of climate change" approach that Honduras applies to its "Better Life" programme is one example of such efforts.

Participation and political representation are important. Although the countries of the region have adopted democratic electoral systems, there is still much progress to be made in order for marginalised sectors, such as women, indigenous communities and people of African descent, to achieve effective participation in public decision making and consultative forums. In this vein, it will be necessary to carry out analyses with gender and ethnicity approaches in order to more accurately determine differences in vulnerability and resilience in the long term, as climate change may worsen the cycle of intergenerational impoverishment.

The initial economic valuation carried out by the ECC CA initiative demonstrates that the impacts of climate change in Central America in an A2-type scenario of rising emissions and global inaction, are significant and growing, with some variation amongst the countries of the region. This evidence confirms the paradox that the developed countries that have polluted the most and have the greatest capacity to adapt will face fewer impacts, while the countries that have contributed least to the problem are less resilient and face greater impacts. This result also lends weight to the idea that the cost of the impacts in an A2-type scenario would be higher than in a B2-type scenario in which the rate of emissions is reduced, and, therefore, also much higher than a scenario in which emissions are stabilized and significantly reduced, the aspiration for the international negotiations.

As a group, the countries of Central America contribute less than 0.3% of total GHG emissions without including land-use change, and less than 0.8% of gross total emissions. An analysis of the sectoral breakdown of emissions in 2000, based on national inventories, identifies deforestation as the greatest contributor. It is responsible for approximately 75% of total GHG emissions in the region, although there is significant variation amongst the countries (see chart 1). Agriculture and livestock farming are in second place with 12%; however, better estimates of the carbon sink effect of this sector are still pending. Initial estimates for 2030 indicate that this sectoral distribution of emissions could change, with the greatest share of the economy being emitted by agriculture and livestock farming (31%), followed by deforestation (25%), transportation (16%) and electricity (13%) (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

CHART 1
CENTRAL AMERICA: SECTORAL DISTRIBUTION OF ESTIMATED GHG EMISSIONS WITH LAND-USE CHANGE, 2000 AND 2030
(In percentages)



2000 Gross emissions reported=335 $MTCO_2e$
Net emissions = 120 $MTCO_2e$
2030 Gross emissions estimated = 310 M TCO_2e
Emissions LUC de 247 a 78 M TCO_2e
Agriculture and livestock emissions increase of 42 to 96 M TCO_2e

Source: ECLAC, CCAD/SICA, UKAID, DANIDA, 2011

In recent years, the governments of Central America have integrated climate change into their national development plans and/or period of government plans, including the National Development Framework 2010-2030 of Belize, the National Development Plan 2015-2018 of Costa Rica, the Strategic Institutional Plan 2013-2016 of Guatemala, the Five-year Development Plan 2014-2019 of El Salvador, the Strategic Government Plan 2014-2018 of Honduras, the National Human Development Plan 2012-2016 of Nicaragua, the Strategic Government Plan 2015-2019 of Panama and the National Development Strategy 2030 of the Dominican Republic.

The countries have also made progress in the establishment of policies and national laws to address climate change. Belize has developed its National Climate Change Policy and National Climate Resilient Investment Plan 2013-2018. Costa Rica has a Plan of Action for its National Climate Change Strategy (ENCC) and a Framework Law on Climate Change under discussion. El Salvador established its National Climate Change Strategy in 2013 and more recently its National Climate Change Plan (PNCC), as mandated in the national Environment Law. Guatemala has passed a Framework Law to Regulate the Reduction of Vulnerability, Mandatory Adaptation to the Effects of Climate Change and the Mitigation of Greenhouse Gases (Decree 7-2013), as well having a National Policy for Disaster Risk Reduction and a National Climate Change Policy (2009). Honduras established its Climate Change Law (Decree 297-2013), along with its National Climate Change Strategy (ENCC) and State Policy for Integrated Risk Management in Honduras (PEGIRH) (Executive Decree PCM-051-2013). Nicaragua has a National Environment and Climate Change Strategy 2010-2015. In Panama, the National Climate Change Strategy of Panama (ENCCP) is under discussion, and the country already has a National Disaster Risk Management Plan 2011-2015 with a Financial Framework. The Dominican Republic has a National Climate Change Plan, a National Action Plan for Adaptation to Climate Change 2008 and a Plan for Climate Change-compatible

Economic Development (Plan DECCC). Additionally, several governments have made progress with strategies or policies for critical sectors such as water, energy and agriculture.

At the Central American Integration System (SICA) level, the Presidents of the member countries have set climate change as one of their five priorities. The Regional Climate Change Strategy (ERCC), approved by the Council of Ministers of the CCAD in 2010, addresses the challenges proposing actions with a multisectoral approach. Several Councils of Ministers have established mandates for sectoral actions, including the Regional Environmental Framework Strategy (ERAM), the Central American Policy for Integrated Risk Management (PCGIR), Caribbean Catastrophe Risk Insurance Facility (CCRIF) led by COSEFIN, the Central American Strategy for Rural Territory Development (ECADERT), the Regional Agro-environmental and Health Strategy (ERAS) and the Central American Agricultural Policy (PACA).

Some countries in the region are creating NAMAs. Guatemala is developing a NAMA proposal based on efficient refrigeration. Costa Rica has established NAMA for Coffee and Bovine Livestock both of which are seeking support for their implementation. Additionally, this country is also preparing proposals for sugar cane, bananas, eco-efficiency in industry, solid waste, alternative energy (biomass), urban development and transport (freight and public). The Dominican Republic is seeking support for the preparation of a Blue Carbon NAMA for the conservation and restoration of mangroves, and other NAMAs related to tourism and waste, cement/co-processing and the waste sector, energy efficiency in the public sector and the reduction of GHGs on pig farms.

Thus, each country is in the process of establishing specific programmes and initiatives along with the instruments and measures for their implementation, according to the priorities and particular needs of each. The advantages and disadvantages of the different options discussed in the ECC CA framework may vary depending on the country and the international agreements to be established. Due to this changeable and uncertain context, the ECC CA initiative aims to provide a broad analysis that is not necessarily tied to the specific positions of individual countries.

Besides being ethically appropriate to act now rather than leave the problem for future generations, it is also more cost-effective from an economic standpoint. Research suggests that the cost of climate change impacts will be too high down the road if ambitious measures are not taken immediately. Research also confirms that climate change is the greatest market failure to date, as the market has not internalized the value of the climate as a global public good, nor properly accounted for the impact of climate change on society and environmental services. This failure indicates the need to go beyond economic valuations and make ethical decisions regarding the distribution of costs among generations which give an equal value to the needs of future generations. Ecosystems need to be similarly analysed, as they provide many environmental services that will be lost long before the market is able to register these losses and send signals to motivate their appropriate management. Given that the aforementioned future scenarios are long-term and include various “layers” of analysis with uncertainty and methodological difficulties, the results should be interpreted as trends and relative magnitudes, not exact figures.

Given both the structural changes occurring in the global economy and the risks of climate change, it could be opportune to carry out an in-depth review of the productive specialization of economies, considering their insertion in global markets, intraregional value chains and trade, the growing dependence on hydrocarbon consumption for energy—with the associated costs of importation, pollution, and harm to public health—and the degradation of forests and other ecosystems that provide a multitude of products and services.

These challenges will have to be addressed now, at a time when the model of a self-regulating market is showing its limitations. As stated by Bárcena, humanity is living through a change of epoch, and significant structural changes on the scale of the industrial revolution are needed to address climate change and other externalities caused by industrialization and the hydrocarbon-based economy (ECLAC, 2010). Other elements to consider are demographic, such as the significant population increase that will take place before it stabilizes in the second half of this century, the demographic transition and migration between countries and from rural areas to cities. The challenge of achieving inclusive development with a better quality of life and opportunities seems greater still if one considers the responsibility to future generations to ensure intergenerational equality in terms of climate change.

The coming decades will be characterized by the expansion of the knowledge-based society. The globalization of communications promotes deregulation, self- regulation and an increased flow of information, all of which promote democracy. However, this globalization has also contributed to the market becoming the central axis in the definition of identities. Dealing with the consequences of market self-regulation and excessive dependence on hydrocarbons requires greater collective awareness of global public goods, which in turn requires the transformation and strengthening of the processes and structures of global and national governability (ECLAC, 2010; ECLAC, 2012).

In terms of public policy, these challenges will require society-level pacts regarding agreements on the investments and incentives needed for structural changes in production and consumption that reduce climate risk and promote the transition to environmentally sustainable economies; fiscal policies that create a better equilibrium between private and public goods and services in the constellation of measures aimed at the well-being of the population; a more robust management of natural resources and environmental protection that creates incentives for a more diversified and "green" production matrix, and finally; a social and labour agreement which strengthens the redistributive capacity of the State and creates a more inclusive labour institutions (ECLAC, 2010).

Climate change presents a series of multisectoral challenges that need to be tackled jointly by diverse stakeholders, including the public and private sectors, citizens and civil society organizations, academia, integration institutions and the international community.

2. EVIDENCE OF EXTREME EVENTS AND CLIMATE CHANGE SCENARIOS

German Watch's global climate risk index classifies the impacts of extreme events (storms, floods, temperature extremes and heat and cold waves) in a ranking of 183 countries, in which the lowest ranked country is the most vulnerable. Results for the period 1994-2013 show that Honduras was the most affected country by extreme events, followed by Nicaragua (fourth), Dominican Republic (eighth), Guatemala (ninth), El Salvador (twelfth), Belize (twenty-first), Costa Rica (sixtieth) and Panama (ninetieth). Due to the increase in extreme weather events in recent years, the same indicator for the period 2004-2013 shows that countries in the Central American region often rank in the top ten in terms of risk: the Dominican Republic was second in 2004; Guatemala, first and Honduras, seventh in 2005; Nicaragua, third in 2007; Belize, ninth in 2008; El Salvador, first in 2009; Guatemala, second and Honduras, fifth in 2010; El Salvador, fourth and Guatemala ninth in 2011 (Harmeling, 2012; Kreft and others, 2015).

Another index is DARA's Climate Vulnerability Monitor (2012), which summarizes scientific information and research on the global impacts (including losses and benefits) of climate change and the carbon economy from the economic, environmental and health standpoints for the years 2010 and 2030 (annual averages). The Monitor carries out a valuation of the human and economic costs of the climate crisis in two parts: the first part deals with the impact of climate change, which includes 22 indicators, and the second part is an appraisal of the carbon economy, which includes 12 indicators. The appraisal of the carbon economy involves evaluating the economic, health, and environmental situation with special emphasis on the acquisition, and the consumption of fossil fuels, and the release of several types of greenhouse gas pollutants through combustion. This analysis looks at the costs and benefits of the extraction, production and consumption of fossil fuel, independently of the effects of these processes on climate change. The estimate for Central America is presented in Table 1.

The Monitor also estimates the level of vulnerability; however, this level of impact is considered indicative. This indicator of vulnerability is the result of damages incurred, or the lack thereof. The impacts are significant in relative terms, i.e. in relation to the size of the economy or population. Furthermore, greater impacts are the result of greater levels of vulnerability, and vice versa. The Monitor has five categories of vulnerability, which are determined statistically using standard deviation. The classifications are: acute (most vulnerable), severe, high, moderate and low (least vulnerable). Countries with a "low" level of vulnerability experience no impact or some benefits due to climate change. The level of vulnerability for Central America is presented in Table 2.

TABLE 1
CENTRAL AMERICA AND DOMINICAN REPUBLIC: CLIMATE VULNERABILITY MONITOR, NATIONAL LOSS TOTALS, 2010 AND 2030

	Economic cost				Human impacts					
	Climate change impacts		Carbon intensity impact		Climate change impacts and carbon intensity impact		Climate change impacts		Carbon intensity impact	
	% GDP				Mortality		Persons affected			
	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
Belize	7.7	14.2	5.3	10.2	50	60	25 000	30 000	2 000	2 500
Costa Rica	3.1	6.3	0.6	0.9	700	850	75 000	200 000	25 000	30 000
El Salvador	3.6	7.2	0.5	0.8	1 500	1 500	100 000	150 000	45 000	60 000
Guatemala	2.9	5.8	0.8	1.2	3 500	5 000	1 100 000	1200 000	150 000	250 000
Honduras	4.6	9.0	1.5	2.5	2 500	3 000	150 000	250 000	100 000	150 000
Nicaragua	6.3	11.7	2.4	4.3	1 500	2 000	95 000	200 000	55 000	65 000
Panamá	42	8.4	2.1	3.8	550	650	200 000	300 000	25 000	25 000
Dominican Republic	2.4	4.8	0.3	0.3	3 000	3 500	250 000	400 000	75 000	100 000

Note: The impacts are yearly average
Source: DARA (2012).

TABLE 2
CENTRAL AMERICA AND DOMINICAN REPUBLIC: CLIMATE VULNERABILITY MONITOR, VULNERABILITY LEVEL, 2010 AND 2030

	Climate		Carbon	
	2010	**2030**	**2010**	**2030**
Belize	Acute	Acute	High	High
Costa Rica	Moderate	High	Low	Low
El Salvador	Severe	Acute	Low	Low
Guatemala	Moderate	High	Low	Moderate
Honduras	Severe	Acute	Moderate	Moderate
Nicaragua	Moderate	High	Low	Moderate
Panamá	Moderate	Severe	High	Severe
Dominican Republic	High	Acute	High	High

Source: DARA (2012).

International experts believe that while it has been relatively easy to analyze attribution in the case of temperature extremes, doing so with hydro-meteorological events is very complex and presents greater uncertainty. In its special report on extreme events, the IPCC states that extreme changes can be related to changes in the average, variance, probability distribution or all of these indicators combined. The report points out that natural variability will continue to be an important factor for future extreme events, in addition to changes associated with anthropogenic activities (IPCC, 2011).

At the international level, a series of severe hydro meteorological events have taken place in different parts of the world, such as the heat wave in Russia in 2010, the floods in England in 2000, in Pakistan in 2010, and very recently in Thailand. This has led to greater discussion and analysis of the possible contribution of climate change to the increased severity of these events. Recent scientific literature suggests that although there is significant uncertainty, evidence of the relationship between climate change and the increase in event intensity is accumulating, and cases of partial probable attribution are being identified.

There are several reasons why scientists try to establish whether certain meteorological events could be attributed to the effects of greenhouse gas emissions (Hulme, 2014). The first is to develop a new rational understanding of physical processes and create new analytical methods to study them. A second reason is to find out whether specific extreme meteorological conditions are caused by humans, in order to justify, plan and carry out adaptation actions. A third reason is based on the possibility of assigning legal responsibility for the damage caused. This argument is based on the desire to calculate the probability that a given extreme event can be attributed to a specific cause, in this case, to greenhouse gas emissions (Allen and others, 2007). If the damages caused by extreme climate conditions can be attributed to greenhouse gas emissions, even if expressed in terms of an increase in risk, legal suits become a possibility. A final reason is the frustration and the invisibility of climate change. There are still problems in making climate change and its "real" implications visible to certain sectors of society (Rudiak-Gould, 2013).

There are various studies on detection and attribution of extreme events. Some examples are Allen and others (2007), Bindoff and Stott (2013), Hegerl and Zwiers (2011) and Stott and others (2010). In general, these studies seek to detect a change in spatial-temporal averages in monthly and seasonal statistics of some climate variables at the global, continental, or regional scale, and with the help of one or more climate simulation models, attribute this change to a specific factor (for example, a volcanic eruption or the concentration of greenhouse gases). The study of the attribution of meteorological phenomena to human influence has been carried out using different approaches. The most general approach is simple physical reasoning, for example, expecting more intense precipitation in an atmosphere that contains more water vapour. A second approach consists of using statistical analyses of time series of meteorological data to determine whether a given extreme event falls outside the range of "normal" climate. A third method proposed by Allen (2003) and applied by Stott and others (2004) consists of calculating the Fractional Attributable Risk (FAR) of an extreme (or of short term). The literature to date suggests that there is serious concern and demand for information regarding this potential relationship, and that even though there are significant uncertainties, evidence of this relationship is beginning to accumulate and cases of probable partial attribution to climate change are being identified (Hulme, 2014).

One of these recent studies, carried out by Pall and others (2011), uses a framework of probabilistic attribution for the floods that occurred in England and Wales in 2000, contrasting climate data from the events with a model that presupposes a lack of global warming. The authors reported that in nine out of ten cases, results showed that emissions over the last 100 years increased the risk of flooding by 20%, and in two of every three cases, by more than 90%. Hoerling and others (2011) analysed the trend of decreasing winter precipitation in the Mediterranean region and its possible relationship with natural variability, the North Atlantic Oscillation (NAO) and anthropogenic climate change. The authors found that climate change can explain approximately half of the increase in dryness that occurred between 1902 and 2010, primarily due to the rising temperature of the surface of the Mediterranean Sea.

Rahmstrof and Coumou (2011) used a Monte Carlo model to assess the likelihood that the high temperatures in Moscow in July 2010 were probable, given recorded temperatures for July during the last century. They found that without climate change, the probability that this heat wave would not have occurred was 80%. These results and those provided by Tamino (2010) partly contradict a previous study by Dole and others (2011), which concluded that Moscow's heat wave had been caused primarily by natural internal atmospheric variability.

Another group of researchers from Canada (Min and others, 2011) compared precipitation time series for North America with six climate model simulations, with and without climate change, and found that the extreme rainfall patterns observed did not align with the expected natural cycle, but were close to the patterns expected with climate change. These reports suggest that the concern over the possible exacerbation of extreme events by climate change is legitimate, particularly in regions such as Central America, due to its historical exposure to such events.

In 2009, the international initiative Attribution of Climate-Related Events (ACE) was launched with the participation of the Hadley Center, the Department of Energy and Climate Change of the UK, various departments of the National Oceanic and Atmospheric Administration (NOAA), the National Center for Atmospheric Research (NCAR) and several universities. In October 2011, ACE presented a progress summary at the World Climate Research Programme (WCRP) Conference and proposed options for fractional attribution methodology, i.e. attributing the changes in the risks of extreme events to specific factors, including climate change (Stott and others, 2011). Since the creation of ACE, two annual reports on climate attribution have been published in the Bulletin of the American Meteorological Society (Peterson and others, 2012; 2013). There are plans to make this a series of annual reports that complement the Report on the State of the Climate prepared by the World Meteorological Organization (WMO). Attribution science is moving from a test stage to a more developed one. Nevertheless, its study can drive the development of climate models and improve the ability to make seasonal forecasts (Hulme, 2014).

One line of research on the relationship between climate change and extreme events, such as floods and intense precipitation, is based on the laws of thermodynamics which indicate that an increase in temperature gives rise to greater levels of evaporation, evapotranspiration, atmospheric water vapour and an acceleration or destabilization of the water cycle (Flower, Mitchell and Codner, 2007; Ekström and others, 2005). Stott, of the Hadley Center, has estimated that for each additional temperature increase of 1°C, average global atmospheric humidity increases by 7%, which leads to precipitation events of greater intensity (Carey, 2011).

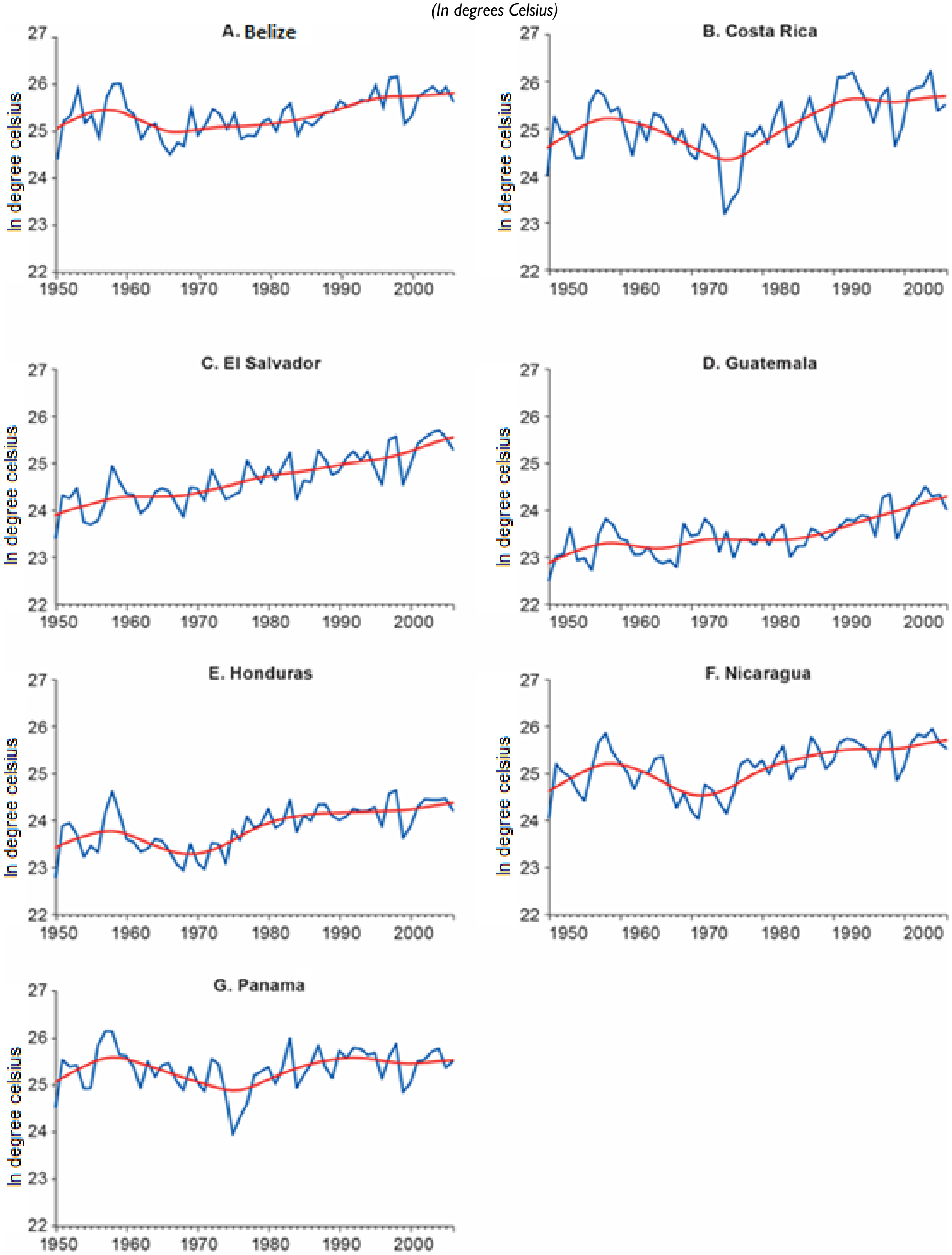
2.1 CLIMATE VARIABILITY AND CLIMATE CHANGE IN CENTRAL AMERICA

Historical climatology shows that Central America has experienced an average temperature increase of approximately 0.5°C over the last 50 years. Under a scenario in which GHG emissions continue their current upward trajectory, the temperature could increase by between 1°C and 2°C by 2050 (ECLAC, CCAD/SICA, DFID and DANIDA, 2011). Furthermore, a study on the trend of droughts in the Mediterranean region has found that the sea surface temperature could act as a transmission channel for climate change, leading to precipitation and extreme events. Time series indicate that the area of the Pacific associated with ENSO (20 N-20 S and 90 W-120 W) has experienced a temperature increase in this century. About the Caribbean Sea, there is evidence of accelerated warming since the second half of the 1990s (Jury, 2011). Another line of preliminary analysis involves considering evidence of changes in extreme event trends, such as tropical storms, hurricanes and floods. According to the IPCC Fourth Report, in nine out of the ten years in the 1995-2005 period, the number of hurricanes in the North Atlantic surpassed the historical trend recorded from 1981 to 2000 (IPCC, 2007b). Droughts have been more intense as well, mainly since 1970, in the tropics and subtropics.

According to the IPCC (Magrin and others, 2007), Central America has experienced high climate variability in recent years. In the last few decades, there have been significant changes in precipitation and increases in temperature. Precipitation level trends show a decrease, especially in the western region of the isthmus. Certain studies (Aguilar and others, 2005) show contrasting precipitation trends throughout Central America, with significant differences in spatial distribution between the Pacific and the Caribbean regions. The high degree of variability in precipitation in this region is primarily caused by the interaction between the different wind systems and the topography.

Historical climatology suggests that Central America has seen an average increase in temperature of approximately 0.54 °C over the last 50 years (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011, using CRU TS3.0). Chart 2 presents historical trends of average annual temperature using the CRU TS 3.0 climatology. It is possible to see that temperature series show an upward trend in most countries. Belize shows a slight rise and then a greater stability as of the mid-1980s. There has been an upward trend in El Salvador, Costa Rica and Guatemala since the 1970s, with an increase of 0.6°C. Nicaragua and Honduras follow a similar pattern with a slight contraction in the 1960s, followed by continuous growth with an increase of 0.4°C. Panama has seen greater volatility since 1980 with deviations with respect to its trend of approximately 0.5°C. Thus, it can be seen that temperature patterns in the region are quite different, with slight increases in Belize, a notable upward trend in Guatemala and El Salvador, a slower rate of growth in Honduras and Nicaragua, and an increase in temperature variability in Panama (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011). The increases in minimum temperature are particularly clear, while those in maximum temperatures are not. Nevertheless, there is a general trend toward decrease in the diurnal temperature range (maximum minus minimum) over the same period (Fernández and others, 2006).

CHART 2
CENTRAL AMERICA: MEAN ANNUAL TEMPERATURE AND HODRICK-PRESCOTT FILTER, 1950 - 2006
(In degrees Celsius)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA (2011) based on climatology CRU TS 3.0.

Chart 3 shows the trajectory of average annual precipitation in the seven countries in the period 1950-2006. The series trend is approximated using the Hodrick-Prescott filter (Hodrick and Prescott, 1997). The series describe a certain cyclical behaviour around an average value. The average values are 2392 mm for Costa Rica (the highest in the region), 2759 mm for Guatemala, 2641 mm for Panama and 2440 mm for Nicaragua. These four countries have the highest average annual precipitation levels on record. The average for Belize is 2165 mm, 2028 mm for Honduras and 1769 mm (the lowest) for El Salvador. The figures clearly show the significant volatility in annual accumulation, a feature of the variability of this key factor in the region (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

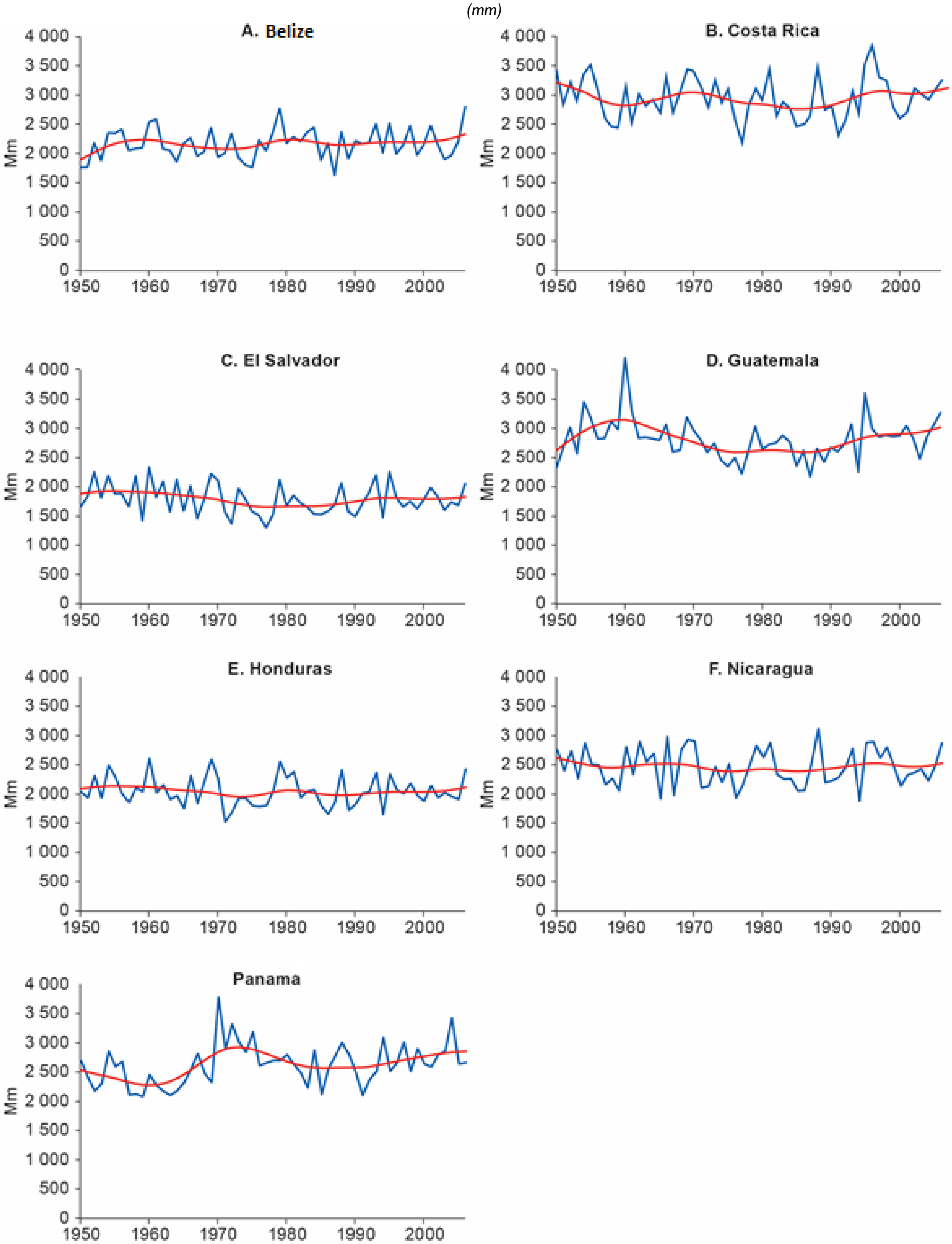
Central America has several small-scale scenarios, including those which use three general circulation models for two scenarios: "SRES" from the IPCC, B2 and A2. [2] These models have been used individually or averaged for various analyses during recent years, [3] the ECC CA initiative has used them at the national and subnational (departments, districts or provinces, depending on the country) scale. Since these scenarios are based on assumptions, uncertainties and the results of the emissions scenarios provided by said models, the results should be interpreted as trends and relative magnitudes, and not as exact numbers.

About temperature, it has been estimated that, by the end of the century, regional temperature will rise by between 2.1°C and 3.3°C under scenario B2 (the more optimistic scenario) and by between 3.7°C and 4.6°C under scenario A2, with respect to the 1980-2000 period. However, there are significant variations in temperature within the region and these variations will continue in the future, even with climate change. Historically, the highlands, especially in Guatemala and Costa Rica, have experienced average temperatures of 15°C to 18°C, a large part of the region has experienced temperatures between 18°C and 27°C, and the Honduras Valley department was the only one to experience temperatures between 27°C and 30°C. Under scenario A2, as soon as 2020, 7 departments could experience temperatures in this highest range. By the end of the century, 58 departments could fall in the same range while the Valley and 10 other departments could experience temperatures of between 30°C and 33°C (see Map 1). Recent estimates based on the new scenarios of radiative forcing called Representative Concentration Pathways (RCP) found in the IPCC Fifth Report (AR5) suggest a temperature increase of 1.8°C to 3.5°C for Central America and Mexico under scenario RCP 6.0 and of 2.9°C to 5.5°C for RCP 8.5 for the period 2081-2100, with respect to the 1986-2005 period (IPCC, 2013b; ECLAC, 2015b).

[2] The features of the scenarios are: Scenario A2: Heterogeneous world, self-sufficient, local entities are conserved. This is the SRES series scenario with the highest emissions by the end of the century. Scenario B2: World with a predominance of local solutions for economic, social, and environmental sustainability, as well as intermediate economic development and change in technology. The scenaio that maintains an upward trend, but on a lower scale than A2 (IPCC, 2000). Both scenarios have been used frequently in other studies in the region.

[3] HADCM3, GFDL R30 and ECHAM4 models were used for B2, and HADGEM1, GFDL, CM2.0 and ECHAM models were used for A2.

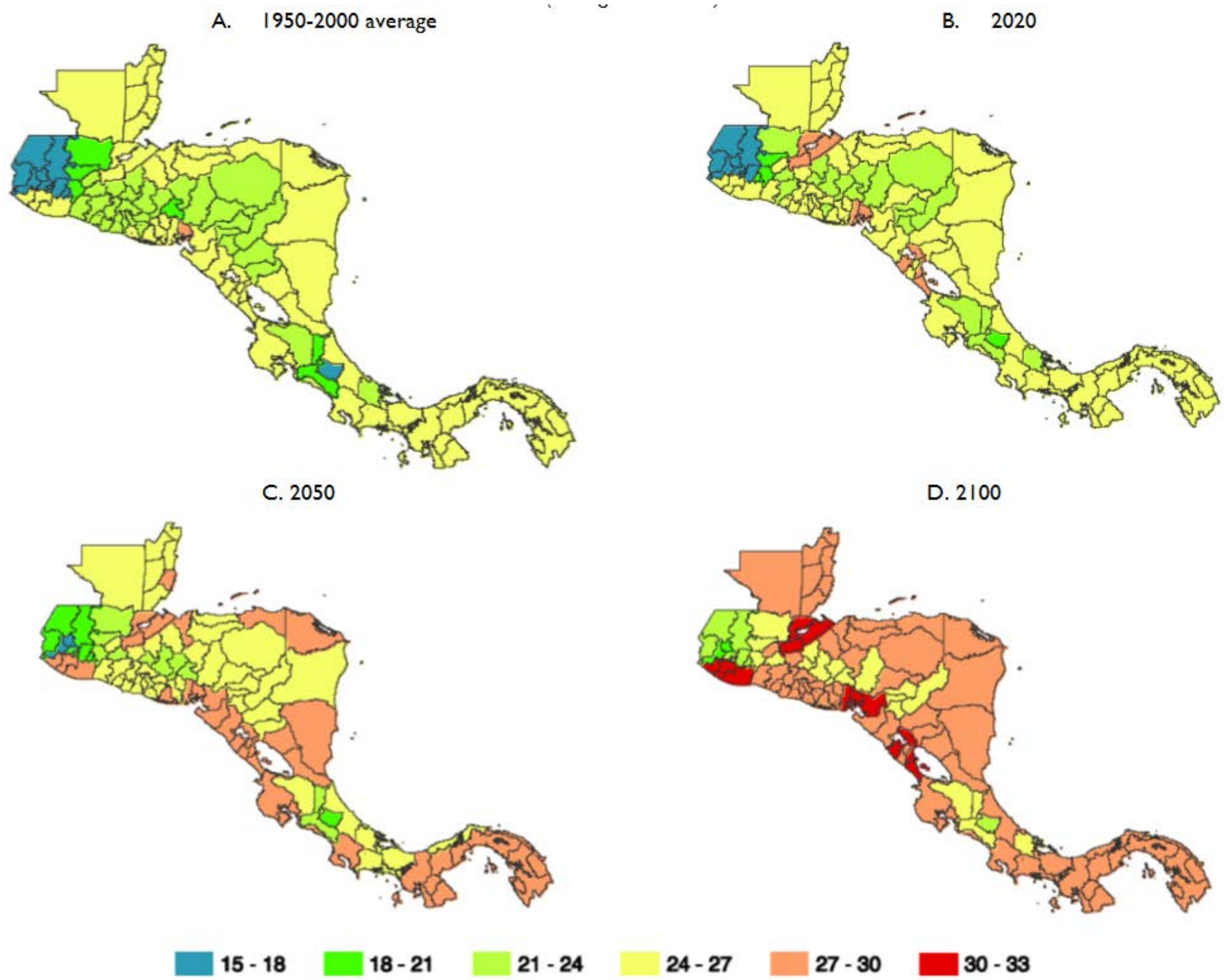
CHART 3
CENTRAL AMERICA: ANNUAL ACCUMULATED PRECIPITATION AND HODRICK-PRESCOTT FILTER, 1950-2006
(mm)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA (2011) based on climatology CRU TS 3.0.

The possible pattern of future precipitation is less certain. Under the less pessimistic scenario (B2), precipitation would decrease by 3% in Panama; 7% in Guatemala; between 10% and 13% in Costa Rica, Belize, El Salvador and Honduras; and 17% in Nicaragua, with an average regional decrease of 11%. Under the more pessimistic scenario (A2) there would be an 18% decrease in precipitation in Panama, 35% in Nicaragua and between 27% and 32% in Costa Rica, Belize, El Salvador, Guatemala and Honduras, with an average regional decrease of 28%. However, even though a smaller decrease in precipitation is expected under scenario B2, rising temperatures will lead to greater evapotranspiration, resulting in reduced availability of water, especially in the second half of the century, thereby affecting ecosystems, agriculture and hydroelectric power generation.

MAP 1
CENTRAL AMERICA: ANNUAL AVERAGE MONTHLY TEMPERATURE BY DEPARTMENT, 1950-2000 AVERAGE AND SCENARIO A2 UP TO 2100
(In degrees Celsius)



Source: ECLAC, CCAD/SICA, UKAID, DANIDA (2012a).

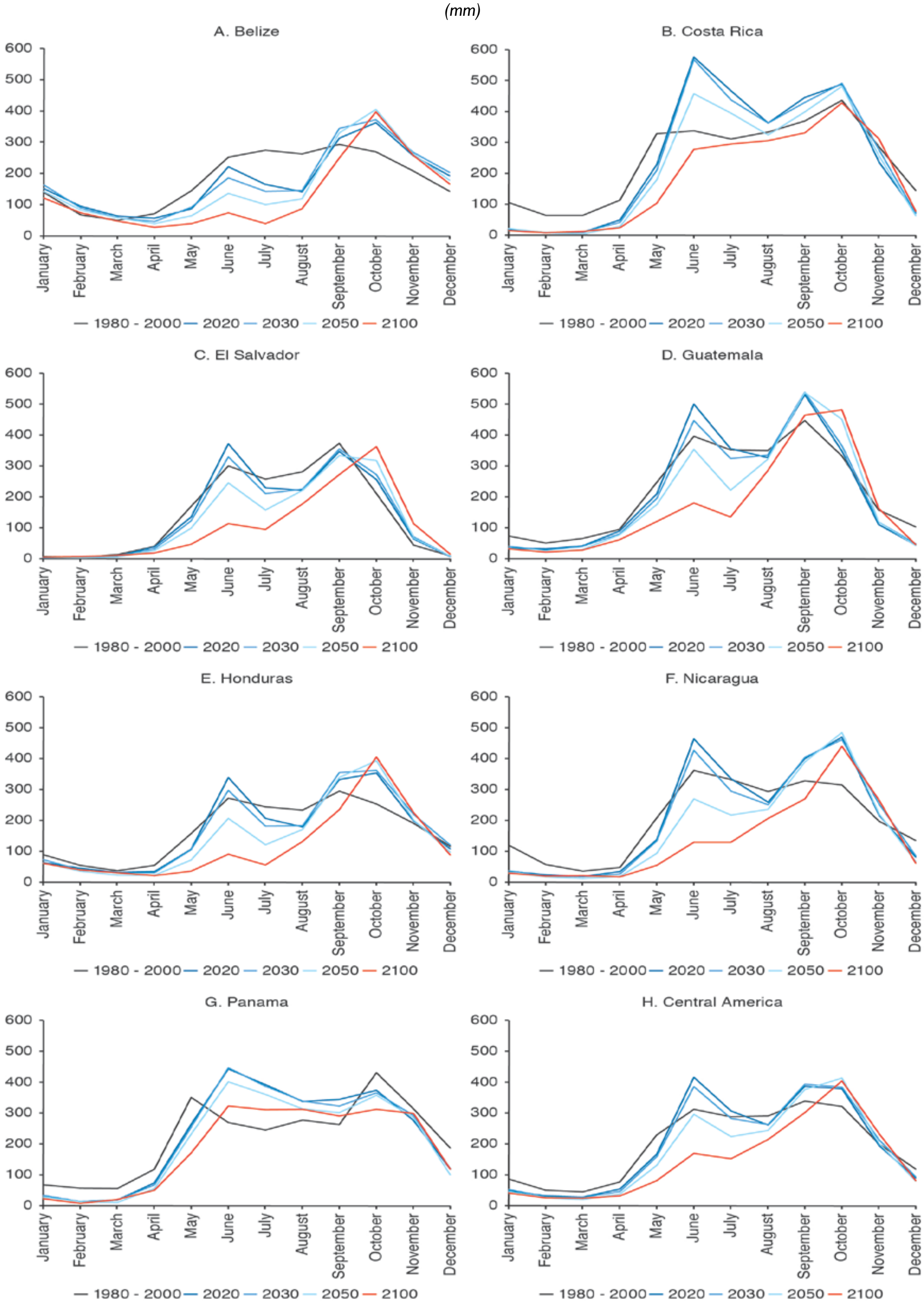
POTENTIAL CHANGES IN INTRA-ANNUAL PATTERN

Water availability is related to both intra-annual precipitation patterns and geographical differences in precipitation. During the period 1950-2000, the Pacific coast experienced a dry season and a rainy season, with rainfall peaking in June, then decreasing in July and August and reaching another peak again in September and October, usually higher than the one in June. By contrast, some departments on the Atlantic coast did not have a single month without rain. However, even in these cases, precipitation began to increase in April, following different intermediate patterns until diminishing again during November and December. It is estimated that under scenario B2, the rainy season could start earlier in the year, with more intense rainfall in the early stages of the season. It is estimated that precipitation would decrease following the period known as "dog days", especially during the second half of the century, resulting in some countries moving away from their bimodal weather pattern. Under scenario A2, it is estimated that the bimodal pattern of precipitation could be exacerbated in the coming decades with an increase in the intensity of both rainy periods and dog days. Later, rainfall in the early stages would gradually decrease, leaving a single annual maximum between October and November (see Chart 4). Costa Rica and Panama would be exceptions and might experience an increase in precipitation at the beginning of the season during the coming decades; subsequently, these countries might experience a decrease in precipitation nearing historical lows, with a relatively stable pattern from June to November.

In October 2011, the tropical depression named 12-E and a related type of low-pressure system affected El Salvador, Costa Rica, Guatemala, Honduras and Nicaragua. Concern about this phenomenon led the presidents of these five countries to hold a special summit, where a team of consultants was brought in to support the countries in their reconstruction efforts with a view to reducing vulnerabilities and adapting to climate change. The intensity and duration of rainfall were considered to be concrete manifestations of the adverse effects of climate change (Comalapa Statement, October 25, 2011). [4] A preliminary analysis prepared by said consulting group sought to find evidence of precipitation variability and the occurrence of intense rainfall events in the region (ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA, 2012d). This analysis used daily records of 24-hour accumulated precipitation for the 1970-2011 period from the main meteorological stations distributed through the Central American countries (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011). The following section presents results from Ilopango, El Salvador.

[4] In preparation for this summit, the Pro Tempore Presidency of CCAD/SICA requested the collaboration of the ECC CA initiative on the document titled "Analysis of the Effects of Climate Change in Central America" , which was prepared by CCAD and the Coordination Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC). The paper relied on input from the CU team at the Subregional Headquarters of ECLAC in Mexico, RTC delegates, the meteorological services of the five countries, and other civil servants who shared their knowledge and facilitated access to meteorological databases.

CHART 4
CENTRAL AMERICA: MONTHLY RAINFALL, 1980–2000 AVERAGE AND SCENARIO A2 UP TO 2100
(mm)



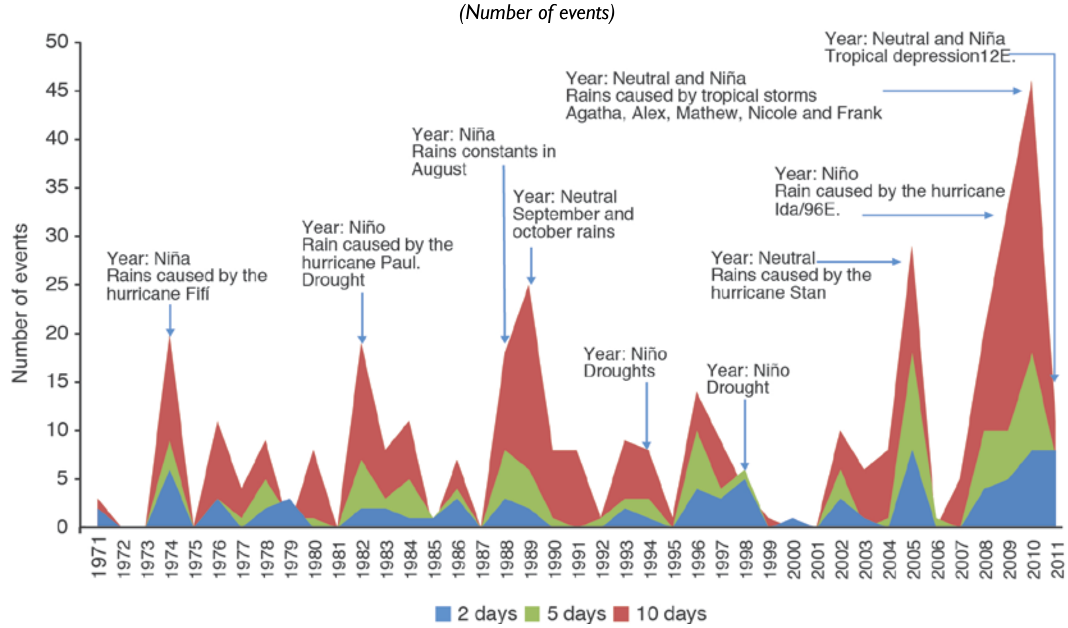
Source: ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA (2012a).

Changes in rainfall intensity: Ilopango, El Salvador

Ilopango is located 10 km to the east of San Salvador. The area has a warm climate with hot, tropical savannah vegetation. It experiences an average annual precipitation of 1765 mm. Ilopango is located 615 meters above sea level (MASL) at 13° 41′ N, 89° 07′ W. The area has experienced changes in land-use as well as urbanization which may have affected records, particularly those of temperature.

Chart 5 shows that, historically, there were between 0 and 5 events with more than 100 mm of rain over two consecutive days, but that the average has increased over the last decade. The number of events with more than 150 mm over five consecutive days has reached up to 10 per year, and there is a positive trend of historical highs of accumulated rainfall from 2005 onwards. Finally, the number of events lasting ten days with more than 200 mm of precipitation shows a clear positive trend about frequency and peaks over the last ten years, mainly due to hurricanes and tropical storms.

CHART 5
EL SALVADOR, ILOPANGO: NUMBER OF EVENTS SURPASSING THRESHOLDS, 1971-2011
(Number of events)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA, 2012d with data provided by MARN.

Note: Drought events were obtained from EM-DAT (2011) records. The year 1987 was not included because of incomplete daily records. The year 2011 includes information up to October 31. The thresholds correspond to 100, 150 and 200 mm accumulated over 2, 5 and 10 consecutive days respectively.

Table 3 shows that the number of events of short duration (two days) with more than 100 mm of rain remained relatively constant between 1971 and 2000, but then doubled in the last decade. The number of events of moderate duration (five days) experienced greater variability between 1981 and 1990. The number increased with respect to the previous decade, then decreased in the 1990s, and finally doubled in the last decade. The number of events of long-duration (ten days) showed the same trend as those of moderate duration during the first few decades analysed but reached 168 days of rain by the last decade, three times higher than in the 1970s. The last result is indicative of the large number of extreme events that have occurred in the region, which have brought more rain than the seasonal norm. Some examples of these extreme events are hurricanes Isidore (2002), Stan (2005), Ida/E96 (2009), Agatha, Alex and Matthew (2010), and tropical depression 12-E (2011).

TABLE 3
EL SALVADOR, ILOPANGO: NUMBER OF EVENTS SURPASSING THRESHOLDS, 1971-2011

(Number of Events)

	2 days of rain	5 days of rain	10 days of rain
1971-1980	16	20	55
1981-1990	14	35	97
1991-2000	16	27	55
2001-2011	37	71	168

Source: ECLAC, CCAD/SICA, UKAID and DANIDA, 2012d with data provided by MARN.
Note: The year 1987 was not included because of incomplete daily records. The year 2011 includes information up to October 31st. The 2001-2011-time period includes an extra year. The thresholds correspond to 100 mm, 150 mm and 200 mm accumulated over 2,5 and 10 consecutive days respectively.

It is estimated that oceans have absorbed approximately 20 times more heat than the atmosphere during the last 50 years, giving rise to higher temperatures in both surface and deep waters (Barnett and others, 2005; Levitus, Antonov and Boyer, 2005). Both factors have contributed to tropical cyclones of greater intensity on the oceans (Hansen, 2005). This hypothesis is based on research that has found a positive relationship between the intensity of tropical cyclones and the surface temperature of the oceans (Emanuel, 1987; Holland, 1997; Henderson-Sellers and others, 1998; Zeng, Wang and Wu, 2007). As mentioned previously, the surface temperatures of the Pacific Ocean and the Caribbean Sea, both bodies of water that influence the climate in Central America, have been rising over the last 100 years. With regard to the future, international scientific literature suggests that hurricane intensity could increase by 5% to 10% during this century (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

In the Fifth Report the IPCC (Magrin and others, 2014) informed that sea levels varied by 2 mm to 7 mm per year between 1950 and 2008 in Central and South America, which was a source of concern for a large percentage of the population of the region that lives on the coast. Izaguirre and others (2013) analysed spatial and temporal variability of Significant Wave Height (SWH) in Central and South America. Results showed a growing trend over the last 28 years in the Pacific basin, with increases of up to 6.5 cm per year in Tierra de Fuego and to the east of the Falkland Islands. The increase in sea level influences marine and coastal ecosystems [5] and represents a threat to marine life and mangroves, as well as tourism and disease control. Losada and others (2013) analysed the long-term changes in the factors contributing to sea level in Latin America and the Caribbean. A significant factor in Rio de la Plata is the storms and interannual variability in the tropical region of the west coast. This study showed a clear relationship between sea level and El Niño on the coast of Peru.

[5] Coral reefs, mangroves, fish and other marine invertebrates provide essential services to ecosystems (IPCC, 2013a; 2013b).

2.2 TRENDS IN EXTREME EVENTS

The most significant feature of rainfall in recent decades has been its variability, including extreme events such as hurricanes and droughts, and variations in annual accumulation as well as accumulation by geographic region, influenced by the Atlantic and Pacific Oceans and by the mountain chains and highlands. For example, the Pacific region has a dry period from December to April, and a humid one from May to November, approximately, with some variations. The annual distribution of rain is bimodal with maximums in June and September-October and a decrease in July, during the period known as "dog days"(Ramírez, 1983; Magaña, Amador and Medina, 1999; García, Zevallos and del Villar, 2003; Amador and others, 2006). The variations in surface temperatures of the tropical Atlantic and Pacific Oceans play an important role in determining the start, end, and duration of the rainy season (Alfaro, Cid and Enfield, 1998; Enfield and Alfaro, 1999; Alfaro and Cid, 1999; Alfaro, 2007). The Caribbean region experiences rain practically the entire year, without a defined dry season. Precipitation from December to March is primarily associated with the polar thrusts (Schultz, Bracken and Bosart, 1998; ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

Storms associated with the occurrence of tropical cyclones are important factors to the precipitation observed. Even when they have similar trajectories, their associated rain distribution can be different (Fernández and Vega, 1996). It is important to highlight the effect of storms not classified as hurricanes or cyclones which produce continuous rain for periods of time greater than 24 hours (usually around two to four days) and which affect land areas, and the surrounding Pacific Ocean and Caribbean Sea. Storms in the Pacific occur from May to November, with greatest frequency in June and September-October. Storms in the Caribbean occur with greatest frequency during winter in the Northern Hemisphere, when the region is influenced by thrusts of cold air from North America (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

In its Fourth Report from 2007, the IPCC had already observed that the frequency of intense rainfall events had increased over most of land masses, consistent with the observed warming and increase in water vapour (IPCC, 2007a and 2007b). In its report on extreme events, the IPCC concludes with medium confidence, that anthropogenic influences have contributed to the intensification of extreme precipitation at the global scale, as well as droughts in some regions, including Central America, due to the decrease in rainfall and/or increase in evapotranspiration. The IPCC also indicates that changes in extremes can be related to changes in averages, variability and probability distributions, or all these factors combined. The IPCC also believes that certain climate events, such as droughts or landslides, could be the result of the cumulative effect of events that are not very extreme on its own. The report points out that natural variability will continue to be an important factor for future extreme events, in addition to changes associated with anthropogenic activities (IPCC, 2011).

Between 1931 and 2015, the Central American countries experienced 375 extreme events associated with hydro-meteorological phenomena (see Chart 6). Honduras experienced the greatest number, with 66, and Belize the least, with 19. The most recurrent events are floods, storms, landslides and mudslides, which account for 82% of total events, and droughts, which account for 9%. During the last three decades, the number of natural disasters in the region grew by 6% per year with respect to the 1970s.

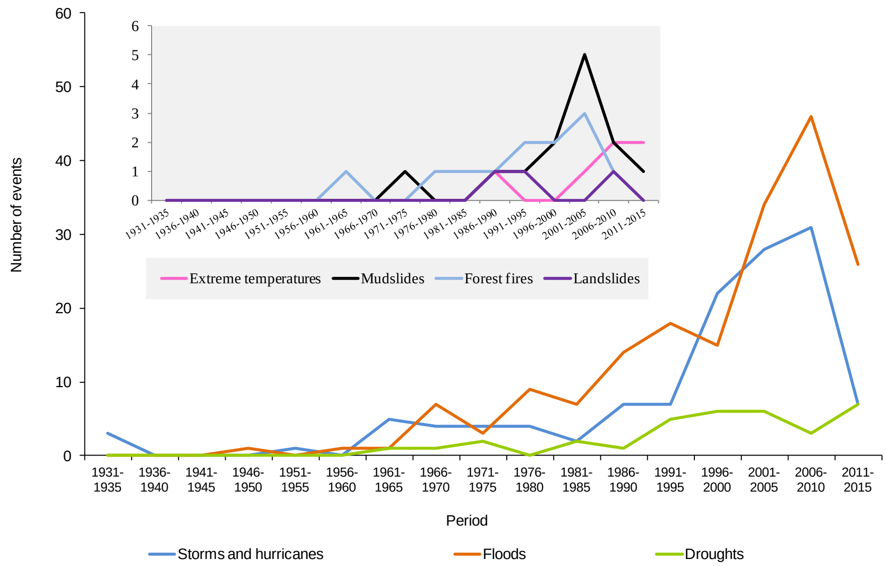
It has been observed that there has been a sustained increase in the number of events over time, especially since the 1960s, with a significant increase from 1991 to 2015. In the last two decades, the number of floods has more than doubled in all the Central American countries with respect to the period 1971-1990. Costa Rica, Honduras and Panama have experienced the most floods, while El Salvador, Guatemala and Nicaragua experience floods with an intermediate frequency. With regards to recorded storms and hurricanes, the Dominican Republic experienced the most in the second period with 21 events, followed by Nicaragua with 17 events (see Chart 7). The other countries experienced between 2 and 13 events. Costa Rica, El Salvador and Guatemala stand out, as they experienced one event each in the first period but experienced the greatest increases in the second. Landslides and extreme temperatures have started to show a growing trajectory in recent years, as have droughts and forest fires since the 1990s. It is important to note that these figures don't include small-scale events that often have severe impacts on specific communities and cumulative effects in the medium and long-term.

According to the IPCC Fourth Report, in nine out of the ten years of the 1995-2005 period, the number of hurricanes in the North Atlantic surpassed the historical trend recorded from 1981 to 2000 (IPCC, 2007b). Droughts have been more intense as well, mainly since 1970, in the tropics and subtropics. Chart 8 illustrates the time series of hurricanes and storms (HURDAT) for the Atlantic Ocean recorded by NOAA between 1878 and 2015. The time series shows great volatility, with an increase in storms and hurricanes, especially over the last two decades. Nevertheless, it is not yet possible to determine that this trend is different from the historical trend (Hegerl and others, 2007; Vecchi and Knutson, 2008). Despite the limitations of the databases of Central America, the records that are available suggest that this trend has also been experienced in the region.

By disaggregating events of short and moderate duration, Chart 9 shows that the frequency of tropical storms of short duration (less than two days) in the Atlantic Ocean has gradually increased, especially since 1960. Considering the increased frequency of intense rains seen in some areas of the region, it would be advisable to analyse the possible relationship between this trend and climate change.

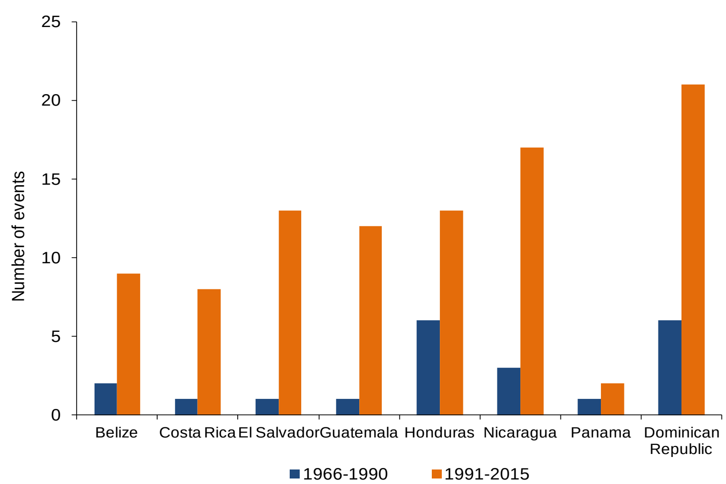
Storms of moderate duration exhibit a possible multidecadal fluctuation, with a trajectory that has changed since 1980. The relationship between the frequency of these events and climate change could be identified once it becomes clear whether the frequency pattern abandons its historic oscillation in the coming decades.

CHART 6
CENTRAL AMERICA: EVOLUTION OF RECORDED EXTREME EVENTS OVER TIME, 1931-2015
(By number and type)



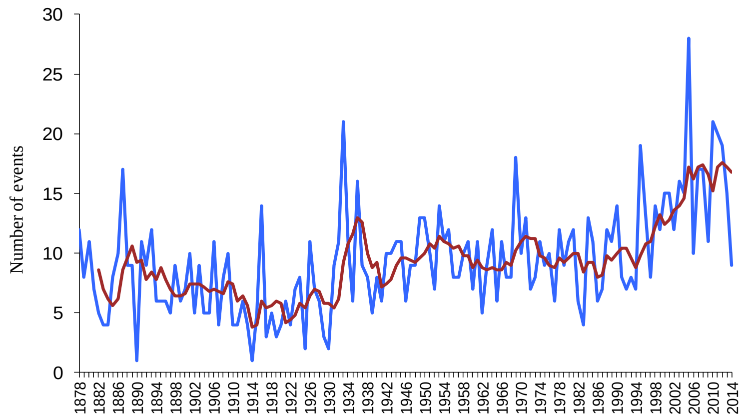
Source: Prepared by the authors using EM-DAT (CRED, 2015).

CHART 7
CENTRAL AMERICA: NUMBER OF TROPICAL STORMS AND HURRICANES RECORDED IN TWO PERIODS, 1971-1990 AND 1991-2015
(By number)



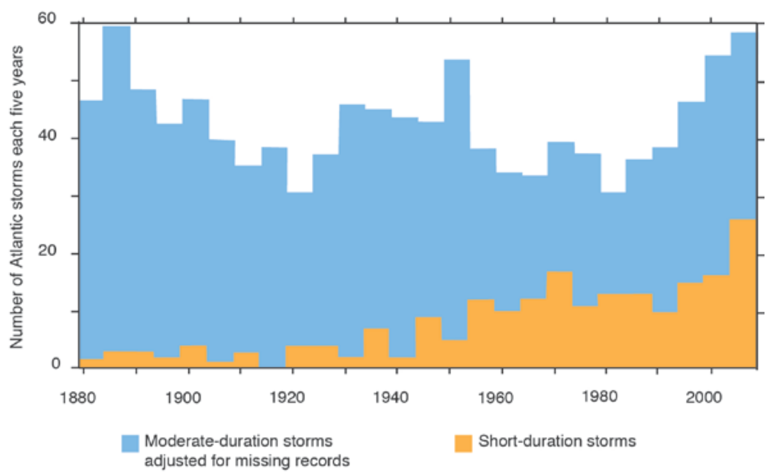
Source: Prepared by the authors using EM-DAT (CRED, 2015); it does not necessarily show all significant events.

CHART 8
NORTH ATLANTIC OCEAN: NUMBER OF HURRICANES, AND TROPICAL AND SUBTROPICAL STORMS, 1878-2015
(Yearly events (blue line) and five-year average (red line))



Source: Prepared by the authors using HURDAT (NOAA, 2015).

CHART 9
ATLANTIC OCEAN: NUMBER OF STORMS BY DURATION (MODERATE AND SHORT), 1878-2006
By five-year periods, moderate (blue), short (orange)



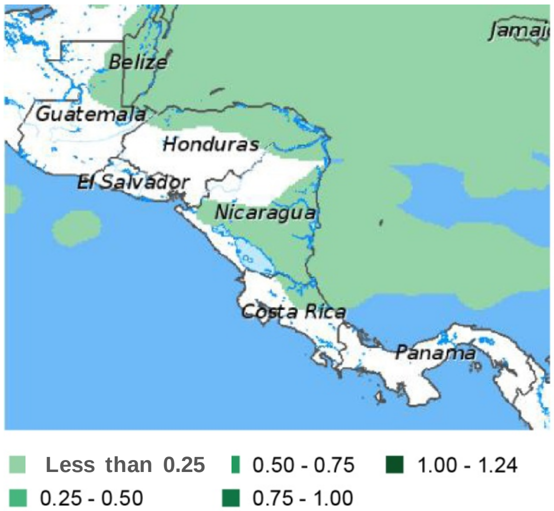
Source: NOAA, 2010.

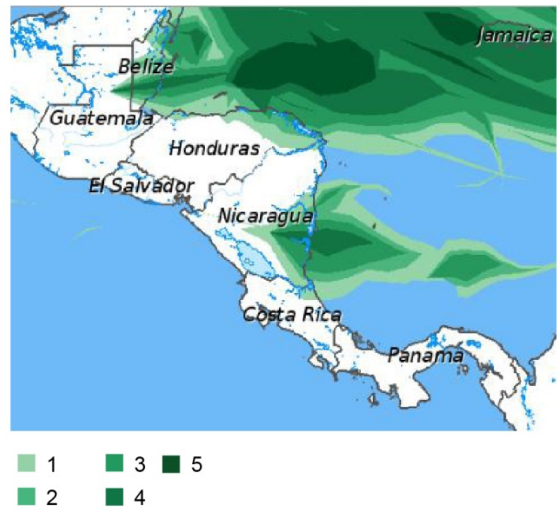
About the spatial distribution of tropical cyclones between 1977 and 2006, it has been observed that the most exposed territories comprise the totality of the Caribbean or Atlantic coast: the entirety of Belize, a large part of Honduras and Nicaragua, and northern Costa Rica. However, Caribbean hurricanes draw, or pull, the Inter-Tropical Convergence Zone (ITCZ) towards northern Central America, thereby provoking "storms" (a few days of heavy rain or large amounts of accumulated rainfall), floods and landslides in areas that are larger than those affected directly by the hurricane; this is what happened with Hurricane Mitch. Similarly, storms and hurricanes originating in the Pacific Ocean are now taking a serious toll on Central America, when, previously, their trajectory was more to the north. Tropical depressions and storms that do not become hurricanes are also bringing heavier rainfall, such as Tropical Depression 12-E, which caused severe damages in El Salvador and parts of Guatemala, Honduras and especially Nicaragua (ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA, 2012d).

MAP 2
CENTRAL AMERICA: SPATIAL DISTRIBUTION OF HURRICANE HAZARDS, 1977-2006

Hurricane frequency
(Average number of hurricanes per year per pixel)

Hurricane intensity
(Maximum intensity recorded at each pixel)





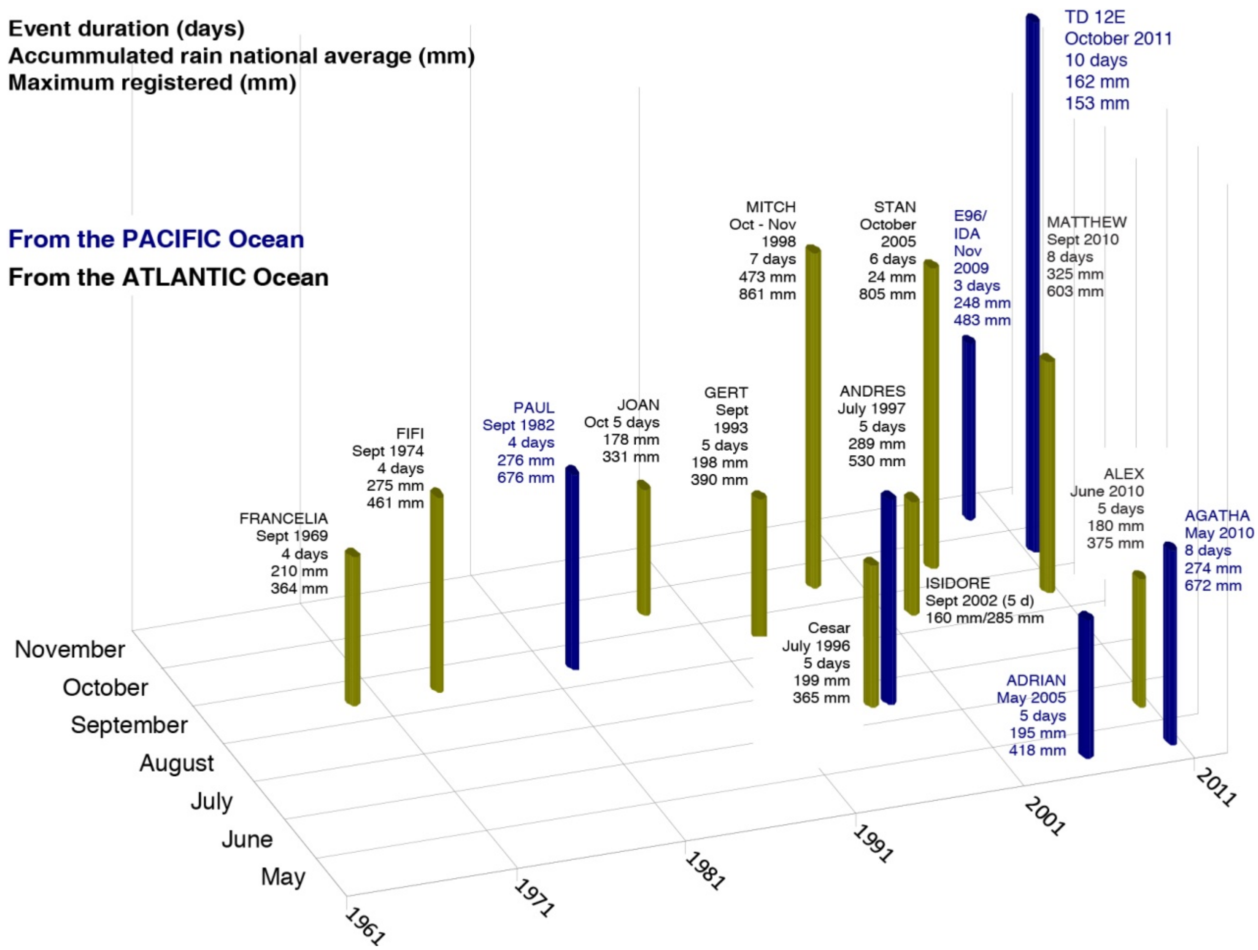
Source: UNEP, UNDP, ISDR and World Bank, 2010.
Note: Only available for category-1 tropical cyclones on the Saffir-Simpson scale.

Source: UNEP, UNDP, ISDR and World Bank, 2010.
Note: Saffir-Simpson Scale.

Chart 10 illustrates the above-mentioned situation in El Salvador, demonstrating the increase in hurricanes, cyclones and other systems that originated in the Caribbean, and the novelty of extreme events originating in the Pacific.

Records show that the frequency of tropical storms of short duration (less than two days) in the Atlantic Ocean has increased, mainly since 1960. The possible relationship between this trend and the possible effects of climate change and a higher concentration of precipitation is a potential line of inquiry. The frequency of storms of moderate duration (five days) is possibly undergoing a multidecadal fluctuation, as the trajectory of these storms has changed since 1980. In its Fifth Report (AR5) (2013b), the IPCC reported that human influence has been detected in the warming of the atmosphere and the ocean, in alterations to the global water cycle, in decreases in the quantity of snow and ice, in global sea levels and in changes to some extreme climate phenomena. This evidence of human influence is greater than when the Fourth Report (AR4) was prepared by the IPCC. It is highly probable that human influence has been the dominant cause of the warming observed since the middle of the 20th century. However, the AR5 (2013a) also indicates with medium confidence, that the decrease in aerosol radiative forcing since 1970 has contributed, at least in part, to the observed increased in tropical cyclone activity in this region. The evidence does not support the claim that these meteorological phenomena are very unlikely in the absence of human-induced climate change, despite the trend of many events that can be easily attributed to external factors (IPCC, 2013b).

CHART 10
EXTREME HYDRO-METEOROLOGICAL EVENTS IN EL SALVADOR, 1961-2011



Source: Ministry for the Environment and Natural Resources of El Salvador, 2011.

About the relationship between intensity of events and climate change, evidence is stronger. The special report by the IPCC on Managing the Risks of Extreme Events and Disasters to Advance Climate Change (SREX) updates AR4 and reaches similar conclusions using the revised uncertainty guide by AR5. The evidence shows with a high level of confidence that most hot and cold extremes are due to warming (IPCC, 2013b, 2012). Most of land areas analysed have experienced a warming of extreme temperature maximums and minimums since 1950 (Donat and others, 2013). The SREX supports the conclusion of the AR4 in that intense annual precipitation has increased disproportionately in comparison to the 1951-2003 average in many regions of average latitude, even when there has been a decrease in total annual precipitation. Regarding drought, the SREX concludes that there were not enough direct observations to suggest a high level of confidence in observed global trends. However, there is medium confidence that since the 1950s, some regions of the world have experienced longer and more intense drought. About tropical storms, the SREX and recent literature indicate that it is difficult to reach conclusions regarding the levels of confidence associated with observed trends prior to the satellite era. Recent evaluations indicate that it is unlikely that annual numbers of tropical storms and hurricanes have increased in the last 100 years in the North Atlantic, but the evidence does show, with greater certainty, an increase in the frequency and intensity of tropical cyclones since 1970 in this region (IPCC, 2013b, 2012).

A pattern of recurrent and abundant floods can be observed in natural flooding areas: river banks, lowlands and coastal regions. The most significant floods have occurred along the coast and in a large part of northern Belize. In Guatemala, coastlines and territories surrounding rivers and lakes are also affected by flooding. In El Salvador, there is a clear risk pattern on the coast and particularly on the banks of the Lempa river along its entire path. In Honduras, the flood risk pattern is concentrated on both coasts. Nicaragua has two regions that are at high risk of flood: the coast and the southwest of the North Atlantic Autonomous Region (RAAN), and the coastal region of Chinandega. In Costa Rica, extreme flooding primarily affects the areas of Guanacaste and the northern provinces of Alajuela, Heredia and Limón. Panama has the lowest incidence of extreme floods. Its most exposed region is a strip of the province of Darién (UNEP, UNDP, EIRD and World Bank, 2010).

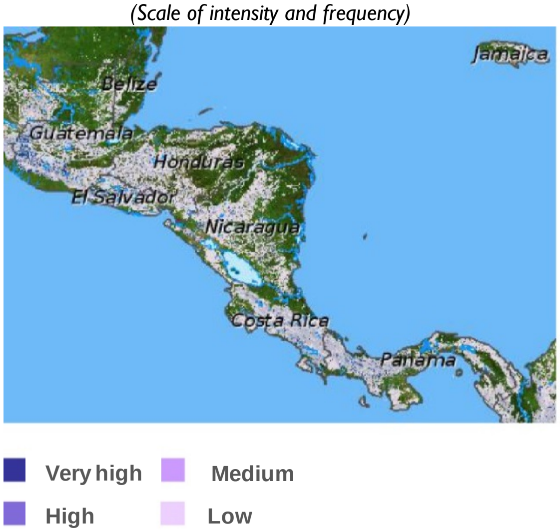
Landslides caused by precipitation are more significant than what it is normally believed when long time series are analysed. Map 3 illustrates that more than 80% of the Central American territory is exposed to the risk of landslides. Regions that are at high risk of landslides coincide with areas that are deforested or in the process of being deforested. The risk of landslides is concentrated in the centre and south of Guatemala. In El Salvador, where only 10% of the land area contains forests, landslides represent a very high risk. On the map, it is possible to see that almost all of its territory is exposed, with high and very high intensities at the midpoint.

In Honduras, the regions at high risk of landslides are concentrated in the centre and southwest of the country. In Nicaragua, these regions are concentrated in the departments of Jinotega, Matagalpa, Chinandega and the rest of the Pacific coast. Almost all of Costa Rica, except for the northern provinces of Limón, Heredia and Alajuela, are exposed to landslides of medium to very high intensity. Almost all of Panama is exposed to the same risk with variable magnitudes, except for the territory of Herrera and small portions of Colón, Panamá, Los Santos and Darién. In Belize, only the western territories are exposed to the risk of landslides of very low to low intensity (UNEP, UNDP, EIRD and World Bank, 2010).

Regarding drought, there is no area in Central America that has not suffered from its effects in the last thirty years. Between 1974 and 2004, Guatemala, Honduras, Nicaragua, the Pacific coast of Costa Rica and the Atlantic coast of Panama experienced the greatest concentration of drought events. The most severe droughts have occurred in the eastern territories, in the departments of Alta Verapaz and part of El Petén, Guatemala; the north of Cortés department and the northwest of Gracias a Dios, Honduras; Rivas department, Nicaragua; and the north of Guanacaste province, Costa Rica (see Map 4). Droughts are associated with environmental degradation, which, combined with adverse climate conditions, increases drought recurrence and dryness. El Niño (ENSO) typically causes significant losses in all the countries in the region, and these losses could be exacerbated by the predicted effects of climate change (UNEP, UNDP, EIRD and World Bank, 2010).

MAP 3
CENTRAL AMERICA: SPATIAL DISTRIBUTION OF THE LANDSLIDE HAZARDS

Landslide risk
(Scale of intensity and frequency)



2007 Forest cover
(Forest types)

Source: UNEP, UNDP, ISDR and World Bank, 2010.

Note: Landslides due to precipitation.

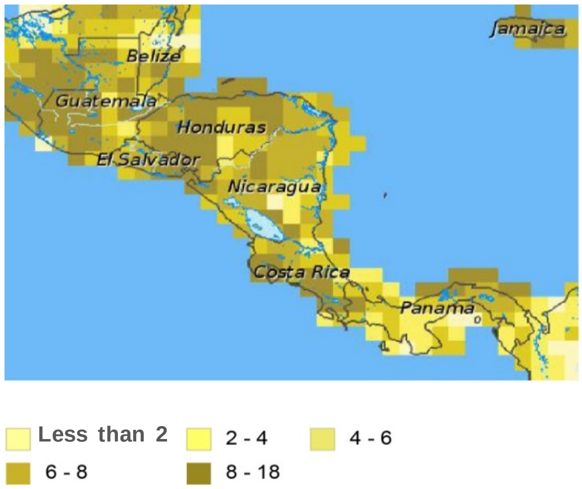
Aridity and drought can occur in the same geographical region, but they are distinct phenomena. Drought is an extreme phenomenon characterized by a scarcity of rainfall relative to the historical average of a given geographical region. According to the United Nations Convention to Combat Desertification (UNCCD), drought is a phenomenon that occurs naturally when rainfall has been significantly lower than normal recorded levels, causing a serious water imbalance that hurts resource production systems in the area. It can occur with certain frequency as part of natural climate variability, but its intensity and duration can be modified by human activity, especially deforestation, degradation of ecosystems and climate change (Wilhite and Buchanan-Smith, 2005). When temperature, precipitation and phenomena such as El Niño undergo permanent changes, the affected area can experience changes in the level of aridity or in the pattern of dry months beyond a drought as an extreme event. Nevertheless, changes of this type can be perceived as an extension or intensification of normal drought conditions.

Central America is home to an area known as the "Dry Corridor" which is more arid than the rest of the region. This corridor, along with other areas in the region, has been severely affected by periods of drought. The Central America Dry Corridor (CSC) encompasses areas in Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama, but most of the corridor is located on the Pacific watershed (MARENA, 2001; Ramírez, 1983; ECLAC, 2002). The region faces periods of drought, particularly in the Pacific watershed. Severe drought in recent years (2009-2010 and 2014-2015) have affected agricultural production, especially in the "dry corridor", which comprises areas of the Pacific watershed, and the interior from Guatemala to Panama. An El Niño event with an irregular rainy season took place in June 2009 which primarily affected the Pacific watershed. Precipitation during the second period of rain, between September and October, was also irregular. This prevented the refilling of water sources and the subsoil, causing the use of water for human, livestock and the second sowing period consumption to be limited (PESA, 2010).

MAP 4
CENTRAL AMERICA: SPATIAL DISTRIBUTION OF DROUGHTS, 1974-2004

Frequency of droughts

(Average number per year drought by pixel)

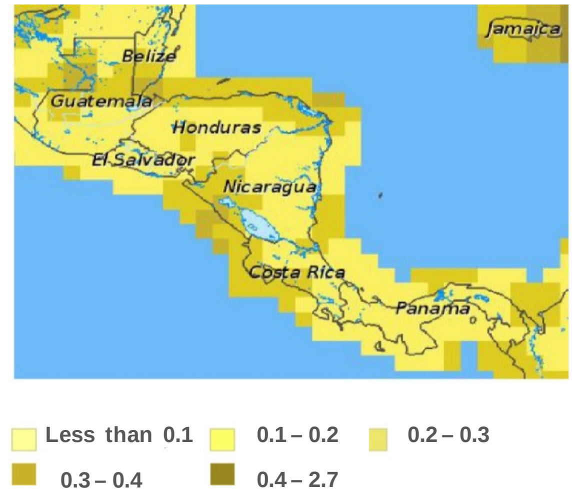


Source: UNEP, UNDP, ISDR and World Bank, 2010.

Note: Calculated using the standardized precipitation index for six months (SPI6). The definition of drought is: three consecutive months with less than 50% of average precipitation for the period 1980-2011.

Severity of droughts

(Coefficient of variation)



Source: UNEP, UNDP, ISDR and World Bank, 2010.

Note: Measure of precipitation variability in relation to climatological precipitation average for the 1980-2011 period.

DROUGHT IN CENTRAL AMERICA 2014-2015

In 2014, Central America was afflicted by a strong drought that affect production of the first season of basic grains, especially maize and beans. The dry corridor was affected by significant rainfall shortages which led to up to 27 consecutive days and a total of 45 days without rain between July and August (FEWS NET, 2014; Morel, 2014; WB, 2014). The lack of rain coincided with the most critical phases for crop development, i.e. when the need for sufficient water is the greatest (FEWS NET, 2014). More than 500,000 families in Guatemala, Honduras, Nicaragua and El Salvador experienced serious food insecurity due to severe drought (WB, 2014).

In El Salvador, at least 65,000 hectares were affected, and basic grains were irreversibly damaged. Two dry periods between June and July damaged 34% of maize and 20% of beans as a proportion of national production. The most affected regions were in the south and east of the departments of Santa Ana, Chalatenango, Usulután, San Miguel, Morazán and La Unión (FEWS NET, 2014).

In Guatemala, drought affected 70% of the territory and the poorest 54% of the population. Approximately 236,000 families faced situations of food insecurity (WB, 2014). Up to 75% of maize and bean crops were lost, and thousands of head of cattle were lost (UN News Centre, 2014). The lack of rainfall had greater repercussions in the east of the country, in the departments of Jutiapa, Zacapa, Chiquimula, El Progreso and Jalapa. As of October, it had been reported that 30,000 families had finished their food reserves, which aggravated an urgent situation of food insecurity (FEWS NET, 2014; UN News Centre, 2014).

In Honduras, the western regions were the most impacted by the lack of rainfall, including the departments of El Paraíso, Choluteca, Francisco Morazán, Valle, La Paz, Intibucá, Lempira, Ocotepeque, Copán and Comayagua (FEWS NET, 2014; UN News Centre, 2014). By June 2014, 2,000 tons of red beans had been purchased from Ethiopia, which caused a steep rise in the price of this crop and aggravated the already precarious situation for low-income families (Castro, 2014).

According to the Nicaraguan Institute for Territorial Studies (Ineter), there was a historic decrease in rainfall (75%) in May, which reached up to 88% in the Central Pacific region (Álvarez and Navas, 2014). Nicaragua lost approximately 75% of its first maize crop in 2014 over an area that stretches from the Pacific coast to the centre and north of its territory. The departments that were most affected are Nueva Segovia, Jinotega, Madriz, Estelí, Matagalpa, León and Chinandega where more than 2,000 head of cattle died (FEWS NET, 2014; Morel, 2014).

The year 2015 was the second consecutive year in which a severe drought caused by El Niño drastically reduced yields of beans and maize in the first season (May to August) in El Salvador, Guatemala, Honduras and Nicaragua. The accumulated rainfall represents between 30% and 50% of the historical average. This has caused losses of up to 60% of maize crops and up to 80% of bean crops for many small producers in the region. This has placed hundreds of thousands of households and 2.5 million people in situations of serious food insecurity, with a great need for emergency food assistance. In total, 3 million tons of maize were lost throughout the region, and there was a reduction of 8% relative to the harvest from 2014 (FAO, 2015; FEWS NET, 2015a).

Honduras and El Salvador were the countries that were hardest hit by this drought. Both countries lost 60% of maize crops and 80% or more of bean crops in the first growing season in the most affected regions, as a consequence of the lack of rainfall. In El Salvador, these percentages are the equivalent of 88,000 hectares of maize and 2,400 hectares of beans. It is estimated that the number of people still in need of emergency assistance has reached 253,000 in Honduras and 192,000 in El Salvador (FAO, 2015; Lutheran Relief Web, 2015).

It is estimated that 80% of crops from the first growing season have been lost in the affected areas of Guatemala, including 55,000 tons of maize and 11,500 tons of beans, which has impacted more than 170,000 families (approximately, 900,000 people) who don't have food reserves (FAO, 2015; Reuters, 2015). Currently, the western highland is the most affected area. It is estimated that households in this region will be in a state of crisis until November due to the lack of rainfall during the first growing season and the losses experienced in coffee production due to blight (FEWS NET, 2015c). In Nicaragua, the prolonged period of "dog days" has affected the departments of Chinandega, western Estelí, north-western Nueva Segovia, western Madriz, Boaco and Carazo, which represent approximately 30% of total national production. In these departments, damages have been greater than 50%, and within the most impacted areas, a total loss of crops has been reported (FEWS NET, 2015b). Annual results will depend on climate conditions of the second production cycle and of the smaller, third cycle wherever it is carried out.

MAP 5
CENTRAL AMERICA: KEY AREAS OF CONCERN REGARDING SEVERE FOOD INSECURITY

Source: FEWS NET, 2015a

Note: Although this report focuses solely on Central America, FEWS NET estimated no emergency aid to 1.5 million people in Haiti and that 2 million people in Guatemala, Honduras, El Salvador and Nicaragua will be in crisis by March 2016.

ESTIMATES OF ECONOMIC LOSSES ASSOCIATED WITH CLIMATIC EXTREME EVENTS

The estimation of economic losses attributable to extreme events began approximately four decades ago through a common effort by national and regional institutions and the United Nations, including ECLAC. 22 major events are covered, some of which affected several countries in the region, causing estimated cumulative losses of approximately 23 billion dollars in 2008 prices (see table 4).[6] Of this amount, 49% corresponded to productive sectors, of which 66% corresponded to agriculture and 12% in trade. Additionally, 26% of economic losses corresponded to infrastructure. Finally, it is worth noting that this record includes a growing number of droughts, storms and tropical depressions in the last decade.

In international negotiations, Central American governments have prioritized not only adaptation but also the establishment of the Warsaw mechanism in order to have a formal framework in which to treat losses and damages related to climate change. This priority does not stem only from the current high vulnerability of the region to extreme events, but also from the concern derived from greater evidence of the probable effects of climate change in the intensification of these events.

Scenarios on the possible trajectories of precipitation with climate change suggest greater variability and a probable downwards trend in terms of quantity, particularly in the second half of this century. It is important to state that the scenarios of possible impacts on precipitation are more uncertain than those dealing with temperatures. Under the less pessimistic scenario (B2), precipitation would decrease by 4% towards 2050 and by 11% by the end of the century, as an average

[6] These events include five events valued with the Dominican Republic.

for Central America, with significant variations depending on the country. For example, toward the end of the century, the decreases estimated at the national level are: 3% in Panama, 7% in Guatemala, between 10% and 13% in Costa Rica, Belize, El Salvador and Honduras, and 17% in Nicaragua. Under the most pessimistic scenario (A2) there would be a 14% decrease in precipitation by 2050 and 28% by the end of the century, with an estimated 18% decrease in Panama, 35% in Nicaragua and between 27% and 32% in Costa Rica, Belize, El Salvador, Guatemala and Honduras. [7] (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011). Under the new emissions scenarios in AR5 by the IPCC, it is estimated that there will be a change in precipitation of between 5% and -17% for Central America under RCP 6.0, and between 11% and -26% with RCP 8.5 [8] (IPCC, 2013b, ECLAC, 2015b).

POTENTIAL IMPACTS ON ARIDITY AND DRY MONTHS

However, even though a smaller decrease in precipitation is expected under scenario B2, rising temperatures will lead to greater evapotranspiration and result in reduced availability of water, especially in the second half of the century, thereby affecting ecosystems, agriculture and hydroelectric power generation. Under the more pessimistic scenario (A2), the repercussions would be greater. An aridity analysis prepared by the Economics of Climate Change in Central America initiative (ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA, 2012b) finds that temperature and precipitation levels from the period 1950-2000 generate an aridity index of 1.6 for Central America, thus falling under the international classification of "humid". Seven departments (León, Estelí, and Managua in Nicaragua, El Paraíso in Honduras, and Chiquimula, El Progreso and Zacapa in Guatemala) are exceptions. They have indices of 1.25 or lower, and therefore are classified as "sub-humid". These areas are part of the Central American dry corridor. At the other end of the spectrum, the Western Highlands of Guatemala have the greatest humidity, with an aridity index value of 1.96.

Towards the end of the current century, it is estimated that the regional average of the aridity index could decrease to 1.4 in the less pessimistic scenario (B2), and 1.2 in the most pessimistic scenario (A2). In the latter scenario, the region would, on average, be "sub-humid" (0.91 to 1.25). Map 6 illustrates the gradual increase in aridity under scenario A2: while 7 departments have an aridity index value of 1.25 or less in the historical period, this number could rise to 20 by 2020, 38 by 2050, and 68 by the end of the century. By the end of the century, a large part of the region could experience aridity conditions similar to those currently experienced in the driest regions of the dry corridor.

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[7] These two generations of scenarios have different parameters, and the RCPs do not yet have predetermined socioeconomic scenarios, meaning that the two generations are not easily comparable. Nevertheless, until 2100, scenario RCP 6.0 has a CO_2 concentration trajectory similar to, but higher than, scenario B2, and RCP 8.5 is closer to SRES A1F1 with a scenario similar to, but higher than, scenario A2 (IPCC, 2013b, citing Malte Meinshausen).

[8] The *National Institute for Environmental Studies* of Japan created RCP 6.0 using the *Asia-Pacific Integrated Model* (AIM) and the *International Institute for Applied Systems Analysis* of Austria created RCP 8.5 using three models for energy (MESSAGE), forest management (DIMA) and agriculture (AEZ-WFS).

TABLE 4
CENTRAL AMERICA AND DOMINICAN REPUBLIC: ECONOMIC LOSSES CAUSED BY MAJOR DISASTERS

(In millions of dollars at 2008 prices)

Country	Year	Event	Total for all sector	Social sectors	Housing	Education	Health	Culture	Infrastructure	Communications and transport	Electricity	Water and sanitation	Irrigation. drainage and others	Productive sectors	Agriculture	Industry	Commerce	Tourism	Environment	The impact on women and other
Belize	2000	H. Keith	398.9	55.4	50.3	2.2	2.9	…	65.2	60.7	3.1	1.4	…	242.4	91.2	…	33.6	117.6	35,9	…
	2007	H. Dean	108.0	20.7	20.2	0.3	0.2	…	7.1	6.4	0.6	0.1	…	76.2	70.5	…	…	5.7	4,0	…
	National Total		506,9	76.1	70.5	2.5	3.0	…	72.3	67.1	3.7	1.5	…	318.6	161.7	…	33.6	123.3	39.9	…
Costa Rica	1996	H. Cesar	201.3	47.1	26.5	15.1	5.5	…	126.6	122.0	1.6	3.0	…	27.6	16.6	3.8	5.1	2.1	…	…
	1997	El Niño	110.0	1.6	1.5	…	0.1	…	28.7	…	28.6	0.1	…	71.7	70.2	1.5	…	…	8,0	…
	1998	H. Mitch	120.3	4.6	3.0	0.5	1.1	…	33.2	31.9	0.1	1.2	…	82.5	82.5	…	…	…	…	…
	2011	DT.12E	80,3	0.8	0.8	…	…	…	47.2	47.2	…	…	…	32.3	32.3	…	…	…	…	…
	National Total		511,9	54.1	31.8	15.6	6.7	…	235.7	201.1	30.3	4.3	…	214.1	201.6	5.3	5.1	2.1	8.0	…
El Salvador	1998	H. Mitch	512.7	49.7	18.0	15.3	16.4	…	98.2	93.0	0.5	3.2	1.5	355.6	209.1	97.6	48.9	…	9,2	…
	2001	Drought	37.4	…	…	…	…	…	4.5	…	4.5	…	…	32.9	31.0	1.9	…	…	…	…
	2005	TT. Stan	357.6	164.7	124.7	21.3	18.7	…	126.6	113.6	…	13.0	…	66.3	53.7	3.4	4.7	4.5	…	…
	2009	TT. IDA	316,0	39.8	18.5	11.1	10.3	…	133.2	118.6	-5.1	19.7	…	82.7	42.7	15.5	24.5	…	60.3	…
	2010	TT. Agatha	110,7	43.4	20.0	12.0	11.4	…	35.1	32.4	0.5	2.2	…	20.4	11.3	1.8	7.2	0.1	12.0	…
	2011	DT.12E	863,8	198.2	134.7	20.5	43.0	…	267.6	233.9	6.6	27.1	…	324.5	166.8	30.6	125.7	1.4	73.3	0,2
	National Total		2 198,2	495.8	315.9	80.2	99.8	…	665.2	591.5	7.0	65.2	1.5	882.3	514.5	150.8	211.0	6.0	154.7	0,2
Guatemala	1982	Floods	180.1	11.5	10.9	0.2	0.4	…	50.8	19.9	25.4	3.3	2.2	117.8	117.8	…	…	…	…	…
	1998	H. Mitch	988.0	63.5	46.6	6.5	10.4	…	153.0	118.5	13.2	21.3	…	764.8	659.6	81.4	23.8	…	6,7	…
	2001	Drought	26.2	…	…	…	…	…	8.4	…	8.4	…	…	17.8	15.0	2.8	…	…	…	…
	2005	TT. Stan	1 003.4	169.7	145.1	8.9	15.7	…	492.8	474.1	5.6	13.1	…	296.3	85.7	62.5	89.2	58.9	44,6	…
	2010	TT. Agatha/ Pacaya volcano eruption	977,0	194.7	95.5	80.9	15.6	2.8	366.8	324.0	11.7	14.5	16.6	130.7	83.0	39.2	4.2	4.4	258.2	26,6
	2011	DT.12E	318,6	54.9	43.5	3.2	6.5	1.7	36.7	35.3	0.1	1.1	0.2	80.3	66.9	2.4	10.9	0.1	140.5	6,1
	National Total		3 493,3	494.3	341.6	99.7	48.6	4.5	1 108.5	971.8	64.4	53.3	19.0	1 407.7	1 028.0	188.3	128.1	63.4	450.0	32,7
Honduras	1974	H. Fiji	523.1	102.6	102.6	…	…	…	16.6	…	16.6	…	…	403.9	303.5	34.9	…	65.5	…	…
	1998	H. Mitch	5 010.7	580.3	454.5	82.2	43.6	…	911.5	764.9	76.5	37.5	32.6	3 457.2	2 683.1	497.4	276.7	…	61,7	…
	2001	Drought	58.5	…	…	…	…	…	12.6	…	3.8	8.8	…	45.9	39.3	6.6	…	…	…	…
	2011	DT.12E	195,3	60.3	50.5	1.9	7.9	…	34.4	33.4	0.03	1.0	…	67.2	61.7	2.3	3.2	…	32.1	1,3
	National Total		5 787,6	743.2	607.6	84.1	51.5	…	975.1	798.3	96.9	47.3	32.6	3 974.2	3 087.6	541.2	279.9	65.5	93.8	1,3

(Continued)

Country	Year	Event	Total for all sector	Social sectors	Housing	Education	Health	Culture	Infrastructure	Communications and transport	Electricity	Water and sanitation	Irrigation. drainage and others	Productive sectors	Agriculture	Industry	Commerce	Tourism	Environment	The impact on women and other
Nicaragua	1982	Floods	795.5	100.0	59.6	33.5	6.9	…	400.5	351.6	10.7	33.5	4.7	295.0	244.8	42.6	7.6	…	…	…
	1988	H. Joan	1 412.7	606.5	518.3	77.2	11.0	…	289.3	261.0	1.4	14.3	12.6	234.3	141.0	52.9	40.4	…	282,6	…
	1996	H. Cesar	68.7	12.5	11.8	0.3	0.4	…	19.9	19.2	0.4	0.3	…	36.3	31.4	…	4.9	…	…	…
	1998	H. Mitch	1 303.7	356.5	258.3	70.1	28.1	…	448.4	404.6	18.6	25.2	…	487.4	244.6	126.7	116.1	…	11,4	…
	2001	Drought	49.1	…	…	…	…	…	7.7	…	…	7.7	…	41.4	35.4	6.0	…	…	…	…
	2007	Felix/ Floods	883.0	94.3	77.8	7.7	8.8	…	149.1	143.8	3.6	1.7	…	74.1	74.1	…	…	…	565,5	…
	2011	DT.12E	426,4	48.1	19.4	0.2	28.5	…	253.8	187.6	3.4	62.8	…	70.8	60.9	6.3	3.5	0.1	53.6	0,1
	National Total		4 939,1	1 217.9	945.2	189.0	83.7	…	1 568.7	1 367.8	38.1	145.5	17.3	1 239.3	832.2	234.5	172.5	0.1	913.1	0,1
Dominican Republic	1979	H. David and Federico	1 701,8	163.9	56.4	62.0	45.5	…	300.9	184.2	102.4	14.2	…	1 237.1	608.2	320.4	308.5	…	…	…
	1998	H. George	2 897,1	426.4	306.3	90.9	29.2	…	879.0	438.5	117.4	21.7	301.4	1 428.1	696.6	427.0	74.0	230.5	163.7	…
	2003	Floods	49,8	3.5	0.5	0.9	2.1	…	9.8	8.5	0.2	1.1	…	36.4	36.4	…	…	…	…	…
	2004	H. Jeanne	347,7	18.1	13.1	1.7	3.4	…	106.0	99.8	4.2	2.0	…	220.2	85.8	23.3	111.1	…	3.4	…
	2008	TT. Noel	455,9	84.7	64.3	15.2	5.2	…	142.2	46.9	70.3	25.0	…	225.5	170.5	53.0	1.9	…	3.6	…
	National Total		5 452,3	696.6	440.6	170.7	85.4	…	1 437.8	777.9	294.5	64.0	301.4	3 147.3	1 597.5	823.7	495.5	230.5	170.7	…
Accumulated losses			22 889,7	3 778,1	2 753.1	641.7	378.6	4.5	6 063.7	4 775.4	535.3	381.1	371.8	11 183.4	7 423.1	1 943.8	1 325.6	490.9	1 830.3	34.3

Source: ECLAC, several years.

Note: Deflated by the Consumer Price Index (CPI) of the United States. H. = Huracán; TS. = Tropical Storm.

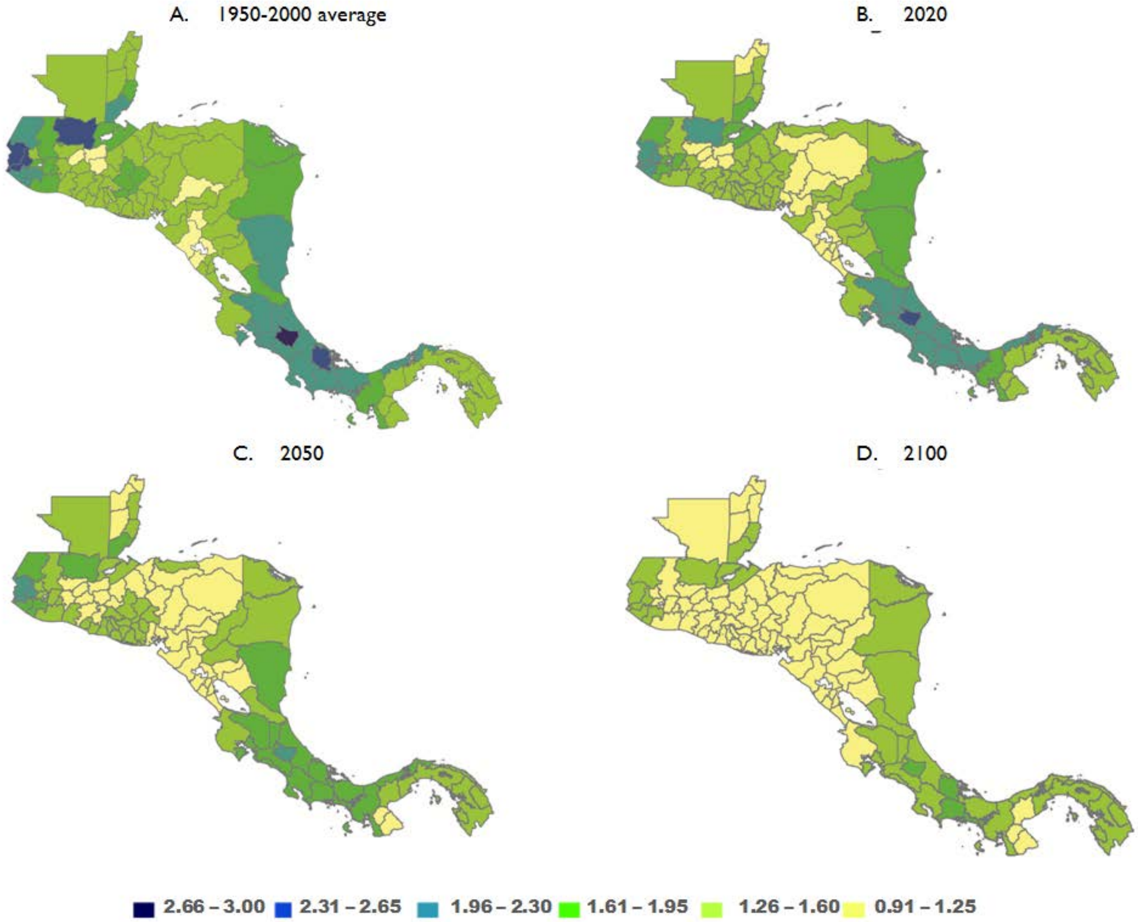
The Economics of Climate Change in Central America initiative (ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA, 2012b) also included an analysis of the number of dry months per year during the period 1950-2000 and under the climate change scenarios. A dry month is one in which precipitation is less than 50% of evapotranspiration for that same month (CAZALAC, PHI and UNESCO, 2005). During the reference period, the Pacific region had the highest number of dry months per year, ranging between four and six months, mainly in Guatemala, El Salvador, Honduras and Nicaragua. By contrast, the Atlantic region had the lowest number. In fact, historically, the District of Toledo (Belize), the departments of Alta Verapaz and Izabal (Guatemala), and Atlántida (Honduras) and the Atlantic region of Costa Rica have not experience dry months in general. The rest of the region has between one and two dry months. The Central region and the Western Highlands of Guatemala have more diverse climates, with between one and six dry months.

In the decades to come, there could be greater variability, manifesting itself as both an increase and decrease in dry months. Considering that current variability, both inter- and intra-annual, gives rise to serious impacts on the region, it is of utmost importance to improve the capacity to adapt and manage risk in the short term. As of 2050, there will be a more generalized trend of increases in the number of dry months and a gradual differentiation between the two scenarios, with A2 being the more severe of the two. Short term efforts to respond to climate variability and extreme events will be key to reducing losses in the short term and in preparing the region for severe cumulative changes that could take place in the medium term.

Under scenario B2, by 2020 the number of dry months would increase in 13 departments and would decrease in 18. 64 departments would experience conditions that are relatively stable with respect to the 1950-2000 average. Under scenario B2, by 2050 the number of dry months would increase in 12 departments and decrease in 24, while 59 would experience conditions similar to historical ones. These three groups would represent 8%, 23% and 69% of the region's area, respectively. Under scenario B2, until the year 2050, most departments would generally experience limited changes in terms of an increase or decrease in the number of dry months. In the long-term, more than a fifth of the departments would see an increase in the number of dry months. Under scenario B2, by 2100 the number of dry months would increase in 22 departments and decrease in 30, while 43 would experience conditions similar to historical ones. By 2100, 28% of the region would experience an increase in the number of dry months, 27% would experience fewer dry months, and 45% would see conditions similar to the historical ones.

It is estimated that under scenario A2, by 2020, there would be an increase in the number of dry months in 35 departments and a decrease in 14, while 46 would remain stable. These three groups would represent 39%, 13% and 48% of the region's territory, respectively, and where the changes would be more notable (see Map 7). By 2050 changes would become more severe: the number of dry months would increase in 36 departments (34% of the region), decrease in 10 (6%) and remain relatively stable in 49 (60%) with respect to the historical average. Under scenario B2, by 2100 the number of dry months would increase in 47 departments and decrease in 11, while 37 would experience conditions similar to historical ones. Therefore, by 2100, 53% of the region would experience an increase in the number of dry months, 8% would experience fewer dry months, and 39% would see conditions similar to historical ones.

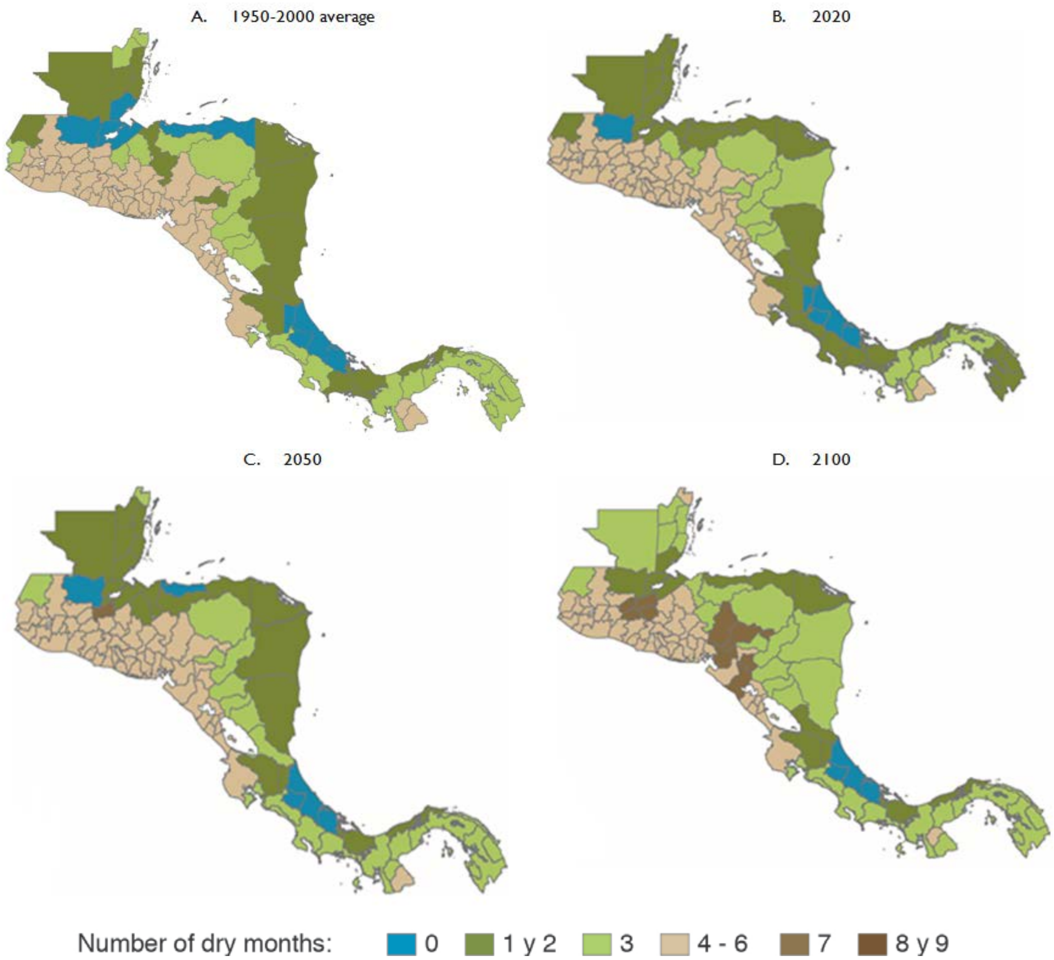
MAP 6
CENTRAL AMERICA: ARIDITY INDEX VALUES BY DEPARTMENT, 1950–2000 AVERAGE AND SCENARIO A2 UP TO 2100
(Aridity index units)



Source: ECLAC, CCAD/SICA, UKAID, DANIDA (2012b).

Under this scenario, the provinces of Limón and Cartago in Costa Rica and Boca del Toro in Panama would be the only provinces without dry months by the end of the century. It is worth noting that there will be an increase in aridity in the majority of the departments on the Atlantic coast, primarily in those that currently have between one and two dry months, but in the future these departments will have three dry months. It is also worth mentioning that there will be an increase in the number of dry months in certain regions of Guatemala, El Salvador, Honduras and Nicaragua after 2070. It is expected that the departments of Zacapa, Chiquimula, El Progreso and Jalapa in the dry corridor of Guatemala, the departments of Choluteca, El Paraíso and Francisco Morazán in Honduras, and León and Estelí in Nicaragua will have seven dry months compared to the historical patterns of six months in the departments of Guatemala and five of Honduras and Nicaragua. The results show signs of possible fluctuations to even greater numbers of dry months toward the end of the century. Changes in the intra-annual dry month pattern would be more pronounced in Guatemala, Honduras and Nicaragua, due to the possible occurrence of dry months in parts of their territory in June, July and August under scenario A2. The period of "dog days" usually occurs during these months, but, historically, humidity has not been low enough for this period to be defined as dry months. These changes could be significant due to their impact on agricultural cycles and operating rules for hydroelectric plants.

MAP 7
CENTRAL AMERICA: NUMBER OF DRY MONTHS PER YEAR BY DEPARTMENT, 1950–2000 AVERAGE AND SCENARIO A2 UP TO 2100
(In number of dry months)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA (2012b).

To summarize, Central America is producing evidence of a significant increase in the frequency of extreme events, such as floods, storms and hurricanes. Science indicates that the temperature increase of the Central American land mass and the surrounding oceans should give rise to greater evaporation, more extreme accumulated precipitation events and more intense hurricanes, and the intensity of the rains being experienced by the region confirm this.

The climate change scenarios generate different impacts on temperature and precipitation depending on country, department and geo climatic region. In general, the temperature in the region has already shown an increase in recent decades, and gradual increases would continue to be experienced every decade. These increases would be greater in scale if global emissions continue to rise in a scenario resembling A2. The scenarios provide more complex results for precipitation, with smaller changes for B2 and greater probability of severe decreases for A2 in the medium term, although there will be certain positive and negative fluctuations in the upcoming decades.

To summarize, this study shows that the climate change scenarios estimate different impacts on temperature and precipitation depending on the country, department and geoclimatic region.

Nevertheless, if global emissions continue their current upward trend, the most probable scenario will be the more pessimistic one (A2). Given the variability of conditions and the cumulative trend of aridity estimated for the upcoming decades, Central American societies need to become bold managers of water, ensuring its sustainable and efficient use for production and human consumption. Even without climate change, the demand for water will increase significantly in the region. With climate change, it is estimated that there will be a decrease in humidity and the overall availability of renewable water, particularly for the five countries to the north of Costa Rica (ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA, 2012b).

There are several work groups in the region that analyze the climate of the region. One such group is the Central American Climate Forum (FCAC), which is a work group coordinated by the Regional Committee on Hydraulic Resources (CRRH) of SICA, consisting of experts in meteorology, climatology and hydrology from the Meteorological and Hydrological Services, universities and private businesses. The aim of this group is to issue, update and verify quarterly climate predictions and their applications for risk management in agriculture, fishing, water resources and food security in Central America. There is also the Regional Forum for the Application of Climate Forecasts to Food and Nutrition Security (FSN), which creates scenarios of possible impacts on sectors related to Food and Nutrition Security and generates recommendations to provide decision makers and the society in general with information that allows them to prevent, respond to, and mitigate the possible impacts of climate variability in their field.

BOX 1
RECOMMENDATIONS FOR ADDRESSING CLIMATE RISKS

Given that current variability, both inter- and intra- annual, gives rise to serious impacts on the region, it is of utmost importance to improve the capacity to adapt and manage risk in the short term. The following are potential options for reducing the effects of climate variability:

- Respond to climate variability and extreme events in the short term to reduce losses in the short term and prepare the region for severe cumulative changes that could take place in the medium term.
- Protect natural ecosystems and their biodiversity, including forests, mountain and river systems, coastlines, including corals and mangroves. This is essential for maintaining the multiple services that these provide to humans and other living creatures.
- Protect and restore ecosystems that are dependent on relatively humid climate. This is an important development challenge even without taking climate change into account.

- Refine the analysis of potential impacts on sectors such as agriculture, water consumption, health, and hydroelectricity. Information that is georeferenced and disaggregated by department and geoclimatic region and divided temporally by cut-off years and intra-annual patterns is a useful tool for this refinement. Specification on smaller scales is also important to develop adaptation actions for specific geographic regions.

- Expand and strengthen the network of meteorological and hydro-meteorological stations as well as the network of climatology and hydrology professionals. Climate information is a useful tool for refining the analysis of potential impacts on certain sectors, and for formulating adaptation actions for specific geographical regions.

- Estimating the complementarity of the effect of climate change and extreme events, and even single events. A group of international experts is trying to establish methods that will allow for the estimation of this complementarity. Therefore, in Central America, the hypothesis that the increase in number of extreme events is partly attributable to climate change beyond natural climate variability is worthy of consideration and it is proposed that this type of technical analysis continue to be undertaken by regional experts and international partners.

Evidence of changes in the climate and current growing impacts of extreme events, such as tropical depression 12-E, prove that urgent measures need to be taken. At the same time, the growing threat of even worse impacts and costs in the future means that these reconstruction measures should be different than in the past. They need to consider changes in infrastructure standards, efforts to protect river basins and natural coastal barriers such as mangroves, efficient water management that takes into account the design and location of homes, social infrastructure and communities, among many other possible measures. Such investment would reduce both vulnerability and the costs associated with future extreme events, while simultaneously building greater resistance to the increased impacts that are estimated to gradually result from climate change.

The region requires a proactive, comprehensive and intersectoral approach to prevention and mitigation of the negative effects of extreme events, taken by public and private actors, overcoming a reactive response. This requires taking decisions and implementing measures to prevent and reduce vulnerabilities and strengthen warning systems and provide a response with the best information available, and at the same time, generate greater better forecasting capacities at the national and local scales (Landa, Magaña and Neri, 2008). The sensitivity of the region to the growing impacts of extreme events allows for the organization of responses to be an effective channel to create a new culture that considers the coexistence of humanity and nature essential, with the consequent socioeconomic practices and use of land. Given this context, the following are potential options for adaptation to climate change and its impact on extreme events are:

- Integrate settlement, infrastructure, equipment and secure housing programmes into poverty-reduction strategies with prevention criteria and disaster control.

- Establish laws, programmes and incentives for the design and renovation of settlements and housing resistant to extreme events, efficient in water-use, and other bioclimatic features adaptable to local conditions, providing appropriate technology according to the means and experience of the self-builders.
- Increase the level of environmental security of basic infrastructure, including roads, bridges, education and healthcare infrastructure, and hydraulic works to prevent floods and droughts.
- Implement land use strategies and land management plans based on technical studies, including climate vulnerability to determine urban, agricultural, forest and other natural ecosystem uses, including protected areas. [9]
- Reforestation of areas, hillsides and areas prone to landslides as part of programmes to achieve sustainable use and improve quality of life; actions that can contribute to reducing GHG emissions or could be paid for as environmental services. Similarly, re-establish mangroves and coastal protection barriers which are beneficial for fishing productivity and local ecotourism.
- Make the population aware of its role in the prevention of disasters and create processes for community organization and education regarding measures to mitigate the impact of extreme events, including secure housing, relocation of communities, local plans of action, refuges, emergency deposits and other actions regarding mitigation, self-protection and self-help.
- Establish systems to monitor natural and anthropogenic phenomena to issue early warnings.
- Study in more detail future scenarios on the intensity and frequency of extreme events and their costs; refine methodologies of economic valuation and specific contingency fund requirements.
- Expand extreme event evaluation coverage to small and medium events, with local impact and high recurrence to better understand risk.
- Adopt the approaches of the Sendai Framework for Disaster Risk Reduction (2015-2030) in order to promote a culture of prevention and reduce the risk of disasters with a view to sustainable human development.

[9] Environmental and urban planning is one of the fundamental strategies for achieving sustainable development and a more optimal geographic distribution of the population of its activities and natural wealth, and to prevent losses and damages due to extreme events. For example, urban settlements tend to deteriorate support systems provided by the river basin/region following the extraction of energy and materials. Compact settlements allow for low occupation of the ground, and thus, preserve biodiversity and facilitate the incorporation of a low-carbon energy matrix, constructive technology that reduces energy consumption in homes and transportation, and optimize infrastructure and equipment.

- Create national policies on the subject and incorporate them into national development plans and in to sectoral strategies, plans and projects.
- Improve the capacity of National Prevention and Aid Systems for Disasters to design, promote and execute disaster administration policies and have adequate standards for civil protection and disaster management.
- Strengthen regional mechanisms for risk and disaster management coordination, including the work done by CEPREDENAC, the Regional Climate Forum and the Regional Forum for Application of Climate Predictions to Food and Nutrition Security.

Source: ECLAC, CCAD/SICA, UKAID and DANIDA (2012b).

3. POTENTIAL IMPACTS AND POLICY OPTIONS FOR KEY SECTORS

This section will explore the results of some analyses available for Central America on the potential impacts of climate change on areas such as water resources, hydroelectricity, agriculture (specifically basic grains and coffee), biodiversity and types of forests in the region, health, fiscal and trade policy. Given that the previously mentioned future scenarios are long term and include various "layers" of analysis with uncertainty and methodological difficulties, the results should be interpreted as trends and relative magnitudes, not exact figures. In general, this analysis seeks to illustrate the potential impacts of climate change if public policies and actions regarding adaptation are not created by stakeholders and bring attention to the strategic importance of taking proactive and precautionary measures.

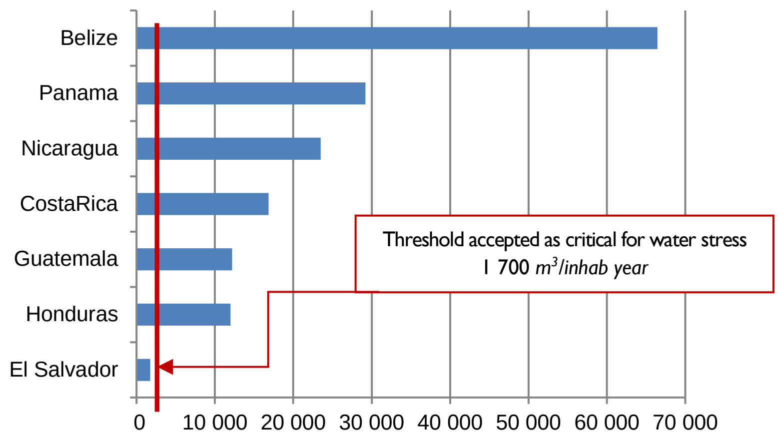
It is important to note that the estimates made for these scenarios seek to identify the impacts of changes in temperature and precipitation that are attributable to climate change, and therefore, the values of all other variables are fixed at their historical reference values. The estimates should therefore be interpreted as possible outcomes if adaptation measures are not implemented. There are two other important considerations: first, the analysis does not estimate the future cumulative effect of productive practices by humans that undermine sustainability, such as soil degradation and erosion, which would contribute to reducing future agricultural yields or hydroelectric generation even if there were no climate change; and second, some of the analyses focus on the department level, identifying differences throughout the entire region, but they do not look at smaller areas within these geographical units.

3.1 WATER DEMAND AND AVAILABILITY

Central America has high water availability, with an average of 23,000 m^3/year per capita in 2005 (World Water Council cited in ECLAC, CCAD/SICA, UKAID and DANIDA, 2011). However, the distribution of this resource between countries, between the Pacific and Atlantic coasts and throughout the population is very unequal, and there is significant intra- and inter-annual variation. On the one hand, Belize has 66,400 m^3/year, while on the other hand, El Salvador has 1,752 m^3/year, a value close to the water stress value (see Chart 11). This situation is related to precipitation and gives rise to alternating periods of severe drought and floods, both of which harm access to this basic need.

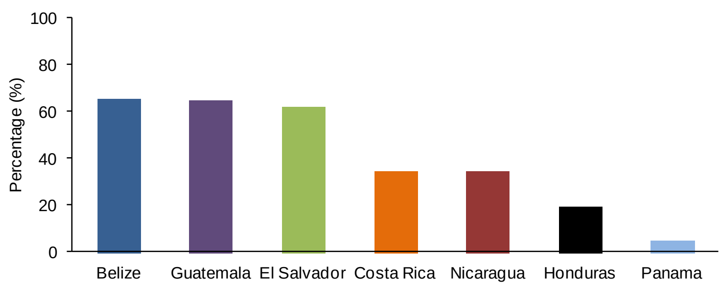
Central America has 23 main river basins that are shared between two or more countries, and that represent 11% of all basins globally (SICA and CCAD, 2005). These basins account for 40% of the territory of the region, totalling 191,449.3 km^2, greater than the area of any single country in the region (see Chart 12). The largest basins are of the Usumacinta, San Juan and Coco rivers (Hernández and Ríos, 2006). Sharing basins creates a complex relationship between countries. Some countries are upstream, and some are downstream, while some share watersheds. This creates dependencies with respect to the availability of water, irrigation works, flooding, water transport and pollution. Vulnerability and the need for shared management increase in the face of climate change, which could modify the quantity and quality of water, the transport of sediments and the trajectory of the rivers.

CHART 11
CENTRAL AMERICA: ACTUAL WATER AVAILABILITY
(m^3/inhab year)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA, 2011.

CHART 12
CENTRAL AMERICA: EXTENSION OF INTERNATIONAL BASINS
(In percentages)



Source: FUNPADEM and UCR, 2000.

The amount of water available per capita in a baseline scenario that considers the evolution of the economy and the population without climate change is estimated using the Turc method (1954), considering precipitation and evapotranspiration. The average decrease in availability in the region from 2005 to 2100 is estimated to be 36%, ranging from 21% in Costa Rica to 59% in Guatemala. In absolute terms, El Salvador would have the lowest availability, with 1,366 m^3/year per capita. Belize would suffer a 43% decrease, falling from 66,428 m^3/year per capita to 37,558 m^3/year per capita. Nevertheless, its water availability would continue to be high. Toward 2050, Belize, Nicaragua, Costa Rica and Panama would suffer decreases, but availability would remain above 10,000 m^3/year per capita, while Guatemala and Honduras would have availability lower than 10,000 m^3/year per capita. El Salvador would be below 1,700 m^3/year per capita and in a state of water stress. In the second half of the century, all the countries would see further decreases, and Guatemala would drop to a range of 2,000 to 5,000 m^3/year per capital due to population growth (ECLAC, UKAID and CCAD/SICA, 2010).

The scenarios with climate change estimate an average regional reduction of 82% under B2 and 90% under A2 by the year 2100, compared to 36% under the baseline scenario. Under scenario B2, the decreases would range from 73% in Costa Rica to 88% in Honduras by 2100. In absolute terms, Honduras would fall under the water stress limit. El Salvador would fall to an even lower availability value of less than 400 m³/year per capita. Belize would continue to have the highest per capita water availability in the region. Under scenario A2, the decreases would range from 77% in Panama to 97% in Nicaragua by 2100. Costa Rica and Panama would experience decreases of 84% and 77%, respectively, by 2100, but would not reach the limit of water stress. Honduras and Nicaragua would fall below this limit, joining El Salvador which falls below this limit in even the baseline scenario. However, the regional average would remain above the water stress limit, with almost 2,500 m³/year per capital, largely due to the relatively high availability in Belize and Panama. Panama would have the greatest availability, surpassing Belize (see Chart 13 and Map 8).

TABLE 5
CENTRAL AMERICA: PER CAPITA REDUCTION OF WATER AVAILABILITY, BASELINE SCENARIO, B2 AND A2, 2005-2100

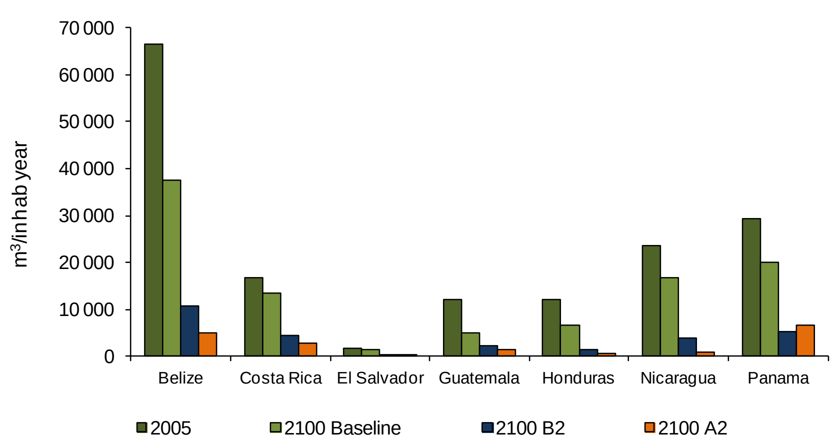
(In cubic meters per inhabitant per year and percentage of reduction)

Country	Per capita availability *m³/inhab year*				Availability reduction, %		
	2005	Baseline Scenario	B2 Scenario	A2 Scenario	Reduction of Baseline Scenario, %	Reduction of B2 Scenario, %	Reduction of A2 Scenario, %
		By the end of the period	By the end of the period	By the end of the period	By the end of the period	By the end of the period	By the end of the period
Belize	66 429	37 558	10 826	5 051	43	84	92
Costa Rica	16 859	13 389	4 572	2 730	21	73	84
El Salvador	1 752	1 366	374	122	22	79	93
Guatemala	12 197	5 019	2 211	1 467	59	82	88
Honduras	12 008	6 680	1 453	482	44	88	96
Nicaragua	23 486	16 772	3 857	765	29	84	97
Panama	29 193	20 064	5 382	6 681	31	82	77
Average	23 132	14 407	4 097	2 471	36	82	90

Source: ECLAC, UKAID and CCAD/SICA, 2010.

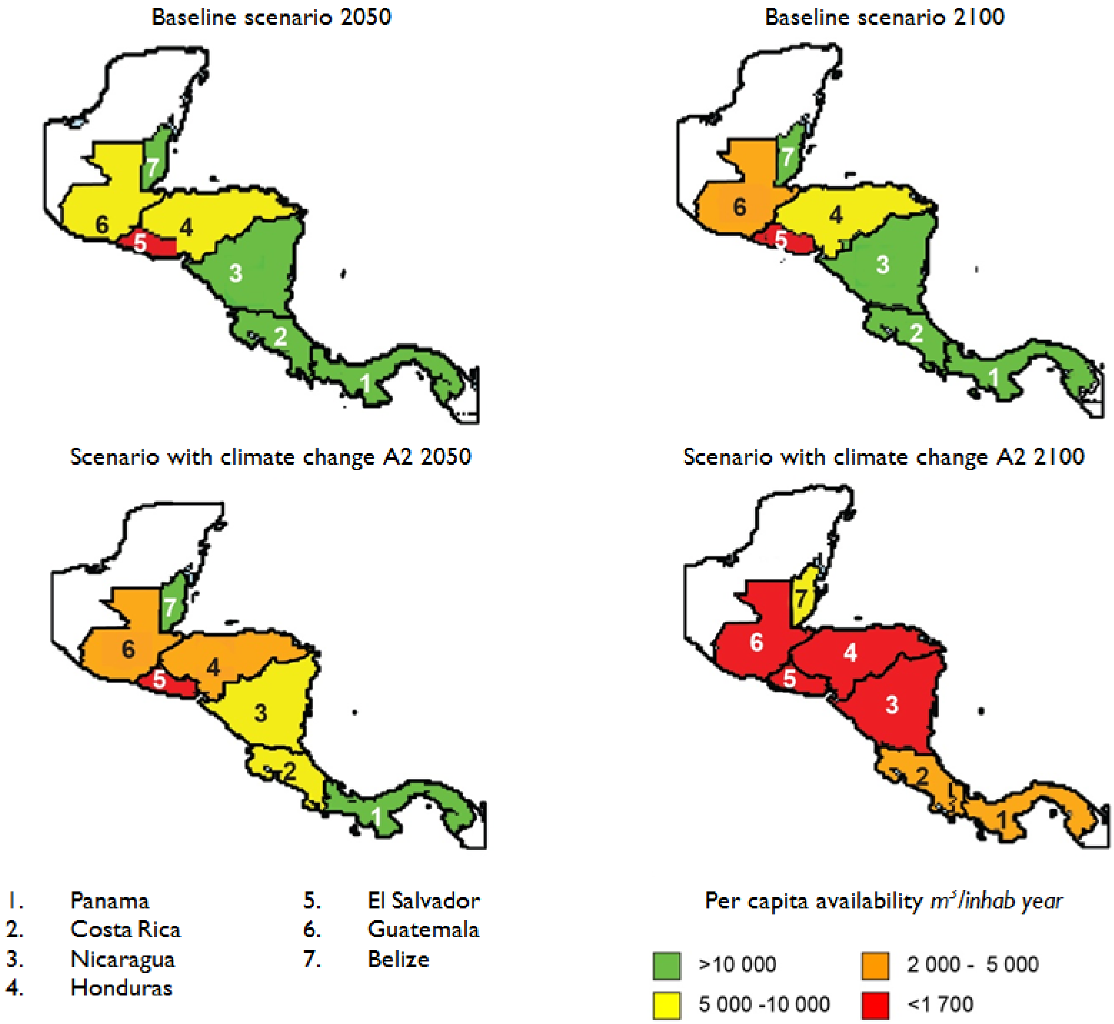
CHART 13
CENTRAL AMERICA: WATER PER CAPITA AVAILABILITY IN 2005 AND WITH BASELINE SCENARIO, B2 AND A2 TO 2100

(Cubic meter per capita per year)



Source: ECLAC, UKAID and CCAD/SICA, 2010.

MAP 8
CENTRAL AMERICA: WATER PER CAPITA AVAILABILITY IN BASELINE SCENARIO AND A2 REFERRED TO WATER STRESS INDEX TO 2050 AND 2100
(Cubic meter per capita per year)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA, 2011.

Note: The averages of the HADCM3, GFDL R3.0 and ECHAM4 models were used for scenario B2 and the average of the HADGEM1, GFDL CM2.0 and ECHAM5 models were used for scenario A2.

In a scenario that accounts for population growth but does not involve water-saving measures, demand for water could grow by almost 300% by 2050 and by more than 1600% by 2100, the equivalent of a water-use intensity of 36%—without considering climate change. With climate change factored in, this figure could reach 140% under scenario B2 and more than 370% under scenario A2 if measures to adapt and save water are not implemented. These levels would be much higher than the 20% accepted internationally as the threshold for water stress. Scenario A2 suggests conditions similar to those of current-day Egypt and some countries in the Arabian Peninsula. (ECLAC, CCAD/SICA, UKAID and DANIDA, 2012d)

Given this scenario, Central American societies can take a fundamental step toward adaptation by becoming attentive and efficient managers of their water resources. If the key indicator for mitigation efforts is the reduction of CO_2e emissions, the key indicator for adaptation could be the efficiency of water use per capita and per unit of GDP. The comprehensive management of water is essential for the response to climate change in agricultural production, food security, hydroelectricity generation and the protection of forests, ecosystems and biodiversity. It is also essential to ensuring access to potable water and sanitation services for the entire population. There are various national institutional frameworks for water resources, and they do not always lend themselves to coordinated management. This is probably one of the biggest challenges in addressing climate change.

The coordinated management of this resource at the regional level is a priority, as 40% of the region is made up of transnational river basins. Establishing a coordinated regional system for comprehensive water management is ambitious and will require much political will and technical and financial efforts for several decades. The Central American Integration System (SICA) has recognized the opportunity and the challenge of comprehensive water management since the late 1990s. Currently, the environmental sub-system of SICA (Central American Commission for Environment and Development, or CCAD), the Coordination Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC) and CRRH are undertaking a coordinated effort to complete the Central American Strategy for the Integrated Management of Water Resources (ECAGIRH) with a time line of ten years and to create a three-year plan called the Central American Action Plan for the Integrated Management of Water Resources (PACAGIRH).

The region also has the Forum for Potable Water and Sanitation for Central America and the Dominican Republic (FOCARD-APS), which is a regional SICA organization that seeks to foster cooperation between countries on this issue and to promote concerted actions to benefit the health and development of the more than 40 million people that live in Central America and the Dominican Republic. FOCARD has allowed for situational diagnoses regarding the integration of disaster risk management and adaptation to climate change in the water and sanitation sector in Costa Rica, El Salvador, Guatemala, Panama and the Dominican Republic. Furthermore, there is the Regional Environmental Framework Strategy (ERAM) 2015-2020 which again examines the topic of Comprehensive Water Management in its strategic lines. The Central American Policy for Integrated Risk Management (PCGIR) is considering the standardization of the framework of policies and strategies related to risk-water-environment, as well as the incorporation of a climate change risk management approach. The Regional Agro-environmental and Health Strategy (ERAS) is another regional strategy.

Similarly, the CRRH is working on the constitution of an information platform for the reduction of vulnerability to disasters of hydro-meteorological origins, which includes among other components, a Regional Climatic Database and the development of Central America Center for Meteorological and Hydrological Integration (CIMHAC) to provide predictions, alerts and timely warnings regarding hydro-meteorological or extreme climate events that could affect the availability of water in the region.

To contribute to the improvement of the governance of the water resources sector, all countries in the region have erected laws to promote the management of water resources. A water law was passed in Belize in 2010, in Honduras in 2009 and in Nicaragua in 2007 (Law 620). Costa Rica has a water law dating back to 1942, and Panama, back to 1966. El Salvador has had a bill for the General Water Law since 2012, and Guatemala has had a National Water Policy and Strategy since 2011.

BOX 2
RECOMMENDATIONS FOR ADAPTATION WITH REGARD TO THE INCLUSIVE AND SUSTAINABLE USE OF WATER

Based on studies and consultations, the following options are proposed for water management:

- Manage water in "closed cycles": protection of sources, collection without waste, appropriate treatment prior to consumption, distribution without leaks, responsible consumption, recollection, treatment, reuse and recycling of residual water, and its reintegration into the environment, i.e. not just a "supply and sanitation service".
- Integrate water management in "hydrographic basins" in coordination with all levels of government to develop work programs by political-administrative regions and ensure its viability.
- Define an ecological volume in terms of the "ideal environment" to which it aspires as a reference for actions of biodiversity conservation, goods and services of ecosystems and of surface and groundwater water reserves in the present and in the future.
- Increase coverage for access to potable water for the entire poor population.
- Create a framework of social negotiation for water infrastructure that rises above the conflictive baggage of the past and allows for the equitable and sustainable development of communities surrounding the works and conservation areas.
- Establish water infrastructure standards and designs as well as flexible management plans for possible seasonal changes, greater precipitation variability and availability of water depending on location and time. Consider different sizes of reservoirs, including mini-hydraulic storage for specific regions and evaluate the convenience of having reservoir projects that have multiple uses: generation of hydroelectricity, irrigation, human consumption and flow management.
- Identify basins that are threatened by the forecast impacts of climate change and its implications for hydroelectric generation, according to the Central American Energy Strategy 2020 (ECLAC and SICA, 2007) and other uses, such as irrigation.
- Expand electricity generation plans for renewable sources such as solar and wind in order to diversify the future offer in the face of uncertainty regarding water availability.
- Design and reorder human settlements and economic activities according to availability and supply of water. For example, expand the development of decentralized systems for rainwater capture at the domestic level and for public services, and develop systems of local reservoirs of various sizes.
- Promote public health and sanitation programmes, such as cisterns, dry baths, oxidation swamps, in rural areas that could bring water-related and social benefits without requiring large investments in infrastructure.
- Consolidate programmes related to drinking water, sanitation, sewers, the collection, treatment and re-use of treated water to irrigate green areas, gardens, parks and medians.

- Promote greater efficiency in the consumption of water and related energy consumption, i.e. efficiency in pumping, heating and provision of water of different qualities and for different uses.
- Strengthen and expand legal frameworks, promoting gradual improvements in national standards and payment programmes for environmental services and for the efficient use, saving, treatment and recycling of water.
- Develop appropriate ways to manage conflicts related to reservoirs through the diversified use of reservoirs and regulation vessels (e.g. hydroelectricity, fish farming, ecotourism, agricultural irrigation, environmental education, direct benefits to inhabitants of the area, etc.)
- Develop public information campaigns and promote the responsible participation of all sectors as political and social support to instrument the efficient use and protection of this resource.
- In the municipal sector, control leaks, ensure efficient end use through progressive, fair tariffs based on volume of consumption; expand and combine water sources (reused, surface and underground, rainwater capture) to restore the ecological flow, refill aquifers and alternative sources of drinking water, and create housing construction standards and green mortgage programmes.
- In the agricultural sector, implement water saving options such as local dams, ground levelling, reduction of evaporation with bedding, monitor humidity of the soil and of precipitate water and the efficient use of water in irrigation, relocate sensitive agriculture to areas with sufficient precipitation, develop crops that consume less water and that are more resistant to drought, coordinate agricultural planning with water planning and promote the responsible use of fertilizers and plaguicides to prevent water pollution.
- In the industrial and service sectors, including tourism, implement commercial certifications such as the ISO 14000 standard which stipulates the efficient use, recycling and non-polluting use of water; incentivize, both fiscally and financially, the replacement of water-intensive technologies with more efficient ones (for example, dry coffee processing and the reuse of water for cooling in the processing of sugar) and avoid the dumping of untreated industrial waste.
- Promote the orderly fluvial transportation within countries and cabotage between countries and throughout the region.
- Consolidate and strengthen national and regional institutional structures of the water sector.
- Develop a master plan for the comprehensive management of water resources for Central America with a portfolio of projects that can be financed, promoting regional integration in an area that is vital for the population and economies.

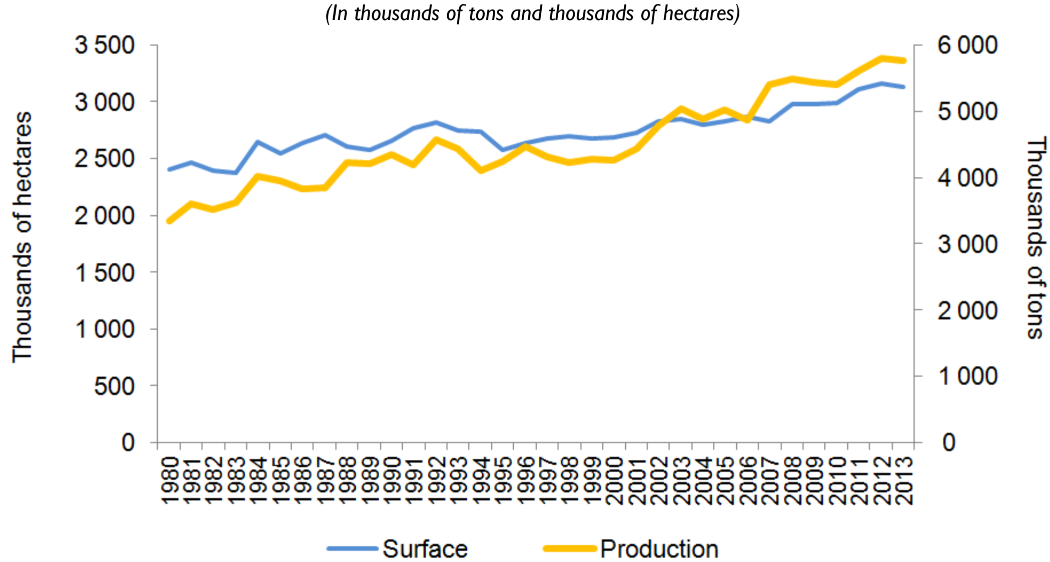
Source: ECLAC, CCAD/SICA, UKAID and DANIDA (2011).

3.2 AGRICULTURE AND FOOD AND NUTRITION SECURITY

Agricultural activities in Central America are particularly sensitive to climate, especially due to the geographical location of the region, its socioeconomic characteristics and technologies. The productive sector has suffered the greatest losses and damages due to extreme events in recent decades (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011; ECLAC and CAC/SICA, 2013a). This is particularly important given that the agricultural sector contributes only 9% of the total regional GDP but employs 30% of the working population and generates key inputs for the agroindustry sector, which contributed between 3% (Panama) and 16% (Nicaragua) of national GDP in 2013 (SIAGRO-CEPALSTAT).

Chart 14 shows the production trends of, and the surface area dedicated to growing maize, beans, rice, sorghum and wheat, using data from the SIAGRO system of ECLAC. Production grew by approximately one million tons, while surface area grew by 260,000 hectares between 1980 and 1990. Between 1990 and 2000, the production of basic grains stabilized at approximately 4.3 million metric tons (t), while the growing area was approximately 2.7 million hectares. From 2000, the production of basic grains rose again, reaching a maximum of 5.8 million tons in 2013, while the growing surface reached 3 million hectares.

CHART 14
CENTRAL AMERICA: PRODUCTION AND HARVESTED AREA OF BASIC GRAINS, 1980- 2013.
(In thousands of tons and thousands of hectares)



Source: ECLACSTAT, 2013.
Note: Includes rice, beans, corn, sorghum and wheat

The proportion of basic grains, maize, beans and rice as a part of agricultural production varies among countries, and in some cases, has decreased. In 2011, basic grains in Guatemala represented 18.5% of the agricultural GDP, 17.7% in El Salvador, 16.4 in Nicaragua, 9.6% Honduras, Panama and Costa Rica 7.4% 2.8% (SIAGRO, 2013). These three grains are basic components of the human diet and are part of the group of nutritious cereals and legumes due to their content of carbohydrate, protein, minerals, vitamins and other nutrients. In 2009, maize, beans and rice provided approximately 25% of food energy to every person in the world. Rice provides approximately 19% due to its high consumption in many Asian countries. In Central America, these basic grains provide 37% of food energy per person, with corn predominating with 31% (FAOSTAT, 2013).

Within the sector, subsistence farmers represent almost 60% of the farmers of the region. [10] These small-scale farmers own just 6.5% of the growing surface, and most of this land is low-yield due to a lack of commercial and irrigation technology (Ramirez, 2010). Their living conditions partly explain the migration toward cities (with the consequent predominance of urban populations over rural ones) and extra-regional migrations, primarily to the United States.

The per capita consumption of basic grains has increased. On the supply side, cultivated area, production and yields have increased. Nevertheless, regional production has been insufficient for covering domestic consumer demand, especially for maize and rice. For example, the apparent consumption of maize has shown greater growth than net production, especially when it comes to yellow corn imports (primarily used for industrial production and animal feed), which represent approximately 88% of the total import. The increase in imports skyrocketed at the end of the 1990s. Between 1980 and 1986, a period of armed conflict in several countries, there was a slight decrease in consumption of the three basic grains, from 140 kg to 128 kg per person per year. In 2007, consumption reached a maximum of 210 kg per person per year. In the following years, consumption stabilized at around 200 kg per person per year, relative to 140 kg in 1980 (ECLAC and CCAC/SICA, 2013a).

Coffee production makes a significant contribution to the economy of the region. It is an important source of foreign currency as it is one of the main exports, and a source of income for numerous producers and labourers, including those that live in poverty. The majority of coffee produced is exported: in 2010, the region exported approximately 85% of the coffee produced. However, the importance of coffee to the economy and trade has decreased as Central American economies have diversified their production and exports. In 2012, coffee's share of trade varied according to the country; it was greatest in Honduras, representing 17% of exports, 13% in Nicaragua, 8.5% in Guatemala, 7% in El Salvador, 3.6% in Costa Rica and 1% for Panama. For low-income households, especially in El Salvador, Honduras, Nicaragua and Guatemala, work related to coffee production is an important source of income. This activity employs around 1.8 million people per year in these countries. The income is particularly important for families with limited opportunities to diversify their crops and livelihoods (FEWS NET, RUTA and PROMECAFE, 2014).

The work of estimating the effects of climate change on agriculture in Central America was started more than a decade ago and established important benchmarks. (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011) A recent study, based on the Decision Support for Agro-technology Transfer (DSSAT) model, estimates a probable decrease of 12% in bean production by 2020 and of 19% by 2050 in El Salvador, Nicaragua, Honduras and Guatemala under scenario A2. The study also predicts decreases of between 4% and 21% in maize production by 2050, depending on the availability and retention of water in the soil. The same study found that Guatemala could be less affected, with changes that range from an increase of 0.4% to a decrease of 11% (CIAT, CRS and CIMMYT, 2012). Another study of seven departments in Honduras that used the same DDSAT in addition to four general circulation models for scenario A2 estimates reductions of 4% in maize yields

[10] **Source:** ECLAC, using databases of official figures from the Agricultural Censuses of Costa Rica, Guatemala, Honduras, Nicaragua and Panama. El Salvador MAGA/OPA, National Study of the Agricultural Sector, Survey on Land Use and Ownership.

and 11% in bean yields toward 2025, and of 12% in maize and 32% in beans toward 2050 (Medeiros and McCandless, 2011).

The project called Coffee Under Pressure, coordinated by the International Centre for Tropical Agriculture (CIAT), carried out an analysis of aptitude distribution [11] within the current coffee growing areas of El Salvador, Guatemala, Nicaragua and Mexico, and found that, in general, aptitude would decrease significantly by 2050. Due to the increase in temperature, the project estimates a reduction in production capacity of the Arabica varieties in low-altitude regions, with a probable displacement of productive areas to higher altitudes, with the optimal altitude being 1,600 amls (above meters sea level) relative to the current 1,200 amls. The results also provide valuable information for finding ideal production areas within the specific departments. By 2050, it is estimated that ideal areas in El Salvador would be in the higher regions in the west, including Ahuachapán, Chalatenango and La Libertad, and on the foothills of several volcanoes, though with a lower aptitude coefficient for the latter. In Nicaragua, the best regions would be concentrated in the south of Jinotega and certain high regions of Nueva Segovia, Matagalpa, Madríz and Estelí; the greatest reduction would be in Carazo and Managua. Finally, in Guatemala, the best regions in 2050 would be found in the high regions of Quetzaltenango, Suchitepéquez, Chimaltenango, Sacatepéquez, Santa Rosa, Jalapa and Huehuetenango. The areas with the greatest loss of aptitude (up to 30%) could be Baja Verapaz, El Progreso, Chiquimula, Zacapa, and Jutiapa (all within the current dry corridor), as well as Santa Rosa and Izabal.

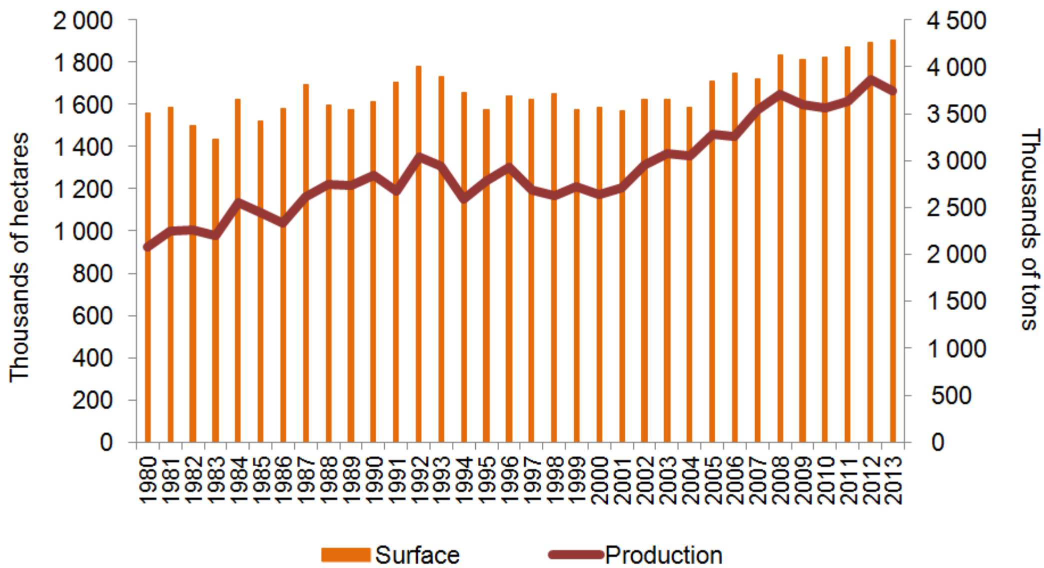
Analyses of the potential impacts of climate change on basic grains (ECLAC and CAC/SICA, 2013a) and coffee (ECLAC and CAC/SICA, 2014) were carried out within the framework of the working programme of a technical group on climate change and comprehensive risk management of the Central American Agricultural Council (CAC) along with ECLAC. These analyses estimate the levels of production and yields of basic grains and coffee in 95 subnational geographic units (departments, provinces, districts and counties of the region) in the 2000s. It involved preparing an adjusted climatology of averages of temperature and monthly precipitation for the same decade. Using the method of production functions, it estimates the effect of temperature and precipitation on yields. Based on this function, it estimates the potential impacts of climate change using two scenarios (B2 and A2) created by the IPCC, the first less pessimistic and the second, more pessimistic. This analysis used production and yield information by department provided by the Ministries of Agriculture. Time series at the departmental level were only available for the 2001-2009 period. [12] The availability of information by department guided the timeline of analysis.

[11] The future aptitude for cultivation is estimated using each of the global circulation models (GCM) through MaxEnt algorithms for coffee and Ecocrop for alternative crops. Two measures of uncertainty are calculated: the percentage of models that predict changes in the same direction, as well as the average of all models for a given location and the coefficient of variance (CV) among the models. This analysis was carried out using a regression analysis in which aptitude was treated as a dependent variable and the changes in bioclimatic variables between the present and the future as independent variables.

[12] In this document, the term "department" is used as a generic term for these administrative divisions when speaking of the region as a whole. The Kuna Yala and Ngöbe-Bugle regions of Panama have their own estimates. Due to geographical location and availability of data, it is recommended that figures from the province of Panama be used for the region of Madugandí and figures from Darién be used for the regions of Emberá-Wounan and Wargandí.

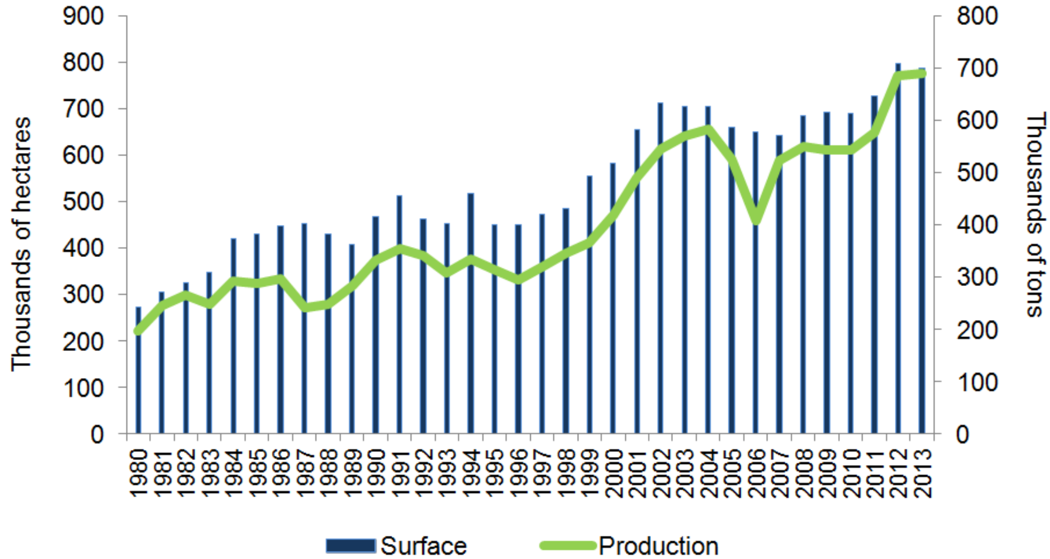
Central America produced 3.7 million tons (t) of maize (see Chart 15), 689,000 t of beans (see Chart 16) and 1.9 million t of rice (see Chart 17) in 2013. The annual production growth rate during the last decade was 2% in the last decade. Guatemala is the largest producer of maize with approximately 1.6 million t per year, representing 42% of regional production, followed by El Salvador and Honduras with 867,000 t and 596,000 t respectively. White maize accounts for 90% of the regional production of this grain. Nicaragua and Guatemala were the largest producers of beans, with 230,000 t and 228,000 t annually. Together, both countries produced about 70% of the regional total. Nicaragua, Costa Rica and Panama were the largest producers of rice, with 460,000 t, 287,000 t and 224,000 t respectively. In 2013, 741,000 t of coffee were produced in Central America (see Chart 18). In 2013, Guatemala and Honduras were the largest coffee producers, with approximately 253,000 t and 273,000 t respectively. In 2013, Costa Rica, Guatemala and Honduras reported yields of 1 t/ha.

CHART 15
CENTRAL AMERICA: HARVESTED AREA AND PRODUCTION OF CORN, 1980-2013
(Thousands of hectares and thousands of tons)



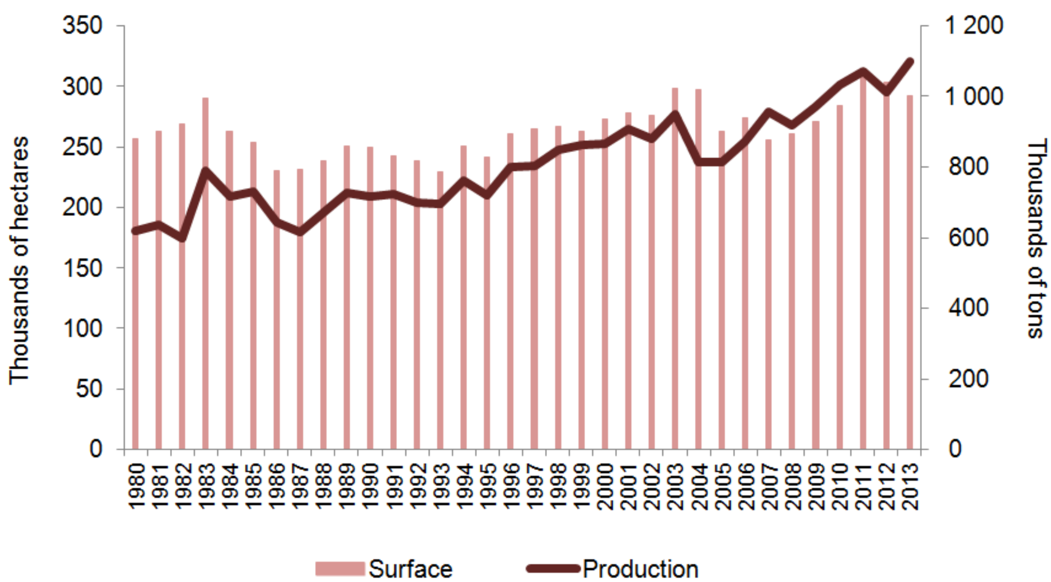
Source: ECLAC and CAC/SICA, 2013a.

CHART 16
CENTRAL AMERICA: PRODUCTION AND HARVESTED AREA OF BEANS, 1980-2013
(Thousands of tons and thousands of hectares)



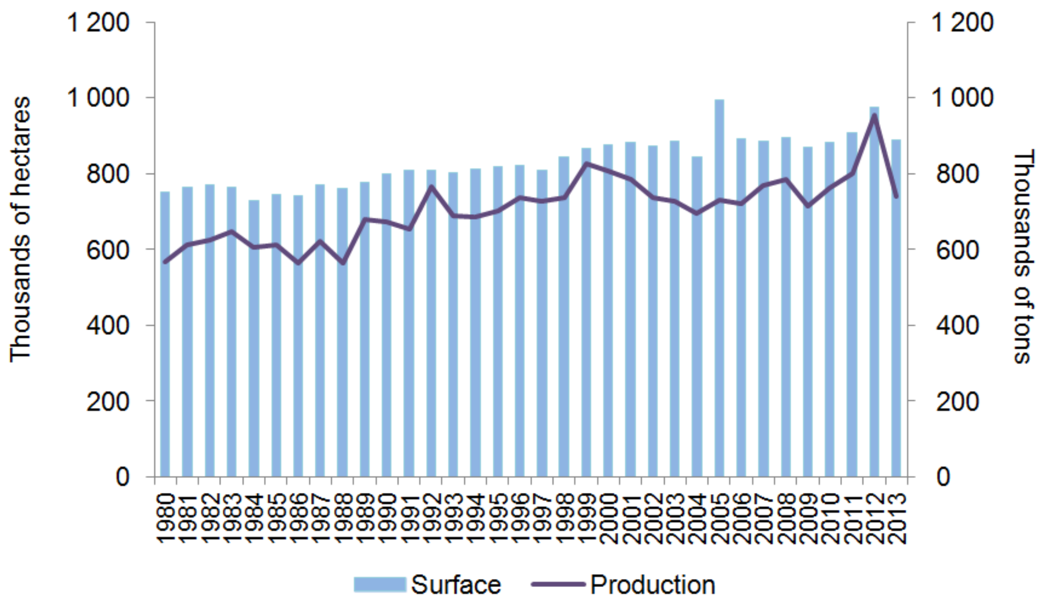
Source: ECLAC and CAC/SICA, 2013a.

CHART 17
CENTRAL AMERICA: PRODUCTION AND HARVESTED AREA OF RICE, 1980-2013
(Thousands of hectares and thousands of tons)



Source: ECLAC and CAC/SICA, 2013a.

CHART 18
CENTRAL AMERICA: PRODUCTION AND HARVESTED AREA OF COFFEE, 1980-2013
(In thousands of hectares and thousands of tons)



Source: ECLAC and CAC/SICA, 2014.

MAIZE PRODUCTION AND YIELDS IN THE FACE OF CLIMATE CHANGE

El Petén and Alta Verapaz in Guatemala and the north-eastern region of Honduras (Olancho) were the departments with the greatest maize production in the 2001-2009 period. In general, maize production is concentrated in the northern part of the region, where the majority of departments in Guatemala, El Salvador and Honduras, and three in Nicaragua, produce more than 70,000 tons per year. Between 1980 and 2013, yields increased by 1.2 t/ha in Central America, reaching 2.5 t/ha in 2013, compared to a global increase of 2 t/ha until reaching 5.2 t/ha in 2013. In terms of maize yield by country, the greatest yields were found in El Salvador and Belize with 2.8 t/ha and 2.2 t/ha respectively during the 2001-2009 period. Honduras and Panama had the lowest yields with 0.9 t/ha each during the same period.

The potential impacts of climate change on maize yields under scenarios B2 and A2 (see Table 6) were estimated taking into account the historical coefficients of production functions[13] and allowing average temperature and monthly accumulated rainfall values to vary according to the scenario, while the rest of the variables were held constant without considering adaptation measures. Under scenario B2, by 2020, average regional maize yield could decrease by 4% with the following variations: 1% in Guatemala, 3.5% in El Salvador, 4.8% in Honduras, 5% in Costa Rica, 6% in Nicaragua and 7% in Panama and Belize. Toward 2050, the decreases could range from 4% in Guatemala to 14% in Panama. Toward the end of the century, Belize, Nicaragua, Panama and Honduras would be the most affected, with decreases in yield of more than 24%. At the regional level, the decrease would be 17%.

[13] To consult the econometric estimates of production functions see: ECLAC and CAC/SICA (2013a and 2014).

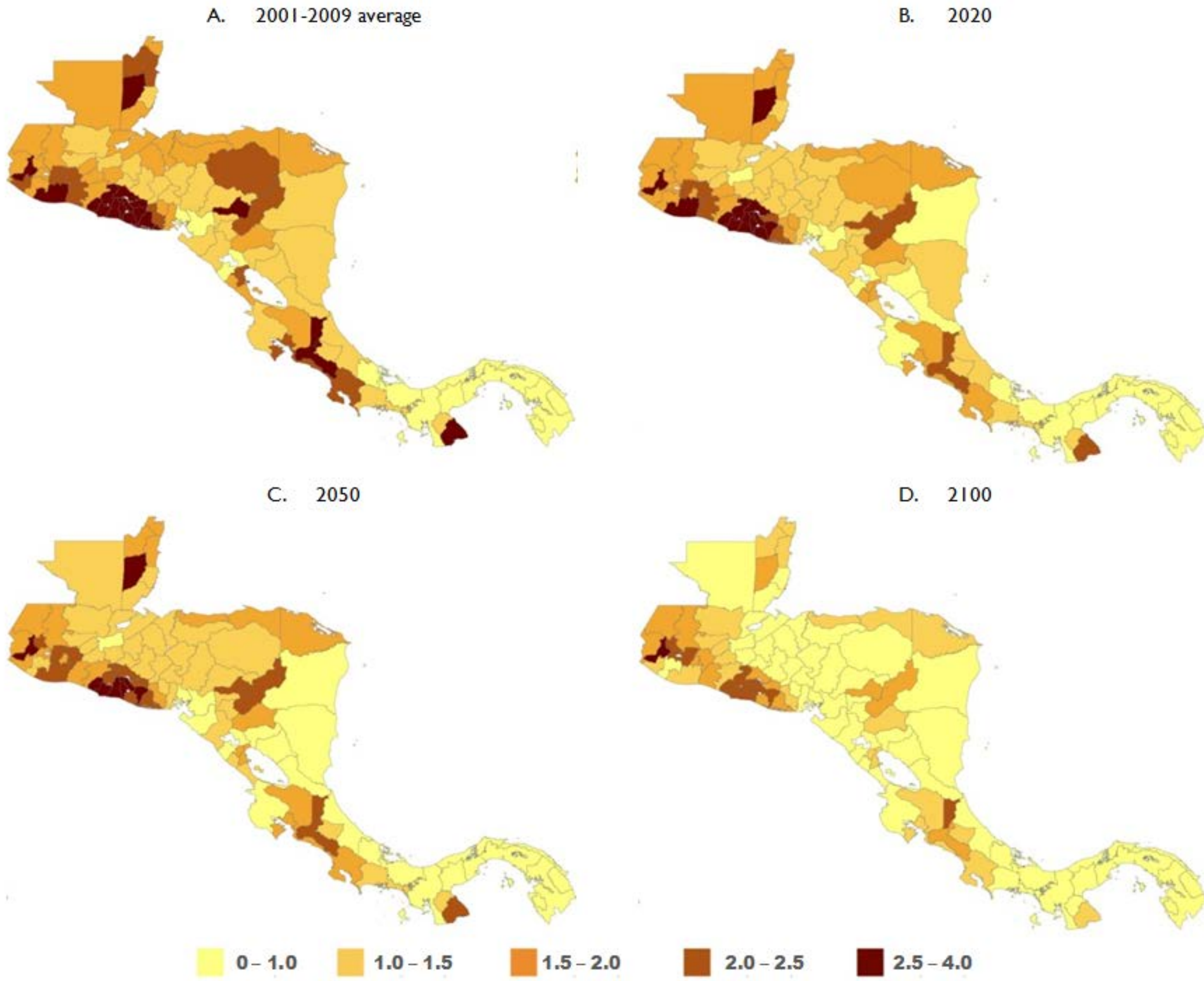
TABLE 6
CENTRAL AMERICA: EVOLUTION OF CORN YIELDS, 2001-2009 AVERAGE AND SCENARIO B2 AND A2 UP TO 2100

	Average yield 2001-2009	2020	2030	2050	2070	2100
	(t/ha)			*(In percentages)*		
				Scenario B2		
Belize	2.16	-6.76	-11.22	-13.79	-20.36	-28.13
Costa Rica	1.83	-5.11	-9.78	-8.60	-8.60	-12.51
El Salvador	2.79	-3.46	-7.18	-9.33	-12.24	-16.18
Guatemala	1.91	-1.00	-3.83	-3.94	-4.77	-7.07
Honduras	1.49	-4.76	-9.91	-12.93	-16.73	-23.69
Nicaragua	1.55	-6.10	-11.65	-13.62	-17.51	-26.00
Panama	0.94	-6.92	-12.56	-14.40	-16.77	-25.10
Central America	1.81	-3.99	-8.19	-9.53	-12.07	-17.27
				Scenario A2		
Belize	2.16	-10.44	-11.99	-21.16	-32.23	-43.35
Costa Rica	1.83	-11.11	-5.95	-15.82	-26.48	-30.12
El Salvador	2.79	-11.50	-8.87	-18.20	-26.60	-37.40
Guatemala	1.91	-7.39	-6.71	-11.35	-14.86	-21.77
Honduras	1.49	-10.89	-11.03	-20.51	-30.23	-42.28
Nicaragua	1.55	-11.06	-10.58	-20.74	-33.36	-45.01
Panama	0.94	-2.04	-2.01	-5.78	-28.03	-43.22
Central America	1.81	-9.15	-8.07	-15.67	-25.13	-34.94

Source: ECLAC and CAC/SICA, 2013a.

In the more pessimistic scenario (A2), the decrease in yield would be greater than in B2, especially after 2030. By 2100, the decrease in the regional average would be double that in B2. By 2020, average regional yield would decrease by 9% and the most affected countries would be El Salvador, Costa Rica and Nicaragua with decreases of 11%. By 2050, average regional yield would decrease by 16%, ranging from 6% in Panama to 21% in Belize, Nicaragua and Honduras. By the end of the century, average regional yield would decrease by 35% ranging from 22% in Guatemala to 45% in Nicaragua. Six countries could suffer decreases of more than 33%. The range of changes in yields by department would be as follows: Belize between -36% and -55%, Costa Rica between -12% and -49%, El Salvador between -27% and -79%, Guatemala between 23% and -70%, Honduras between -32% and -61%, Nicaragua between -29% and -69% and Panama between -30% and -67%. Panama would continue to have the lowest relative yields, while Guatemala would have the highest, benefiting from the lower temperatures in its high lands. The Guatemalan departments of Guatemala, Quetzaltenango, El Quiché, Chimaltenango, Totonicapán and Sololá could experience increases, while Izabal, Suchitepéquez, El Petén, Chiquimula and Escuintla could see decreases of greater than 50%.

MAP 9
CENTRAL AMERICA: CORN YIELDS BY DEPARTMENT, 2001-2009 AVERAGE AND SCENARIO A2 UP TO 2100
(t/ha)



Source: ECLAC and CAC/SICA, 2013a.

As an example, five departments (north-eastern Honduras and Jutiapa, El Quiché, Petén and Alta Verapaz in Guatemala) had an average annual maize production of more than 100,000 tons in the 2001-2009 period, with average yields of 2.0, 1.9, 1.7, 1.7 and 1.4 t/ha respectively (see Map 9). Under scenario A2, these yields could decrease to 1.5, 1.7, 1.7, 1.3 and 1.2 t/ha respectively by 2050 and to 0.8, 1.3, 1.8, 0.8 and 1.1 t/ha respectively by 2100. Yields in El Quiché could remain the same or increase slightly.

To summarize the relationship between rain, temperature and yields in the historical reference period: 32 departments recorded yields lower than 1.5 t/ha, with an average annual accumulated rainfall of 1607 mm and an average temperature of 24.1°C. Under scenario B2, toward 2050, 39 departments could experience similar conditions, and by the end of the century, 49 departments could have a regional average precipitation of 1250 mm and an average temperature of 27.1°C. Under scenario A2, the decreases would be greater: 45 departments would have yields lower than 1.5 t/ha by 2050 and 59 departments would have such yields by the end of the century.

BEAN PRODUCTION AND YIELDS IN THE FACE OF CLIMATE CHANGE

Bean production has grown in Central America by 3.5% annually during the last three decades. Growing area for beans accounted for approximately 3.6% of total agricultural surface area during the last decade. In general, seeded surface oscillates with an upward trend, and increased from 273,000 ha in 1980 to 786,000 ha in 2013. Between 1980 and 2013, yield remained stable at 0.7 t/ha, while it increased globally from 0.5 t/ha to 0.8 t/ha. The areas with highest yields (0.8 t/ha or more) are the coast of Belize, El Petén and nine other departments in Guatemala, a large part of El Salvador, four departments in Honduras, five departments in Nicaragua and Alajuela in Costa Rica.

Under scenario B2, by 2020, average regional yield would decrease by 3%, ranging from a gain of 4% in Guatemala to losses of 3% in Honduras, 4% in Panama, 5% in El Salvador, 5.5% in Nicaragua, 7% in Belize and 8% in Costa Rica (see Table 7). By 2050, Guatemala would see an increase of 1.5% while the other countries would see decreases, from 7% in Honduras to a maximum of 16% in Panama. By the end of the century, the most affected countries would be Panama, with a reduction of 50%, Belize with 33%, and Costa Rica and Nicaragua with decreases greater than 25%. Yields would decrease in almost all departments, except for 12 departments in the Western Highlands of Guatemala, Jinotega in Nicaragua and San José in Costa Rica, which could see increases.

Under scenario A2 (see Table 7), regional losses would be more than double those of B2 for each cut-off year, with the exception of 2030. By 2020, regional yield would decrease by 11%, and El Salvador, Costa Rica and Nicaragua would be the most affected with decreases of between 14% and 16%. By 2050, regional yield would decrease by 17% ranging from an increase of 0.5% in Panama to a decrease of 24% in El Salvador.

By the end of the current century, regional yield could decrease by 43%. Guatemala would see the smallest decrease (17%) and Panama, the largest (71%). Five countries would see decreases greater than 45%. The range of changes in yields by department, grouped by countries, would be as follows: Belize between -43% and -73%, Costa Rica between -11% and -83%, El Salvador between -28% and -100%, Guatemala between an increase of 100% and a decrease of 82%, Honduras between -28% and -77%, Nicaragua between -0% and -81% and Panama between -29% and -100%. Panama would continue to have the lowest yields, and especially so in the second half of the century. The biggest contrast would be found in Guatemala, where seven departments from the Highlands (Chimaltenango, El Quiché, Huehuetenango, Quetzaltenango, San Marcos, Sololá and Totonicapán) could see increases of more than 40% in their yields, while El Petén, Escuintla, Izabal and Suchitepéquez could see decreases of more than 50%.

As an example, six departments (north-eastern and central-eastern Honduras, Jinotega, Atlántico Sur and Matagalpa in Nicaragua, and Jutiapa in Guatemala, (see Map 10)) had an average annual beans production of more than 21,000 tons in the 2001-2009 period, with average yields of 0.8, 0.7, 0.9, 0.7, 0.8 and 0.9 t/ha respectively. Under scenario A2, these yields could decrease to 0.7, 0.6, 0.9, 0.5, 0.7 and 0.8 t/ha respectively by 2050 and to 0.4, 0.5, 0.9, 0.1, 0.5 and 0.6 t/ha respectively by 2100. Yields for Jinotega would remain consistent.

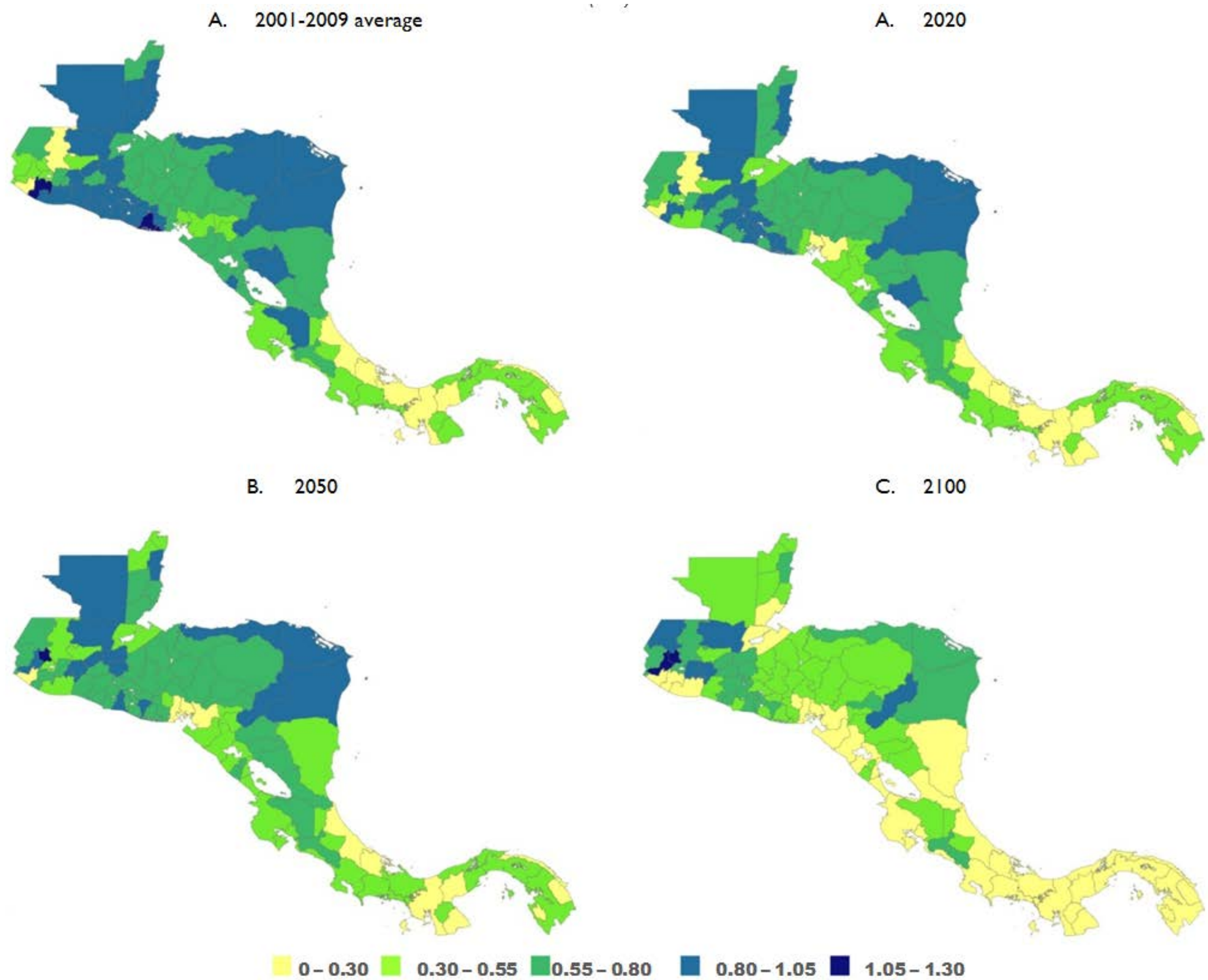
TABLE 7
CENTRAL AMERICA: EVOLUTION OF BEAN YIELDS, 2001-2009 AVERAGE AND SCENARIO B2 AND A2 UP TO 2100

	Average yield 2001-2009	2020	2030	2050	2070	2100
	(t/ha)			*(In percentages)*		
				Scenario B2		
Belize	0.8	-6.92	-10.60	-13.10	-25.06	-32.98
Costa Rica	0.5	-7.71	-16.56	-9.61	-13.46	-28.37
El Salvador	0.9	-4.70	-7.36	-8.69	-13.72	-17.26
Guatemala	0.7	3.71	1.52	1.50	1.76	0.94
Honduras	0.7	-3.35	-6.68	-7.10	-12.70	-20.39
Nicaragua	0.7	-5.52	-12.01	-11.68	-15.95	-26.11
Panama	0.3	-4.06	-22.08	-15.98	-28.09	-50.02
Central America	0.7	-2.86	-7.88	-7.53	-12.26	-19.32
				Scenario A2		
Belize	0.8	-9.06	-13.90	-23.38	-36.69	-53.57
Costa Rica	0.5	-15.65	-7.09	-20.16	-42.22	-47.64
El Salvador	0.9	-16.47	-13.19	-24.14	-35.00	-48.92
Guatemala	0.7	-6.99	-6.94	-8.79	-10.14	-17.44
Honduras	0.7	-11.77	-11.40	-19.00	-28.29	-42.04
Nicaragua	0.7	-14.45	-12.80	-22.74	-39.80	-54.39
Panama	0.3	-1.03	-2.55	0.60	-43.00	-70.60
Central America	0.7	-11.13	-10.20	-17.09	-29.99	-43.21

Source: ECLAC and CAC/SICA, 2013a.

To summarize the relationship between rain, temperature and yields in the historical reference period: 27 departments recorded yields lower than 0.55 t/ha, with an average annual accumulated rainfall of 1,607 mm and an average temperature of 24.1°C. Under scenario B2, toward 2050, 28 departments could experience similar conditions, and by the end of the century, 38 departments could have a regional average precipitation of 1,250 mm and an average temperature of 27.1°C. Under scenario A2, the decreases would be greater: 36 departments would have yields lower than 0.55 t/ha by 2050, and by the end of the century, 58 departments would have such yields, with an average annual accumulated rainfall of 844 mm and an average temperature of 28.4°C.

MAP 10
CENTRAL AMERICA: BEAN YIELDS BY DEPARTMENT, 2001-2009 AVERAGE AND SCENARIO A2 UP TO 2100.
(t/ha)



Source: ECLAC and CAC/SICA, 2013a.

RICE PRODUCTION AND YIELDS IN THE FACE OF CLIMATE CHANGE

Rice production in Central America grew at a lower rate than the worldwide one during the 1980-1995 period (0.6% annual average), but between 1995 and 2013, it grew at 2.3% annually. The area of land used for rice production grew at an annual rate of 0.57% between 1980 and 2013, having increased from 256,000 ha in 1980 to 292,000 ha in 2013. During the same period of time, yields increased from 2.8 t/ha to 3.8 t/ha, more than that of other grains, while the global average grew from 2.7 t/ha to 4.4 t/ha. The southern region of the Pacific coast, comprising departments in Nicaragua, Costa Rica and Panama, had the highest rice production between 2001 and 2009. Chiriquí in Panama had the highest annual average with 142,000 tons. La Libertad and Chalatenango in El Salvador surpassed 7 t/ha between 2001 and 2009, and El Salvador, central-western and northern Honduras, El Petén, San Marcos and Quetzaltenango, Chiquimula and Escuintla in Guatemala and Belize and Orange Walk in Belize had yields greater than 3 t/ha but their production is limited. Guanacaste, Puntarenas and Alajuela in Costa Rica were the departments with the highest yields and production with 3.3 t/ha. Panama, one of the largest producers, has a lower range of yields.

Under scenario B2, by 2020, the regional average of yields will decrease by 8%, with the following national average decreases: 5% in Guatemala, 7% in Costa Rica and El Salvador, 8% in Honduras, 9% in Panama and 11% in Belize and Nicaragua (see Table 8). By 2050, decreases would range from 10% in Guatemala to 23% in Nicaragua, with an average regional decrease of 15%. By the end of the century, Guatemala would experience a reduction of 20% while Honduras, Panama, Belize and Nicaragua would experience reductions greater than the regional average of 30%. Only El Quiche, Quetzaltenango and Totonicapán in Guatemala would see increases in yields. Sixteen departments, concentrated in Nicaragua and Panama, would see decreases greater than 50%.

TABLE 8
CENTRAL AMERICA: EVOLUTION OF RICE YIELDS, 2001-2009 AVERAGE AND SCENARIO B2 AND A2 UP TO 2100

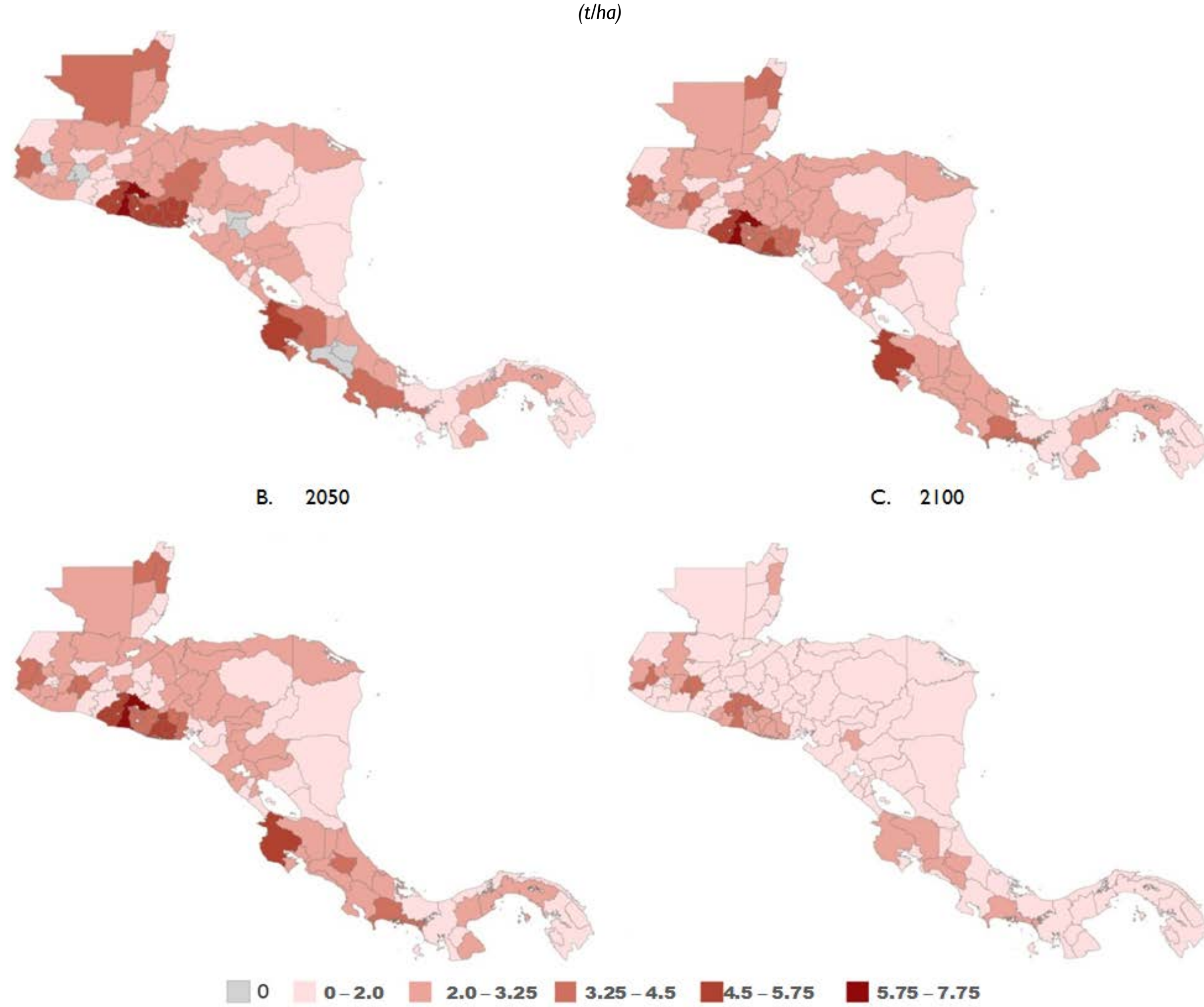
	Average yield 2001-2009	2020	2030	2050	2070	2100
	(t/ha)	*(In percentages)*				
		Scenario B2				
Belize	2.8	-10.56	-12.97	-18.65	-31.76	-40.42
Costa Rica	3.3	-7.02	-11.91	-13.30	-17.96	-25.37
El Salvador	5.3	-6.81	-10.01	-13.64	-20.35	-26.20
Guatemala	2.6	-4.63	-7.46	-9.79	-15.48	-20.27
Honduras	2.3	-7.90	-11.92	-15.68	-23.98	-32.48
Nicaragua	2.2	-11.43	-18.78	-23.25	-32.71	-47.41
Panama	1.8	-8.82	-16.50	-18.08	-24.97	-34.25
Central America	2.9	-7.53	-11.88	-15.06	-22.41	-30.23
		Scenario A2				
Belize	2.8	-9.87	-15.61	-24.74	-41.54	-56.98
Costa Rica	3.3	-10.01	-9.09	-19.85	-32.83	-39.98
El Salvador	5.3	-13.11	-12.05	-24.32	-36.21	-50.32
Guatemala	2.6	-9.33	-10.38	-19.27	-28.63	-41.71
Honduras	2.3	-11.60	-13.80	-24.37	-36.67	-49.92
Nicaragua	2.2	-15.94	-18.84	-33.60	-53.55	-68.84
Panama	1.8	-6.07	-7.19	-12.07	-35.38	-48.89
Central America	2.9	-11.07	-12.26	-22.60	-36.78	-50.25

Source: ECLAC and CAC/SICA, 2013a.

Under scenario A2, it is predicted that the decrease in rice yield will be greater than that under B2, especially after 2030. By 2020, the average regional decrease would be 11%, and the most affected country would be Nicaragua, where yield would decrease by 16%. By 2050, the region would suffer an average decrease of 23%, ranging from 12% in Panama to 34% in Nicaragua. It is estimated that by the end of the century, the average regional decrease would be 50%, ranging from 49% to 69%. Nicaragua and Belize would be the most affected with decreases greater than the average (69% and 57% respectively). Under this scenario, Guatemala would be the least affected with 42%.

Towards the end of the century, the departmental decreases in each country would be: 48-68% in Belize, 17-47% in Costa Rica, 39-97% in El Salvador, 35-74% in Honduras, 41-100% in Nicaragua and 28-100% in Panama. The greatest yields by 2100, higher than 2 t/ha, would be seen in one department in Belize, two in Costa Rica, twelve in El Salvador, four Guatemala and one province in Panama. The lowest yields, less than 1 t/ha, would occur in 33 departments in Nicaragua and Panama.

MAP 11
CENTRAL AMERICA: RICE YIELDS BY DEPARTMENT, 2001-2009 AVERAGE AND SCENARIO A2 UP TO 2100
(t/ha)



Source: ECLAC and CAC/SICA, 2013a.

As an example, there will be seven departments with rice production greater than the 2001-2009 annual average of 28,500 tons: Chiriquí, Coclé and Veraguas in Panamá; Guanacaste, Puntarenas and Alajuela in Costa Rica; and Matagalpa in Nicaragua (see Map 11), with average yields of 3.9, 2.5, 1.8, 5.0, 3.6, 3.3 and 2.9 t/ha respectively. Under scenario A2, these yields could decrease to 3.6, 2.3, 1.7, 4.0, 3.0, 2.8 and 2.0 t/ha respectively by 2050 and to 2.5, 1.7, 1.2, 2.9, 1.9, 2.2 and 1.1 t/ha respectively by 2100.

To summarize the relationship between rain, temperature and yields in the historical reference period: 23 departments recorded yields lower than 2 t/ha, with an average annual accumulated rainfall of 1,607 mm and an average temperature of 24.1°C. Under scenario B2, toward 2050, 30 departments could experience similar conditions, and by the end of the century, 50 departments could have a regional average precipitation of 1,250mm and an average temperature of 27.1°C. Under scenario A2, the decreases would be greater: 39 departments would have yields lower than 2 t/ha by 2050, and by the end of the century, 58 departments would have such yields, with an average annual accumulated rainfall of 844 mm and an average temperature of 28.4 °C.

COFFEE PRODUCTION AND YIELDS IN THE FACE OF CLIMATE CHANGE

Coffee yields reached a regional average of 0.8 t/ha in 2009, but with significant variation among departments. 32 departments reported yields higher than the world average, coinciding in 14 departments with greater production volumes. These 32 departments are: Orange Walk and Toledo in Belize; San José, Heredia, Alajuela, Guanacaste, Puntarenas and Cartago in Costa Rica; San Salvador in El Salvador; Chiquimula, Sololá, El Quiche, Huehuetenango, Santa Rosa, Izabal, Guatemala, Escuintla, Sacatepéquez, Jalapa, El Progreso, San Marcos, Totonicapán, El Petén, Chimaltenango and Suchitepéquez in Guatemala; Ocotepeque, Copán, Lempira, Intibucá and Comayagua in Honduras; and Jinotega and Matagalpa in Nicaragua. Nevertheless, average regional yield increases by just 0.1 t/ha, while global yields grew from 0.48 t/ha to 0.79 t/ha during the last three decades.

In Costa Rica, coffee production has varied from 88,000 t to 118,000 t between 1980 and 2011, with 135,000 t on average. The variability of yield is the cause of fluctuations in production, with a range of 1 t/ha to 1.7 t/ha, and an average of 1.3 t/ha. In general, there has been a growth in production since the 1980s, but since the 90s, the rate has remained stable and even decreased for periods. El Salvador has seen a downward trend in production and yield, especially since 1992, when it reached a high of 198,000 t and 1.1 t/ha of yield. The downwards trend was interrupted in 1999 and 2010. Production in 2011 fell to 77,000 t with a yield of 0.5 t/ha. Guatemala maintained a growing trend both in production and yield in the 1980-2011 period. Yield increased from 0.7 t/ha to 1 t/ha in 2011. Production increased by 177,000 t in 1980 to 269,000 t in 2011. In Honduras, production increased by 70,000 t in 1980 to 195,000 t in 2000. However, since then, both production and yield have shown downward trends. The greatest drop in yields occurred in 2005, when they reached 0.5 t/ha. Since 2005, production has shown an upward trend, reaching 238,000 t in 2011. It is important to mention that production grew more than yield, due to an increased in cultivated surface area. There was a decrease in coffee production and yield in Nicaragua in the 1980s, falling from 57,000 t in 1980 to 33,000 t in 1991. This coincided with a reduction in cultivated surface area, from 97,000 ha to 74,000 ha. Yield decreased from 0.6 t /ha to 0.4 t /ha during the same period. In the 1990s, cultivated surface area, yield and production recovered and surpassed previous levels. In 2000, production reached 93,000 t and yield reached 0.9 t/ha. Since then, production and yield have fluctuated, but with a general upward trend. In Panama, following notable growth at the beginning of the 1980s, production fluctuated between 7,500 t and 13,000 t with an average of approximately 11,000 t, and yield varied from 0.5 t /ha to 0.7 t/ha.

The following departments of Central America experienced the greatest production: Santa Rosa (the largest producer with 51,495 t), Huehuetenango and Chiquimula in Guatemala; Santa Ana in El Salvador; El Paraíso, Copán, Comayagua and Santa Barbara in Honduras; Jinotega and Matagalpa in Nicaragua; and San José (the second largest producer with 47,165 t) and Alajuela in Costa Rica. Another 71 departments saw average production of 20,600 t and 12 departments do not have production records. The greatest coffee yields for the 2001-2009 period occurred in Belize, keeping in mind the low production area and reported production; Chiquimula, Sololá, El Quiché, Huehuetenango and Santa Rosa in Guatemala; San José, Heredia, Guanacaste and Alajuela in Costa Rica; and Ocotepeque, Copán, Lempira and Intibucá in Honduras. The lowest yields were reported in Panama; the Pacific coast of Nicaragua; La Unión, Usulután, Cabañas and La Paz in El Salvador; and Choluteca, Atlántida and Olancho in Honduras. Departments that do not report coffee production are included in the historical average (diagonal black lines). However, in these cases, future estimates correspond to the yield that would be obtained according to estimated climate variables.

Taking into account the climate conditions of scenario B2, yields would decrease by 2020, mostly in the Pacific region. The most affected departments would be: San Miguel, Cuscatlán, Santa Ana and Chalatenango in El Salvador; Retalhuleu, Suchitepéquez and Santa Rosa in Guatemala; Ocotepeque, Lempira and Yoro in Honduras and Toledo in Belize. In 2050, decreases would extend to the central region of Nicaragua in Nueva Segovia, Estelí and Matagalpa; the region of Ngöbe Bugle in Panama: Copán, Yoro and La Paz in Honduras; Santa Ana in El Salvador would resume its decrease as would Chiquimula, Escuintla and Suchitepéquez in Guatemala. By 2070, decreases would continue mainly in the coastal departments such as Limón and Puntarenas in Costa Rica, Sonsonate in El Salvador, Izabal in Guatemala, Cortés in Honduras and Toledo in Belize, as well as San Salvador, Baja Verapaz and Orange Walk. Towards the end of the century, the following areas would have yields of less than 0.4 t/ha: all provinces and regions of Panama, Limón in Costa Rica, Nicaragua (with the exceptions of Jinotega, Región Autónoma del Atlántico Norte, Matagalpa and Madriz), the Pacific region of El Salvador, Morazán, Cabañas and Cuscatlán, the eastern and Atlantic regions of Honduras, as well as Suchitepéquez and El Petén en Guatemala. However, some departments, such as Huehuetenango, El Quiche, Sololá, Orange Walk, Ocotepeque and San José, would continue to have yields higher than 1 t/ha.

Under scenario A2, by 2020, yields in the departments of Toledo in Belize and Santa Rosa in Guatemala would decrease, while those of Alta Verapaz in Guatemala would increase. By this time, those departments in Belize and Nicaragua that have no production records would see yields between 0.4 t/ha and 1 t/ha. By 2050, the decrease in production would spread to departments located in the centre of the region, such as El Petén, Zacapa and Chiquimula in Guatemala; Copán and Yoro in Honduras and Alajuela in Costa Rica; Chiriquí and Ngöbe-Buglé in Panama; and Sonsonate and San Salvador in El Salvador. It is estimated that by 2100 almost all departments will see yields lower than 0.7 t/ha with the exceptions of: Alajuela, Heredia, San José and Cartago in the central valley of Costa Rica; Huehuetenango, El Quiché, Totonicapán, Quetzaltenango and San Marcos in the Western Highlands of Guatemala, as well as Chimaltenango, Guatemala, Sacatepéquez and Suchitepéquez which have regions at higher altitudes; Copán and Ocotepeque in Honduras; and Jinotega in Nicaragua.

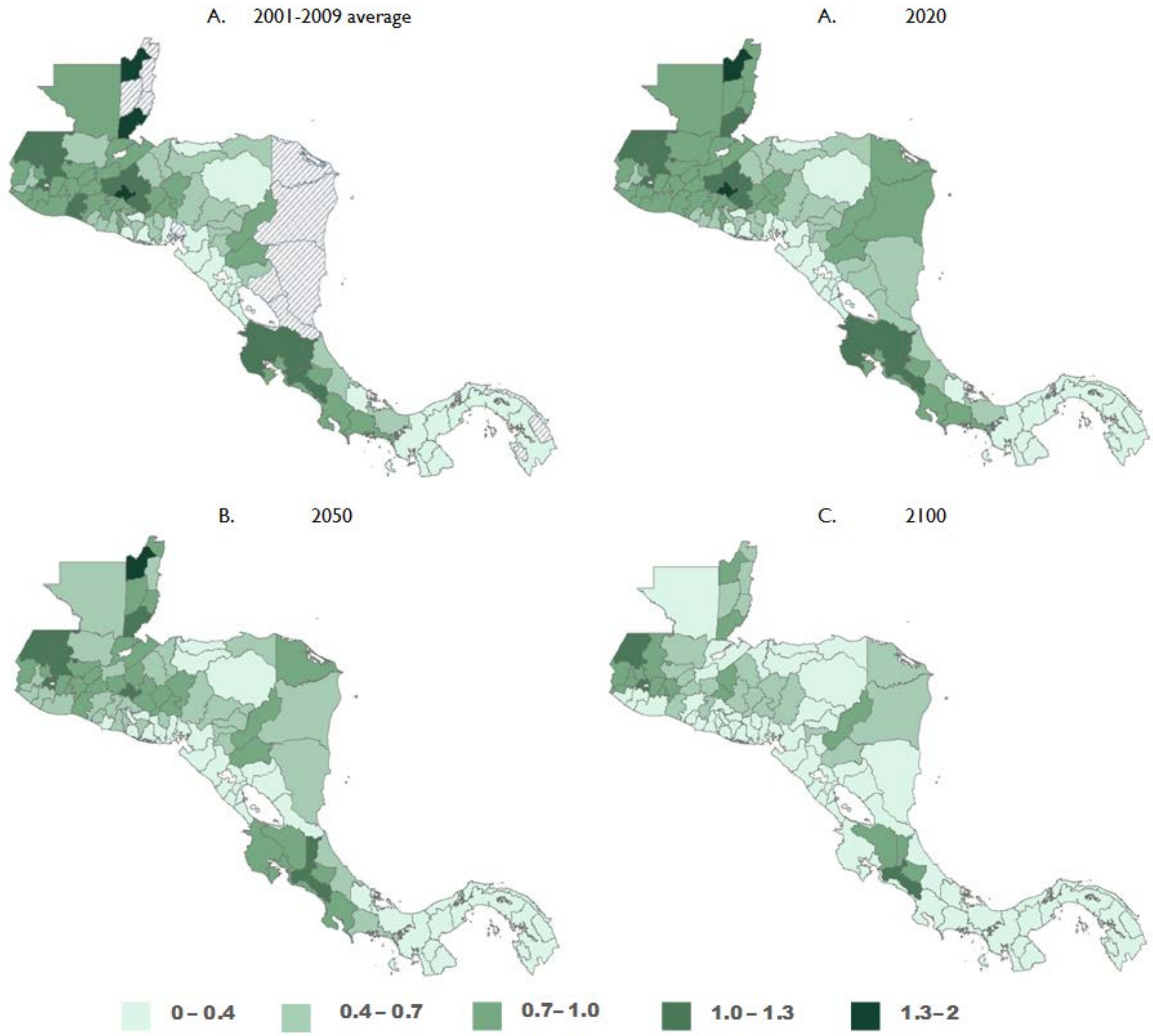
TABLE 9
CENTRAL AMERICA: EVOLUTION OF COFEE YIELDS, 2001-2009 AVERAGE AND SCENARIO B2 AND A2 UP TO 2100

	Average yield 2001-2009	2020	2030	2050	2070	2100
	(t/ha)			*(In percentages)*		
			Scenario B2			
Belize	1.51	-13.96	-17.52	-18.92	-30.65	-37.42
Costa Rica	1.16	-5.16	-8.11	-10.87	-20.72	-34.28
El Salvador	0.54	-7.36	-7.39	-17.20	-26.08	-37.88
Guatemala	0.92	-5.86	-5.40	-9.72	-14.27	-21.27
Honduras	0.72	-4.32	-8.25	-12.12	-18.33	-29.72
Nicaragua	0.65	-7.49	-14.75	-21.92	-28.77	-47.64
Panama	0.57	-7.58	-17.24	-27.26	-47.56	-77.34
Central America	0.78	-6.43	-9.69	-15.82	-24.44	-38.33
			Scenario A2			
Belize	1.51	-4.78	-16.92	-18.66	-34.49	-45.24
Costa Rica	1.16	2.91	-1.27	-11.19	-20.39	-36.14
El Salvador	0.54	0.31	-12.84	-22.29	-37.75	-57.92
Guatemala	0.92	2.44	-6.16	-11.52	-20.23	-35.57
Honduras	0.72	2.32	-6.12	-8.90	-19.00	-32.76
Nicaragua	0.65	-4.85	-10.65	-17.32	-34.63	-53.07
Panama	0.57	3.10	-13.21	-39.74	-54.89	-82.53
Central America	0.78	0.96	-8.71	-17.59	-29.99	-47.87

Source: ECLAC and CAC/SICA, 2014.

To illustrate, the departments were classified into three yield categories: high (greater or equal to 0.8 t/ha, the current global average), medium (between 0.3 t/ha and 0.8 t/ha), and low (less than 0.3 t/ha). As mentioned previously, 32 departments (34% of the total) recorded historic yields of 0.8 t/ha or greater, primarily in Costa Rica, Guatemala and Honduras. Toward 2050, this number of departments would decrease to 25 (26% of total) under scenario A2. Toward 2100, the number would decrease to 11 (12% of total): Orange Walk in Belize; Cartago, Heredia and San José in Costa Rica; El Quiche, Huehuetenango, Sacatepéquez, Sololá and Totonicapán in Guatemala; and Copán and Ocotepeque in Honduras. Therefore, an additional 14 departments toward 2050 would fall in the medium category under scenario A2: Toledo de Belize; Alajuela and Guanacaste in Costa Rica; Chiquimula, Jalapa, Santa Rosa, Guatemala, San Marcos, Chimaltenango and Izabal in Guatemala; Intibucá, Comayagua and Lempira in Honduras; and Jinotega in Nicaragua (see Map 12).

MAP 12
CENTRAL AMERICA: COFFEE YIELDS BY DEPARTMENT, 2001-2009 AVERAGE AND SCENARIO A2 UP TO 2100
(t/ha)



Source: ECLAC and CAC/SICA, 2014.

COFFEE BLIGHT

There are multiple transmission channels for the impacts of climate change when it comes to coffee and the people responsible for its production. Some examples are the diverse effects of extreme events, the progressive rise in temperature, changes in rainfall patterns and aridity, impacts on ecosystems that provide services that contribute to production (such as shade), and changes in diseases that affect production, such as blight.

The emergency situations caused by extreme climate events, such as the 2012-2013 outbreak of blight, the 2014 drought and tropical depression 12-E in 2011, have been increasingly present on the regional agenda. Faced with these challenges, the Presidents have decreed mandates for the Central American Integration System and declared a state of emergency in several countries. National and regional institutions have prepared and implemented immediate response programmes. There is growing awareness that these phenomena could be increasingly related to global climate changes caused by greenhouse gas emissions.

Coffee blight (*Hemileia vastatrix*) is a fungus that normally reproduces in warm temperatures and constant rain or humid environments at medium or high altitudes. The symptoms are yellow stains on the upper part of the leaf, where the spores reproduce. When the disease is particularly strong, it causes the leaves of the plant to fall, as well as abnormal maturation of the crop and a decrease in production (CICAFE, 2011). Coffee blight germinates in the temperature range of 16 °C to 26 °C, with the optimal range being 20 °C to 25 °C, depending on the type. Other conditions that promote germination are darkness, a minimum 6-hour period of dampness, sudden changes in the environment, plant age, inadequate fertilization and high plant fruit load (MAGA, 2013).

In the 2012-2013 coffee production year, Central America, Mexico and Colombia suffered another plague of blight that significantly affected production and producer income. The International coffee organization (ICO) calculated the loss of crops caused by the plague: El Salvador, 74%, Guatemala, 70%, Costa Rica 64%, Nicaragua, 37% and Honduras, 25%. According to the ICO, the impact on production in 2013/14 will be a decrease of 17% with respect to the previous harvest. The Ministry of Agriculture and Livestock (MAG) of El Salvador and the Salvadorian Coffee Council indicated that 74% of the 152,187 hectares of coffee crops were attacked by fungus. The Ministry of Agriculture and Livestock (MAG) and the Coffee Institute of Costa Rica reported that 64% of the 94,000 hectares of coffee crops was affected (*El Mundo*, 2013).

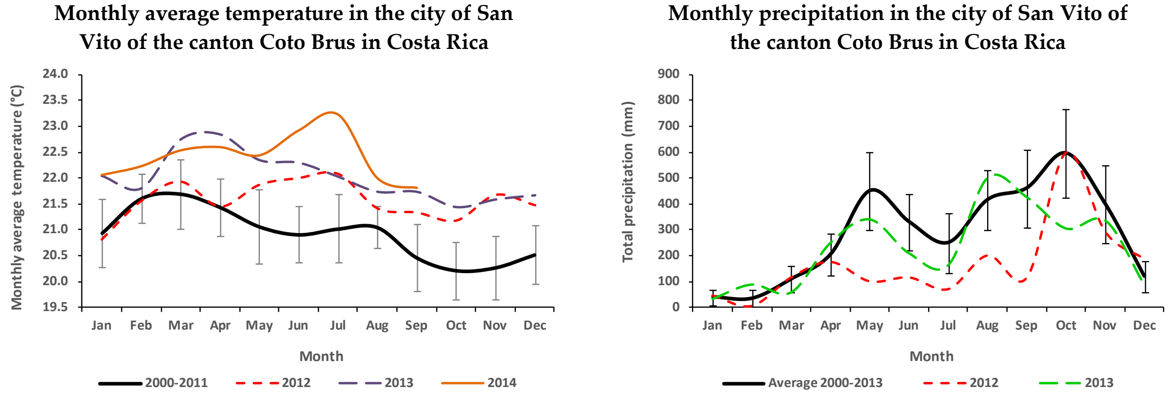
This epidemic and its socioeconomic repercussions led the Ministers of Agriculture of Central America to declare the outbreak a national emergency. The sensitivity of the sector to seemingly minor climate changes was apparent in the impact of the outbreak of blight that reduced the 2012-2013 coffee harvest by between 15% and 25% relative to 2011-2012 production (FEWSNET, RUTA and PROMECAFE, 2014, citing PROMECAFE), which led to a decrease in exports. It is likely that there will be impacts on future cycles. During the July-December period in 2013, there were decreases compared to the same period in 2012: 34% at the regional level, 19% in Costa Rica, 17% in Guatemala, 50% in El Salvador, 55% in Honduras and 44% in Nicaragua (ECLAC, and CAC/SICA, 2014).

The economic cost for the region was calculated to be $500 million, of which 46% corresponded to Honduras, 20% to Guatemala, 15% to El Salvador, 12% to Nicaragua and 7% to Costa Rica, the Dominican Republic and Jamaica combined (ICO, 2013a). Honduras was the most affected in economic terms and in production volume but was one of the least affected countries in terms of growing hectares. The losses affected two million Central Americans who, according to the ITO, earned a living through coffee production, including day labourers and producers. The ICO reported that this disease will cause the loss of 374,000 jobs in Central America, the Dominican Republic and Jamaica due to the decrease in demand for harvest labour (ICO, 2013a). A recent analysis of the relationship between climate variability and blight in Costa Rica is described below.

The changes in the typical behaviour of crop diseases often follow a set of economic, social and environmental variables that influence the vulnerability of plantations or the strength of the pathogen. In the case of the coffee blight plague examined, a change in the climate pattern in 2012 may have caused changes in the duration of the infection cycle (due to increased temperatures) and in the perception of the coffee grower (there is a belief that blight is associated only with high levels of rain) with regard to the need to pay attention to problems caused by plagues and diseases in general. Data collected over several years in the canton of Coto Brus in the province of Puntarenas in Costa Rica, which uses shade on its coffee plantations, illustrate and allow for the analysis of this change (Barquero, 2013a and 2013b).

Analysis of average monthly temperature and precipitation levels in Coto Brus shows a change as of May 2012. Chart 19 shows that average temperature during the 2000-2011 period (black line) reached a maximum value of approximately 21.7°C in March, and a minimum of 20.4°C in October. The monthly temperature in 2012 (red line) was greater than in the reference period as of May-greater in fact than the maximum value-reaching 22°C in July (the vertical lines represent the range of each month in the average). This trend continued in 2013 (purple line), reaching almost 23°C in March and April. In 2014 (orange line), average monthly temperatures continued to be higher than the average for the 2000-2012 period. In July, the average temperature reached higher than 23°C. The figure of monthly precipitation shows that for the average for the 2000-2013 period (black line), there were two rainy periods, one with a maximum of 450 mm in May and the other with 600 mm in October. By contrast, precipitation for 2012 (red line) shows lower levels between January and September, approximately 100 mm lower than the minimum values of the 2000-2013 average (the vertical lines represent the range of each month in the average). Only October saw 600 mm of precipitation, close to the historical average. In 2013, monthly precipitation (green line) was greater than in 2012, but still lower than the average for the 2000-2013 period for the months from May and July (Barquero, 2013a and 2013b).

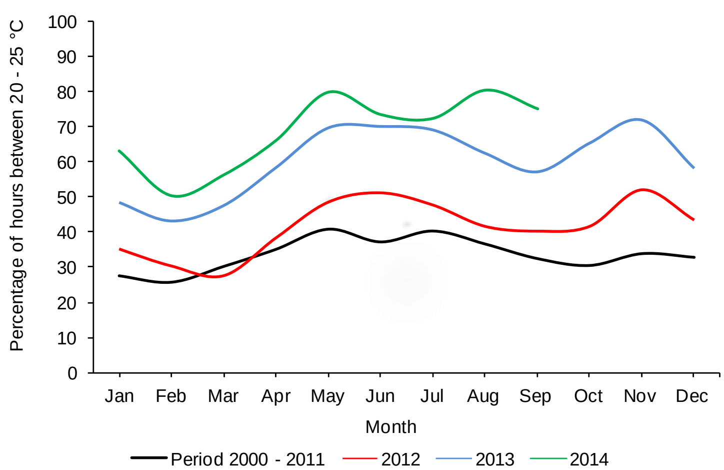
CHART 19
COSTA RICA, COTO BRUS: MONTHLY PRECIPITATION



Source: Barquero, 2013a and 2013b.

An increase in the proportion of hours with temperatures favourable for blight infection was also recorded, in addition to the higher temperatures and reduced levels of rainfall (see Chart 20). After May 2012 (red line), a 20% increase in the prevalence of favourable temperatures was recorded with respect to the average for the 2000-2011 period (black line). In 2013 (blue line), the proportion of hours with temperatures favourable for blight infection is greater than in 2012. In 2014 (green line), this proportion is superior to that of previous years. Between May and September, the percentage of favourable hours surpassed 70%.

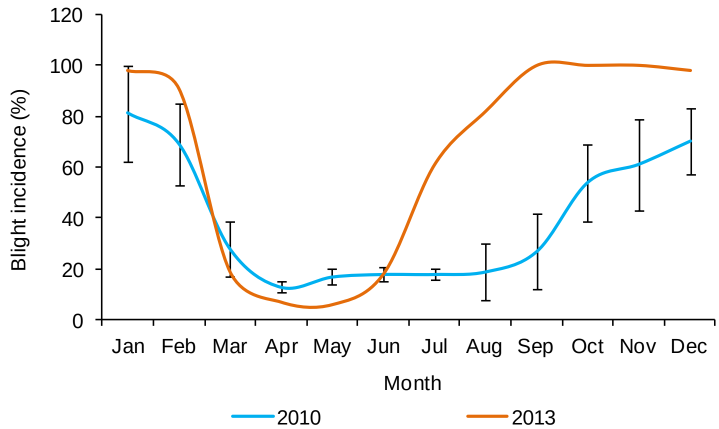
CHART 20
COSTA RICA, COTO BRUS: MONTHLY PROPORTION OF HOURS OF FAVORABLE TEMPERATURES FOR BLIGHT INFECTION



Source: Barquero, 2013a and 2013b.

It is likely that these three changes in climate have allowed for outbreak to occur more rapidly and sooner, as the disease can complete its biological cycle in less time (see Chart 21). Additionally, these conditions favour the permanence of a layer of condensed water on the leaves, due to the greater relative humidity caused by higher temperatures. Due to the earlier occurrence of this disease, it's possible that the application of fungicides took place too late (Barquero, 2013a and 2013b).

CHART 21
COSTA RICA, COTO BRUS: INCIDENCE OF COFFEE BLIGHT
(In percentages)



Source: Barquero, 2013a and 2013b.

Due to their personal experience, coffee producers associated blight with period of significant precipitation, meaning that they did not consider that this disease could develop with less rain. The producers were not aware of the relationship between blight and temperature, or they assumed a stable relationship. Furthermore, due to the fall in international coffee prices during the 2011-2012 harvest, coffee producers had less income to invest in maintenance and neglected phytosanitary care of their plantations. This event shows how sensitive the alteration of a previously-unrecognized climate factor can be, combined with other economic factors and productive practices and conditions (sensitive varieties, ages of the coffee plants, little maintenance such as pruning and low recovery of the organic content of the soil), factors which contributed to the greater vulnerability of the coffee plants. Another aspect of research is the modification of blight species and their infective capacity (Barquero, 2013a and 2013b).

FINAL CONSIDERATIONS FOR BASIC GRAINS AND COFFEE

In conclusion, it is estimated that the impacts of climate change on the production of basic grains in Central America would be notably greater under scenario A2 (growing emissions and global inaction) than under scenario B2 (a slow emissions trajectory). Under scenario A2, by the end of the century, the estimated regional decreases would be: 35%, 43% and 50% for corn, beans and rice, respectively, compared to 17%, 19% and 30% under scenario B2. Therefore, it is important to continue insisting on a global effort to reduce emissions. However, the scenarios suggest that the diversity in yields during the historic period could combine with the variations in impacts of climate change, which would maintain and exacerbate the heterogeneity of departmental and national yields, even without actions to adapt or improve production sustainability. Therefore, the results suggest that there will be different conditions and appropriate adaptation measures depending on the department, and even the region within the department.

The lower impact and potential increases in yield estimated for the Guatemalan Western Highlands and other highlands of the region do not necessarily mean that increasing production area is a recommendable option. Aspects such as appropriate land use for forests and other ecosystems, rugged topography, erosion risks and the care of water basins must be considered. In the same vein, the estimates do not consider the cumulative effect of current agricultural practices on the environment and their own sustainability, such as soil degradation and erosion, which could lead to decreased yields in the future.

The agricultural sector is highly vulnerable to climate change. It is the second largest emitter of greenhouse gases and involves a significant part of the population that lives in poverty and which produces the basic foods of the regional diet. Therefore, a strategic vision is required to maximize the co-benefits and minimize the costs at the farm-level and in value chains. In this sense, efforts to adapt and, to integrate adaptation measures and adaption-based mitigation plans in the agricultural mitigation plans that the region is implementing are very important.

The response to climate change in the agricultural sector will need to be closely coordinated with policies aiming to reduce deforestation, protect biodiversity and manage water resources. It will also require recognizing and considering the potential to widely apply successful techniques that have strengthened the welfare of rural and indigenous populations by establishing more sustainable production processes, such as agro-forestry and other activities that combine farming with the protection of natural ecosystems and payment for environmental services.

Given that the sector is the greatest consumer of water, whose availability could decrease in most of the region due to climate change and population increase, all efforts to increase efficiency in water-use are essential. Programmes to increase the access of dispersed rural populations to sources of renewable energy (e.g. solar and small-scale hydroelectric generation), such as the Central American Sustainable Energy Strategy 2020, are also important.

FOOD AND NUTRITION SECURITY

It is believed that full Food and Nutrition Security (FSN) is achieved when all people have physical, social and economic access to sufficient quantities of safe and nutritious foods that satisfy dietary needs and food preferences and allow them to lead an active and healthy life in a continuous and sustainable manner (FAO, 2008). One indicator of the existing divide in achieving FSN is the prevalence of under nutrition, as calculated by the FAO using household survey data combined with macro data regarding production and trade as well as food balances prepared by the FAO. In "The State of Food Insecurity in the World 2013", it is clarified that the indicator refers to access to food and is a measure of the possible prevalence of lack of foods for the population of a country in a year, and not for different groups within that population (FAO, FIDA and PMA, 2013). This indicator is used by the Millennium Development Goals in Goal 1, Objective 1.9, as it represents the number of hungry people in the world, a number which continues to be very high.

The vast majority of malnourished people live in developing countries, approximately 850 million, slightly less than 15% of the world's population (FAO, FIDA and PMA, 2012). In Central America and the Dominican Republic, the prevalence of under nutrition ranges from 5% to 17% of the population. Guatemala and Nicaragua have the greatest proportion of the population at risk of under nutrition. Some countries have managed to decrease these figures in recent decades. In the 1990-1992 and 2014-2016 period, the percentage of the Nicaraguan population at risk of having a food consumption lower than minimum needs dropped from 54% to 17%. The proportion decreased in

Panama as well, from 26% in 1990-1992 to 10% in 2014-2016. In Guatemala, the estimate varied between 15% and 20% for the same period (see Table 10). [14]

TABLE 10
CENTRAL AMERICA AND DOMINICAN REPUBLIC:
PREVALENCE OF UNDERNOURISHMENT, 1990-2016

(In percentages)

	1990-92	1995-97	2000-02	2005-07	2010-12	2013-15	2014-16
Belize	9.7	6.7	5.8	<5	5.7	6.3	6.2
Costa Rica	5.2	5.6	5.1	5.6	5.3	5.5	<5
El Salvador	16.2	15.4	10.6	10.7	12.6	12.6	12.4
Guatemala	14.9	17.1	20.4	15.9	14.8	15.6	15.6
Honduras	23.0	19.8	18.5	16.4	14.6	12.3	12.2
Nicaragua	54.4	42.9	31.3	23.2	19.5	17.1	16.6
Panama	26.4	25.6	27.6	22.9	13.4	10.0	9.5
Dominican Republic	34.3	27.3	28.4	24.2	15.9	12.5	12.3

Source: FAO. Online database: Food Security Statistics

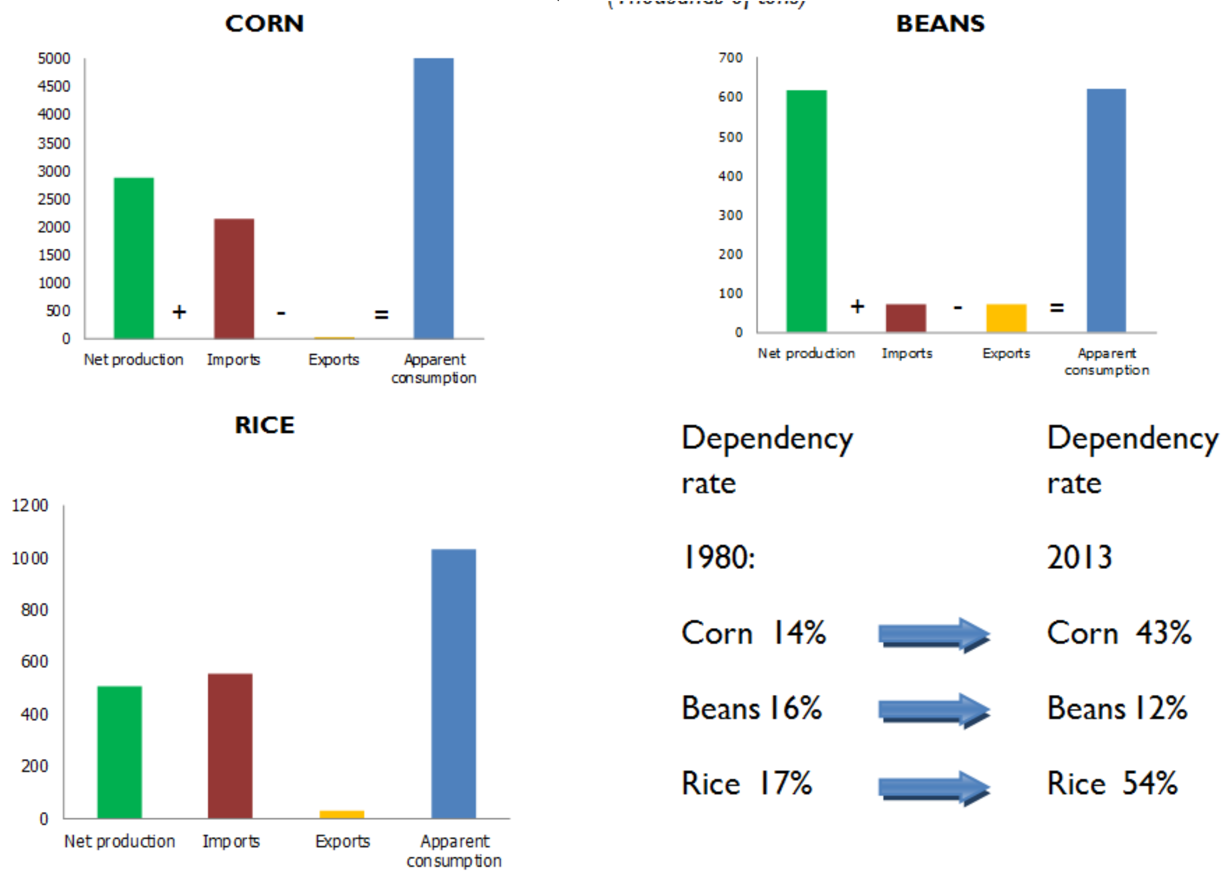
Note: Probability that an individual from the population consumes an amount of calories that is insufficient for meeting energy needs. I.e., the proportion of the population at risk of caloric insufficiency.

According to Salcedo Baca (2005), "food security comprises four components: availability, access, use and stability, which are interrelated through a dynamic process and rely on an institutional foundation that largely determines its performance". For each component, it is possible to identify several factors that influence its performance; these are potential areas for policy interventions. Institutional structures should grantee adequate institutional arrangements and the adoption of a comprehensive and multisectoral vision of the programmes and projects of FSN.

Regarding availability, in 2013, 3.7 million tons of maize, 11.1 million tons of rice and 689,000 tons of beans were produced in Central America (FAOSTAT, 2013; SIAGRO, 2013). Over the last decade, the annual growth rate was 2% for maize and rice production and 3% for beans. Nevertheless, regional production has been insufficient for covering domestic consumption demands, especially for maize and rice. For example, the apparent consumption of maize has shown greater growth than net production (see Chart 22). Since 2000, consumption has grown at an annual average rate of 3.1% while net production has grown at a rate of 2.3%. It must be noted that imports include both white maize for human consumption and yellow maize, primarily for livestock consumption. Together, both varieties represent 88% of total imports. It is important to mention that the apparent consumption is not a measurement of the consumption required to avoid malnutrition, which is higher in countries with population that suffer malnutrition.

[14] According to the National Food and Nutrition Security Indicators System (SIINSAN) of Guatemala, the prevalence of chronic malnutrition of children under 5 years ranged from 82.2% in Totonicapán to 25.3% in El Progreso in 2008.

CHART 22
CENTRAL AMERICA: NET PRODUCTION, EXPORTS, IMPORTS AND APPARENT CONSUMPTION OF BASIC GRAINS, 1980 AND 2013
(Thousands of tons)



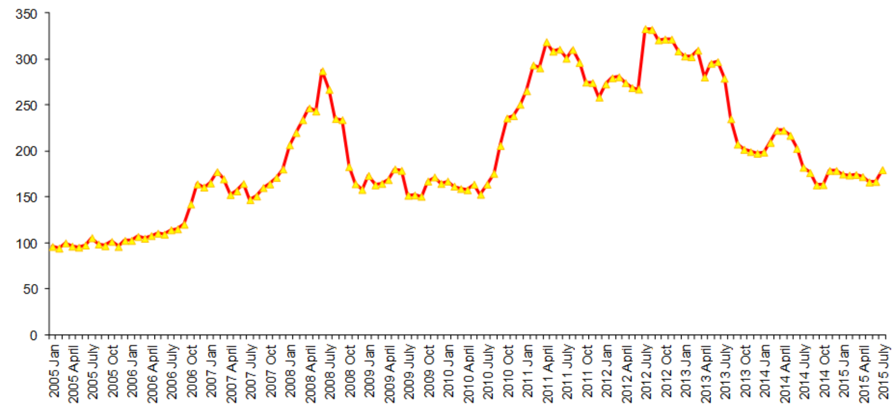
Source: ECLAC and CAC/SICA, 2013a.

Regarding beans, the net production growth rate has been greater than that of apparent consumption from 2000 to 2013, with rates of 5.4% and 4.7% respectively. In years when production is not sufficient for covering needs, imports, primarily from other Central American countries, are used. The apparent consumption of rice has increased, especially since the 1990s, while production has remained flat with some growth in the last ten years with respect to consumption.

With regard to access, average inflation of food prices lay between 3% and 11% in Central American countries for the 1996-2013 period, higher than general inflation in all countries with the exception of Honduras. Costa Rica, Nicaragua and Honduras had the highest inflation in food prices in this period. Panama, El Salvador and Guatemala had lower food price indices (CEPALSTAT, 2013). These inflation rates have negative consequences on access to food and food security, especially for the low-income population. The greater inflation seen in food prices is due to the dependence on imports and the rising trend of international prices. These are factors that are partially related to decreases in offer due to poor climate conditions that affected production in those countries that export to the region.

Chart 23 shows the fluctuations in international maize prices between 2005 and mid-2015, a crucial food for the Central American population. There was a sharp increase in prices at the beginning of 2008 and a subsequent decrease in the same year. Prices rose again in 2010. The current price range is similar to that prior to January 2008.

CHART 23
MONTLY INTERNACIONAL PRICE OF CORN, 2005-2015
(Dollars per ton)



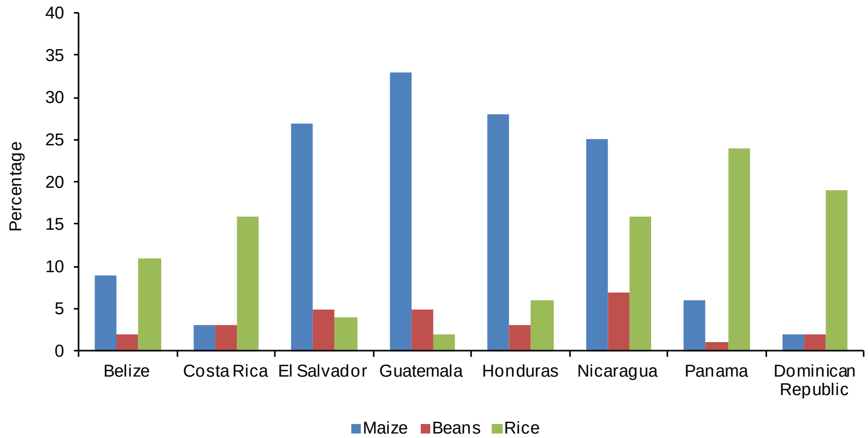
Source: International Monetary Fund (IMF), International Financial Statistics: maize (United States no. 2 yellow, FOB Gulf Ports), rice (Thailand-Bangkok), wheat (United States No. 1 Hard Red Winter, FOB, Gulf Ports) and sorghum (United States, Gulf Ports).

Poverty and inequality also act as barriers to accessing basic grains. By 2008, approximately half of the population in Central America was living in poverty, and a quarter, in extreme poverty. The Gini inequality index is relatively low: between 0.40 and 0.59 according to the latest data reported by country in Central America and the Dominican Republic. Despite the efforts of the last 20 years, poverty and inequality have not been significantly reduced (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

As mentioned earlier, basic grains are the primary source of energy for Central Americans and provide vegetable protein, especially when rice or corn are traditionally combined with beans. It is noteworthy that the food system in the region is characterized by a high level of self-subsistence on the part of small producers of basic grains. Chart 24 shows the proportion of basic grains in energy requirements in each of the countries. These three grains provided 32% of the dietetic energy of the region during the 2009-2011 period, although in 1983, they accounted for 40%.

Maize provided more than 25% of food energy in El Salvador, Guatemala, Honduras and Nicaragua in the 2009-2011 period, while it provided 9%, 3%, 6% and 2% in Belize, Costa Rica, Panama and the Dominican Republic respectively. These are high percentages for one single food. Beans provided 7% of food energy in Nicaragua, while in the remaining countries, the contribution was less than 5%. In Panama, beans accounted for 1%. Rice contributed most to energy consumption in Panama, the Dominican Republic, Nicaragua, Costa Rica and Belize, with 24%, 19%, 16%, 16% and 11% respectively. In total, the three grains provided 48% of food energy in Nicaragua, 40% in Guatemala, 37% in Honduras ad 36% in El Salvador.

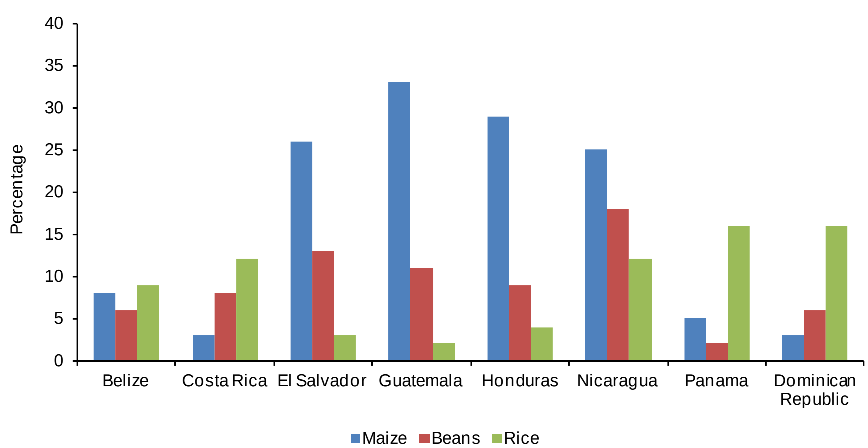
CHART 24
CENTRAL AMERICA AND DOMINICAN REPUBLIC: AVERAGE PROPORTION OF TOTAL ENERGY SUPPLY FOOD PROVIDED BY BASIC GRAINS BY COUNTRY, 2009-2011
(In percentages)



Source: FAOSTAT, 2015.

Chart 25 shows the proportion of basic grains in protein requirements in each of the countries. These three grains provided 35% of protein in the region during the 2009-2011 period. Maize provided more than 25% of food energy in El Salvador, Guatemala, Honduras and Nicaragua in the 2009-2011 period, while it provided 8%, 3%, 5% and 3% in Belize, Costa Rica, Panama and the Dominican Republic respectively. In Nicaragua, Guatemala and El Salvador, beans made the most significant contribution to protein consumption with figures of 18%, 13% and 11%. In Panama and the Dominican Republic, the contribution of rice was 16%, while in Nicaragua and Costa Rica, the contribution was 12%. In Nicaragua alone, the contribution of the three basic grains was 55%.

CHART 25
CENTRAL AMERICA AND DOMINICAN REPUBLIC: AVERAGE PROPORTION OF TOTAL PROTEIN SUPPLY FOOD PROVIDED BY BASIC GRAINS BY COUNTRY, 2009-2011
(In percentages)



Fuente: FAOSTAT, 2015.

INSURANCE IN THE AGRICULTURAL SECTOR

With a few notable exceptions, most countries have experienced decapitalization of the rural economy and the dismantling of programmes for land titling, outreach, post-harvest loss reduction, market access and capacity building. The consumption of basic grain in the countries of the region is increasingly dependent on international markets, where the increased demand for food, combined with the effects of climate variability and change, could increase the risks of shortages and high prices, or significant fluctuations in these prices. The region has the opportunity to collectively face these risks, through their current and future diverse domestic production capacities, the intraregional trade of food, the creation of strategic reserves and the promotion of insurance products (especially micro-insurance) for producers.

These products are worthy of mention as they are financial instruments that meet the goal of guaranteeing financial resources to small- and medium-scale producers, some since before the occurrence of disasters [15] (ECLAC and CAC/SICA, 2013b, and 2015). Governments can move some of the financial resources allotted for reconstruction to measures that prevent disaster risks, including subsidies for agricultural micro-insurance premiums. Agricultural insurance and micro-insurance are a preventive market mechanism for the transference of risk from productive units to insurance and reinsurance companies, with the help of the State. Developing economies have made significant progress in terms of preventive mechanisms for the transference of risks and forming part of the financial strategies to include poor producer households in rural areas. To date, there is limited experience with agricultural micro-insurance in Central America and the Dominican Republic, although there is a large institutional structure for microfinance. This empirical fact is explained by the threats of international macroeconomic, microeconomic and climatic origins against agricultural activity in the region, as well as the increasing structural vulnerability of areas where poor, rural producers live.

With regard to the institutions responsible for the development and strengthening of the agricultural insurance and micro-insurance market, the countries of the region can be divided into two types. On the one hand, there are countries with public insurance companies or trusts that require support to strengthen their insurance products (Costa Rica, Guatemala, Nicaragua, Panama and the Dominican Republic); and on the other hand, there are countries without public insurance companies that demand studies on feasibility, institutional development and the promotion of the insurance market (El Salvador and Honduras). All countries have private insurance companies that offer traditional, nominal and multi-risk agricultural insurance. One private institution (Lafise Nicaragua) offers agricultural insurance (for peanuts and maize) that is based on climatic indices. However, there is no demand for this product, and therefore the market penetration is zero.

Given climate risks and the budgetary restrictions on national governments, traditional agricultural insurance (nominal or multi-risk) marketed to micro and small, rural producers in the region is not likely to be successful, unless novel strategies are adopted to subsidize or provide discounts on premiums. Furthermore, the likelihood of success of insurance instruments in agricultural activities will be greater when they are combined with strategies to reduce the vulnerability of productive units, public and private infrastructure and agricultural production technology, among other factors. Faced with these conditions, analysts, researchers and public-policy

[15] Guaranteeing financial resources to small and medium producers is of particular interest to the CAC/SICA ministers and is part of the ECLAC and CAC/SICA working programme.

decision makers have increased the adoption of strategies for comprehensive risk management and insurance instruments for small and medium rural producers.

The following are policies, strategies and national plans for agriculture and food and nutrition security that incorporate the subject of climate change:

- Belize. National Agriculture Sector Adaptation Strategy to Address Climate Change in Belize, 2014, by the Caribbean Community Climate Change Centre.
- Costa Rica. Policies for the Agricultural Sector and the Development of Rural Areas 2015-2018 and the Strategic Plan 2015-2018, both by MAG.
- El Salvador. Environmental Strategy for Climate Change Adaptation and Mitigation in the Agricultural, Forestry, Fisheries and Aquaculture Sectors, 2015, by MAG.
- Guatemala. Agricultural Policy 2010-2015 by MAGA.
- Honduras. National Food and Nutrition Security Strategy 2010-2022 by the Technical Assistance for the Food and Nutrition Security Technical Unit (UTSAN).
- Nicaragua. Plan for Adaptation to Climate Change and Variability for the Agricultural, Forestry and Fisheries Sectors of Nicaragua, 2010-2015 by the Ministry of Agriculture, Livestock and Forestry (MAGFOR).
- Panama. Strategic Action Plan for the Agricultural Sector 2010-2014 by the Agricultural Development Ministry (MIDA).
- Dominican Republic. National Climate Change Adaptation Strategy in the Agricultural Sector of the Dominican Republic 2014-2020 by the Ministry of Agriculture.

Various instruments work to develop a regional agenda to address the challenges of climate change. These instruments provide a framework for regional efforts, among them the Regional Environmental and Health Strategy, The Central American Agricultural Policy (PACA) 2008-2017, Central American Policy for Integrated Risk Management (PCGIR), the Food and Nutrition Security Policy of Central America and the Dominican Republic (POLSAN), the Regional Policy for Fruticulture Development (POR-FRUTAS), the Caribbean Catastrophe Risk Insurance Facility (CCRIF) led by COSEFIN, the Central American Strategy for Rural Territorial Development (ECADERT), the Regional Climate Change Strategy and the Regional Environmental Framework Strategy. Various statements have also been issued. For example, in August 2015, the Ministers of Agriculture of CAC issued a statement with the goal of promoting Climate-Smart Agriculture (CSA) as an option for increasing agricultural, livestock, fisheries, aquaculture and forestry productivity, creating greater resilience and supporting the adaptation to climate change with a view to improving food and nutrition security. The commitment is to promote CSA based on adaptation, environmental and social sustainability, productivity and competitiveness, food and nutrition security, recovery of degraded land and comprehensive land and water management. The statement aims to promote partnerships between the public, private, academic and civil society sectors in order to strength CSA knowledge management and also to ensure that CSA is reflected in national development plans and strategies. In September 2015, the CAC Ministers decided to bring a regional proposal regarding the relationship between agricultural productivity and climate to the Inter-American Agriculture Board.

BOX 3
RECOMMENDATIONS FOR AGRICULTURE AND BASIC GRAINS WITH REGARD TO CLIMATE CHANGE

Protecting food security in the face of climate change, especially access to basic grains, and making the transition to more sustainable and inclusive agriculture is a major challenge that cannot be put off if poor rural and urban citizens are to be protected. The following are potential lines of action that could form part of the response to the threat of climate change against basic grains:

- Expanding the network of producers, dialogues with actors and agricultural extension and innovation services to identify and spread sustainable adaptation options: changes in cultivation practices, managing soil fertility, humidity and retention, the efficient collection, storage and use of water, seeding times and post-harvest management.
- Protecting and promoting the development and exchange of native variety of plants through joint efforts between producer and agricultural technology institutions in order to have varieties that are resistant to climate change and to protect agro-biodiversity in the region.
- Reduce production in areas that are inappropriate due to the type of soil, orography or climate, and increase it in appropriate areas with the attention needed to the rights of producers and the conservation of ecosystems.
- Recover and rehabilitate degraded land, promoting its sustainable management through appropriate technology, especially in dry areas.
- Increase the formalization of land ownership, including collective, community and indigenous community ownership.
- Promote sustainable and diversified production practices, including agro forestry and agro-silvo-pastoral systems.
- Take advantage of the benefits of cooperation to increase productivity of agricultural activities through economies of scale in the production, commercialization and acquisition of inputs, the development of technical knowledge and practices of environmentally and economically sustainable modes of production, and the acquisition of loans and insurance with better conditions and greater power to negotiate.
- Train a greater number of farmers in modes of production that increase sustainability and resistance to climate variability and change, taking advantage of "farmer-to-farmer" learning experiences and horizontal knowledge creation, as well as collaboration between producers, technicians and researchers.
- Strengthen the knowledge and practices of farmers in sustainable and profitable methods of production, including soil protection, the recycling of waste, the use of seeds that are resistant to climate change and variability, the combination of crops to diversify risks, to guarantee a harvest and income for small and medium producers.

- Make progress in national and regional food security through the promotion of complementary production in different geographic regions, protection of producers and the facilitation of intraregional trade, including regional mechanisms for agricultural safety, food safety, technological innovation and energy efficiency.
- Integrate universities and other public and private research centres to generate research related to the management of risks and agricultural insurance and micro-insurance. At the same time, explore the possibility of creating a network of researchers of the members countries of the Central American Integration System (SICA).
- Increase access to education and health services and sources of renewable energy, such as solar, wind, small-scale hydroelectric and from organic waste produced on the same farm in order to create sustainable energy and production cycles.
- Consider options to expand coverage to areas of risk based on climate change scenarios and using efficient technologies.
- Promote new mechanisms and means to alert the population of adverse phenomena through the use of mobile telephones, radio messages, social networks, etc.
- Strengthen public infrastructure by including measures that reduce the risk of disasters from the proposal and feasibility stage of projects. Risk management needs to be flexible in order to be adapted to new threats that could emerge as a result of climate change.
- Create maps of areas of risk of micro and small rural producers with their participation in order to take measures to reduce these risks, or, when necessary, relocated them to areas of lower risk and/or more stability with respect precipitation, temperature and radiation, or with irrigation infrastructure in order to guarantee the sustainability of the agricultural productive cycle and food and nutrition security.
- Increase public security in rural areas in order to reduce loss of agricultural goods and livestock and to reduce premiums and increase the agricultural insurance and micro-insurance market.
- Involve producer organizations in risk management and the design of insurance products so that these can respond to their needs.
- Increase financial inclusion for productive households in rural areas, through development banks, specialized banks, microfinance institutions and public and private insurance companies that promote financial instruments such as loans, deposits, guarantees and insurance.
- Encourage development banks and public institutions to offer financial training and education, including information on agricultural insurance and micro-insurance to agricultural producers, promoters and extentionists.
- Incentivize the participation of small and medium farmers in cooperatives, associations, mutual and insurance funds.

- Extend credit and incentives that support adaptive and sustainable production in the face of climate change, including measures to improve the efficiency of water use and reduce the use of inputs that emit GHGs and other pollutants.
- Develop agricultural insurance and risk coverage instruments for the sector and increase funds for contingencies and risk reduction.
- Diversify and strengthen sources of income for producer families with a view to sustainability, including payment for environmental services that sustainably manage river basins and forests, harvests of non-timber products, GHG emission reduction bonds, cultivation and processing of organic products, such as organic shade coffee, for "green" markets and domestic and international fair trade.
- Increase the collection of climate data as well as the analysis of its current and potential physical and economic impacts on productive systems for basic grains and value chains.
- Strengthen climate alerts and predictions using dissemination systems that allow producers to easily access recommendations relating to production cycles.
- Analyse in greater depth the current and future effects of the El Niño/La Niña phenomena, including drought and aridity in the dry corridor, as well as the adoption of adaptation strategies that place the countries of the region in a position to address the impact of food and nutrition security on the low-income population in rural and urban areas.
- Create a regional system for climatic, agricultural and financial information that is public, reliable and timely, based on the strengthened national systems and respective national priorities and policies.
- Explore ways to use geo-referenced information available on climate variables and yields in order to achieve the optimal management of risks and to provide transparent information to the insured.
- Manage climate information, loans, production costs and yield by area and locality, complemented by data compiled with producers and their organizations.
- Incorporate climate change in national policies and proposals for the sector and coordinate efforts with the stakeholders responsible in order to reduce deforestation, protect biodiversity and manage water resources.
- Analyze rural infrastructure investment projects to incorporate criteria to protect against climate change and to effectively benefit small producers, increasing the mechanisms for participative management.
- Incorporate incentives in fiscal and competition policies to stimulate productivity, sustainability and adaptation to the value chains of basic grains.
- Explicitly link decisions relating to agricultural development with measures and goals to bring an end to deforestation and to conserve environmental services, including their role in the comprehensive management of water and as carbon sinks.

Source: ECLAC and CAC/SICA, 2013a.

BOX 4
RECOMMENDATIONS FOR COFFEE PRODUCTION WITH REGARD TO CLIMATE CHANGE

Using the analysis prepared by the Technical Group on Climate Change and Comprehensive Risk Management (GTCCGIR) of the CAC/SICA and ECLAC, with significant contributions from institutions such as CIAT, CATIE, CIRAD, PROMECAFE, ICAFE, FAO and GIZ, the GTCCGIR began a technical discussion to create an initial proposal for the renovation and adaptation of the coffee production sector to climate change as an input for a broader discussion in the region. The proposal encompasses a set of lines of action relating to dialogue and work with small producers, value chains, the collection and use of climate data, the diversification of production and income, the emergency plan for blight, the development of an integrated agenda for productive and social services, economic and fiscal incentives, investment in rural infrastructure, strengthening of a certification system and of trade negotiations, and access to financing. The following are the lines of action:

- Promote dialogue and organization with the small coffee producers to facilitate actions that strengthen the exchange of knowledge and access to extension, innovation and other services that improve production and income, taking into account successful experiences and lessons learned in the region.
- Strengthen coffee value chains with participative methods to identify measure that improve the livelihoods of producers as well as the sustainability and adaptive capacities of said chains, incorporating analysis of adaption to climate change and opportunities associated with the transition to low-emission economies, promoting high-quality beans and greater coffee production in order to be placed in niche markets with better prices.
- Increase the collection of climate data on small coffee producers' farms, improving their quality and promoting their exchange and use for decision-making with regard to productive practices.
- Implement emergency plans for blight while paying attention to other diseases and measures required in the medium term.
- Recognize that the diversification of production and income sources is already a part of the traditional management of risk reduction for many small producers, evaluate the potential options with producer families with a perspective of sustainability and adaptation to climate change.
- Prove and disseminate the multiple benefits of and the efforts required to create sustainable and diversified production systems, including calculations that take into account total and compensatory production of various species in a farm, the effect of the reduction of risk and climate externalities that are locally or nationally beneficial, management of basins and water, preservation of ecosystems for touristic and culture uses, among others.

- Evaluate the benefits and costs of an integrated proposal of productive and social services with contributions from the public and private sectors and civil society in order to promote sustainable and inclusive development of the sector. With this proposal for integrated services as a starting point, evaluate the economic and fiscal incentives that currently affect the sector and explore options with treasury authorities to incentivize the organization of producers and the sustainable and adaptive production of coffee in the face of climate change, including measure to improve the efficiency of water use and to reduce the use of inputs that emit GHGs and other pollutants.
- Promote the broadening and improvement of certification systems and export contracts related to specialized markets (fair trade, organic, and carbon footprint).
- Incorporate measures that have been agreed upon in public policies and budgets and design external financing programs, coordinating efforts with the stakeholders responsible for reducing deforestation, protecting biodiversity and managing water resources, especially in inter-institutional instances of coffee and climate change.

Source: ECLAC and CAC/SICA, 2014.

BOX 5
MICRO-INSURANCE, STRATEGIES TO PREVENT RISKS IN THE AGRICULTURAL SECTOR

From the point of view of public policy, the promotion of agricultural insurance and micro-insurance and, in general, strategies for comprehensive risk management require that aspects of the public institutionalism of insurance as well as the development of the insurance business be considered. These aspects are described below:

On the public institutionalism of insurance

- Incorporate in the rules or regulations regarding insurance created by regulatory bodies the authority to design, commercialize and distribute agricultural insurance or micro-insurance, some of which could be linked to climate indices. These rules should meet international standards regarding the regulation and supervision of this type of financial instrument.
- Promote the creation and/or strengthening of a public insurance company in each country, responsible for the creation, promotion, dissemination and commercialization of agricultural insurance products. These products can be traditional or tied to indices, the latter based on yields or climatic variables.
- Use some of the resources allocated for post-disaster emergency attention *ex ante* toward subsidies or discounts on agricultural insurance premiums and toward reducing vulnerabilities, in order to reduce costs and losses. In countries with high levels of rural poverty and indigence, it is recommended that catastrophic agricultural insurance be acquired by the local or national governments, who should assume the responsibility of distributing the financial resources amongst the final beneficiaries, i.e. the rural population.

- Ensure the sustainability of public businesses that provide agricultural insurance and micro-insurance through a partial absorption by the State of the administrative costs, with a possible link to both national and international sources of income established for this goal, particularly through climate financing mechanisms. Of course, this implies introducing transparency measures to avoid operational inefficiency. A contingency fund for agricultural insurance could also be considered to deduct resources in the event of financial deficits.
- Focus subsidies on small producers, to cover a part or all of the cost of an agricultural micro-insurance policy.
- Improve financial sustainability and the long-term commitment with national and private insurance and reinsurance companies, in order to provide security to participants in the insurance market, particularly the insured. Achieve equilibrium between the cost of the premiums and the diversification of risk of the insuring companies through negotiation and monitoring, within the framework of measures for the reduction or containing of risks.
- Avoid the displacement effect of the insurance, through the separation of agricultural insurance from post-disaster assistance. It is important to understand that insurance is just one of the many instruments of risk management.
- Evaluate options for regional associations among the national insurance markets and systems in order to reduce the costs of research, design and administration of instruments, agricultural and climatic information systems and the taking out of insurance policies taking advantage of economies of scale. These actions can range from the PCGIR to the taking out of an insurance policy for catastrophic risks such as that provided by the Central American Council of Ministers of Treasury and Finance (COSEFIN).
- Establish a system to protect the consumer in insurance services.
- Socialize the results of regional discussions on strategic lines for the development of these financial instruments to transfer risk with international financial organizations and institutions, such as the Inter-American Development Bank (IDB), Central American Bank for Economic Integration (BCIE), the World Bank, The United Nations Food and Agriculture Organization (FAO) and the International Fund for Agricultural Development (IFAD), among others.

On the development of the insurance business

- Develop a greater knowledge of the preferences and experiences of risk of the producers through participative methods in order to determine what type of insurance products will be feasible. The IRI has developed such methods at the global scale in order to identify preferences and principal risks.
- Stimulate the confidence of small and medium rural producers through training and participation the management of insurance, with a view to increase the demand for agricultural insurance.
- Promote the creation of a state entity responsible for the formation and commercialization of agricultural insurance in the two countries that do not yet have it, especially aimed at small and medium producers. In the design and planning process of agricultural insurance, it is invaluable to have a public insurance company given the difficulty in

interesting private entities in insuring agricultural activity, especially for small producers. Likewise, the participation of the financial system, insurers and reinsurers, producer unions, service providers and regulatory agencies is necessary.

- Negotiate the reduction of conditions imposed by private insurers and reinsurers regarding the minimum growing area to be insured. A minimum quantity that allows for profits acceptable to insurers and reinsurers must be determined, which is why a point of equilibrium must be found: the instrument should not be too onerous for the producer, but should also not be unattractive from a business point of view. With regard to the above, consider regional associations to take advantage of economies of scale.

Source: ECLAC, CAC/SICA, 2013b and 2015.

3.3 BIODIVERSITY AND ECOSYSTEMS

Central America has a great diversity of ecosystems, including its tropical forests. In 2005, tropical forests covered about 45% of the territory of the region and were home to approximately 7% of the planet's biodiversity (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011; INBio, 2004). Tropical forests are extremely rich in terms of biodiversity and biomass because the energy from the sun at the equator allows life to thrive amidst abundant nutrients. Ecosystems regulate the climate as they help to maintain the gaseous composition of the atmosphere (Salzman, 1998). Forests are carbon sinks that capture atmospheric CO_2 and thereby mitigate the greenhouse gas (GHG) effect worldwide. Ecosystems directly regulate local and regional climate through their role in the water cycle. The water absorbed by plants through their roots evaporates via the leaves. Therefore, air temperature and humidity levels can change if climate change affects this contribution from ecosystems.

Central America depends on its forests, as they are an invaluable resource that provide multiple products and services, as well as compensating to a certain degree for the low-income population's limited access to basic goods via the market and providing shelter against natural disasters such as floods and tidal waves. In many areas, there is a very close relationship between the indigenous people and the forests, not only in terms of productive activities, but also in terms of identity, culture and history.

Unfortunately, these forests are very fragile. The available data shows that the influence of human activities on ecosystems is significant and modifies their availability, structure and systemic behaviour (Millennium Ecosystem Assessment, 2005). It is estimated that between 2000 and 2010, 13 million hectares of forest were converted every year for other uses or were lost due to natural causes (FAO, 2010). Not all of the affected forests have disappeared entirely. Many of them have been partitioned by highways and human development; these changes threaten the health and survival of native plants and animals. Currently there is a large number of species and ecosystems under threat. Their ability to recover naturally without human help no longer seems a viable option, given that their resilience has weakened notably in the last few decades (IPCC, 2007c). Moreover, the majority of climate change impacts tend to intensify downward trends (IPCC, 2007c; Parmesan and Yohe, 2003), which makes it difficult to identify and isolate the specific effects of climate change on ecosystems; this suggests that climate change impacts could be having a greater-than-proportional effect when combined with other negative factors.

In Central America, even without climate change, these pressures will probably continue to intensify, at least until the human population stabilizes around 2070 and until the economy transitions to a model that uses natural resources more efficiently and with less pollution. At the same time, the increase in extreme events seen in recent decades, especially droughts, hurricanes and floods—often aggravates the destruction of ecosystems in the affected areas. For instance, hurricane Felix affected an extensive area of forest in Nicaragua's North Atlantic Autonomous Region in 2007 (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011). In this context, climate change emerges as a significant added risk since it increases temperature levels and modifies precipitation patterns and will likely decrease the volume of rainfall in the medium term. It is also likely that humidity levels will diminish, and that the rising temperature of the sea surface will increase the destruction caused by hurricanes and tropical storms.

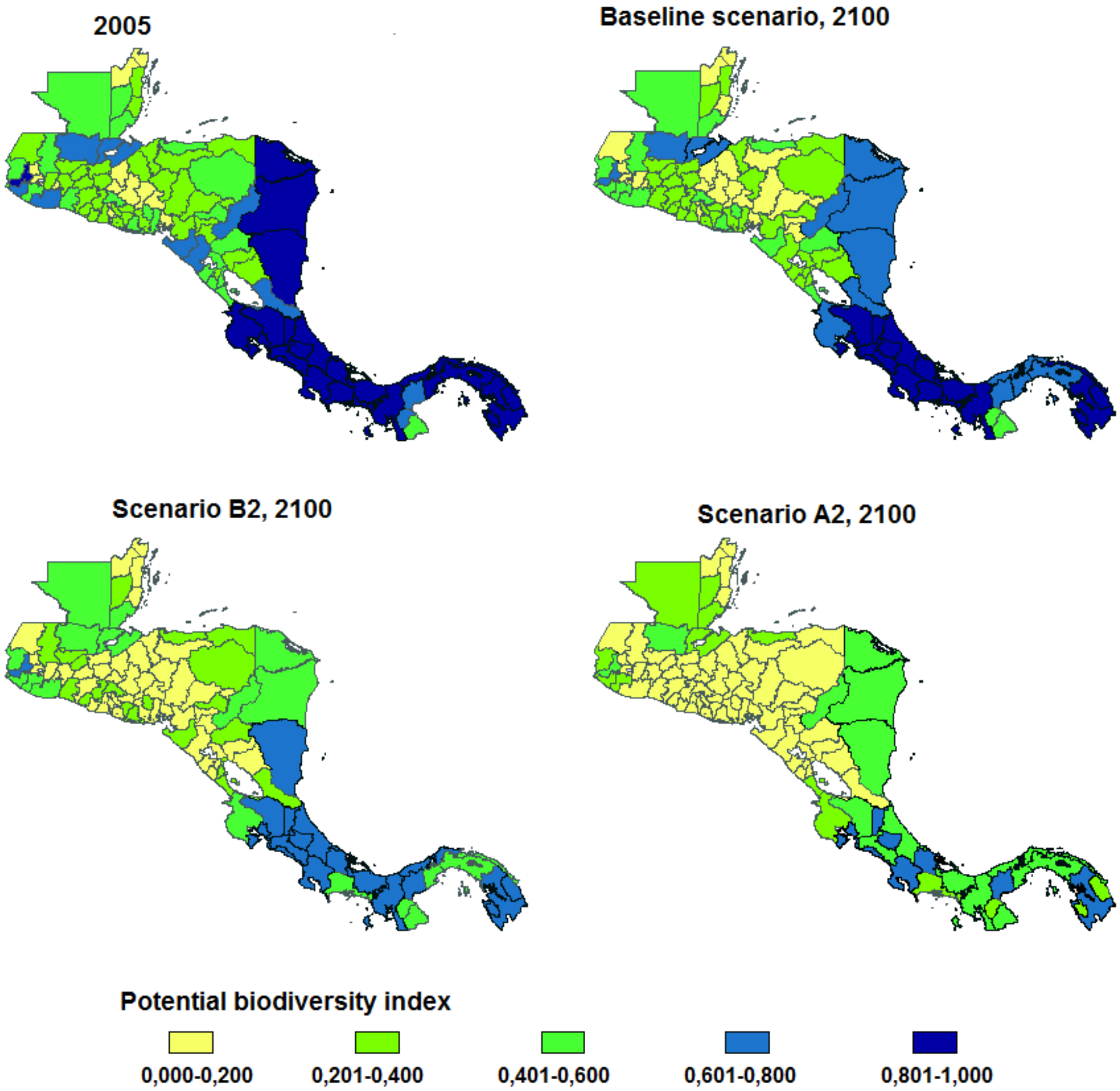
Specialized literature has identified the following possible impacts of climate change on natural ecosystems: changes in evaporation patterns, changes to cloud cover at vegetation level, perturbations to mountain ecosystems, decreases in tropical and montane area and an increase in pre-montane area, and the appearance of tropical very dry forest and dry premontane forest. Habitat loss could also occur due a greater frequency of forest fires, droughts, floods and changes in the soil sediment in low lands; as a result, invasive species and new disease vectors could proliferate.

A different approach to analysis seeks to evaluate the direct impact of climate change on biodiversity. Of the studies carried out, three analyse the entire region using different methods. The study titled "Potential Impacts of Climate Change on the Biodiversity of Central America, Mexico and the Dominican Republic" (CATHALAC and USAID, 2008), carries out a geo-referenced analysis of the richness of species in the regions. For the climate analysis, the study uses climatological data and high-resolution scenarios from SERVIR, PRECIS and WorldClim with three models and scenarios B2 and A2. Using this data, a Climate-Change Severity Index (CCSI) was formulated; this index measures the displacement of species away from their natural comfort zones. According to this analysis, under scenario A2, the Caribbean coast, from Honduras to Panama and the Dominican Republic, rich in biodiversity, will be severely affected by climate change in the 2020s. In the 2080s, all of the ecosystems and species of Central America and the Dominican Republic could be displaced from their natural comfort zones.

The study titled, "Current and Future State of Biodiversity in Central America" (PROMEBIO, 2010) was drafted by CCAD's Strategic Program for Monitoring and Assessment of Biodiversity, located at Zamorano Pan-American Agricultural School (PROMEBIO, 2010). The modelling for this study is based on GLOBIO3 methodology (Global Biodiversity Model), developed by the Netherlands Environmental Assessment Agency and United Nations Environment Programme (UNEP). It accounts for factors relating to human pressure on biodiversity: land use, infrastructure, fragmentation of natural areas, climate change and nitrogen deposition. The analysis allows for the creation of the Mean Species Abundance (MSA) index, which measures abundance relative to original abundance. The index indicates a 52% loss and a 48% relative abundance. The contribution of climate change to biodiversity loss is 2.5%, while land use is responsible for 34%. According to projections for 2030 for three development scenarios, the MSA will decrease by between 41% and 43%. In all three cases, climate change's contribution will increase by approximately 4%.

The studies based on species records have to estimate the total number of existing species, since not all species have been identified. While previous studies used the richness method for species in Central America, the ECC CA initiative opted for a different approach. This study on biodiversity and climate change (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011) uses the Biodiversity Potential Index (BPI), which combines climate and territory variables and indicates how likely it is to find a high amount of biodiversity in a given area. The variables considered are: total surface area, surfaces with non-urban and non-agricultural ecosystems, latitude, level curves, temperature, precipitation and availability of water. Areas with the greatest number of level curves are more likely to have a greater number of ecosystems than areas with fewer level curves. At higher temperatures, there is greater biological activity, as can be seen in the great biodiversity and concentration of forests along the equator. The temperature and precipitation projections resulting from the general circulation models HADCM3 and HADGEM1 for scenarios B2 and A2 respectively show that BPI will decrease significantly in all countries, with the decrease being larger under scenario A2. At the regional level, the simulation estimates a reduction in index value of more than 13% for land-use change (LUC) only, compared to a loss of 18% for LUC and B2 and 36% for LUC and A2 by 2050. By 2100, the decrease will reach 33% and 58% for the two climate change scenarios. The estimated decrease in biodiversity potential by 2100 under scenario B2 ranges from 22% in Belize to 50% in Nicaragua. Under scenario A2, the decreases lie between 70% and 75% for Guatemala, Nicaragua, El Salvador and Honduras, and between 38% and 43% for the other three countries (see Map 13) (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

MAP 13
CENTRAL AMERICA: POTENTIAL BIODIVERSITY INDEX 2005, BASELINE SCENARIO (WITHOUT CLIMATE CHANGE), B2 AND A2 TO 2100
(In index decimal units from 1 to 10)



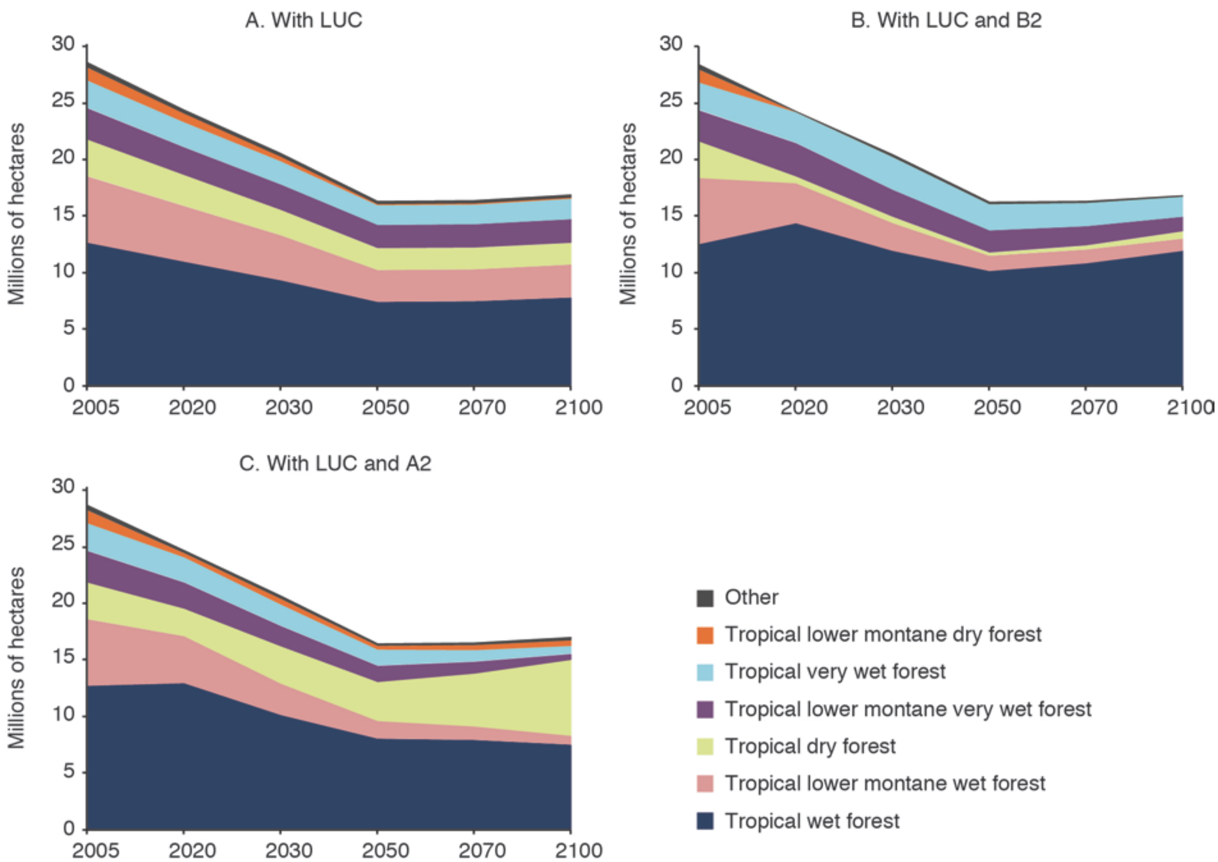
Source: ECLAC, CCAD/SICA, UKAID and DANIDA, 2011.

To complement this analysis of biodiversity, another study on Central American forests has been carried out using the Holdridge Life Zones (HLZ) classification. [16] According to this method, forest cover would decrease in a scenario of land-use change (CUT) without climate change, from approximately 28.5 million hectares to 16.3 and 16.9 million hectares by 2050 and 2100 respectively. This scenario was prepared by experts from from Tropical Agricultural Research and Higher

[16] HLZs are considered to be those areas that have "adequate climate conditions for a given ecosystem" (Holdridge, 1947; Locatelli and Imbach, 2010). An HLZ is a group of vegetal associations within a natural climate division, according to edaphic conditions and succession stages, with similar physiognomy in all parts of the world. These associations define a series of environmental conditions which, together with other living beings, form a unique combination of vegetal physiognomy and animal activity. The HLZ classification provides a logical basis for defining local ecosystems in a comparable framework. To specify climate conditions for the base year (2005), average monthly precipitation and temperature data were obtained from WorldClim for the period 1950-2000 (Hijmans and others, 2005).

Education Center (CATIE). This scenario estimates that the area of land dedicated to agricultural activities would increase by about 30% during this century, thereby reducing the area of forests and pastures, and savannah and bushland by 33% and 83% respectively. These changes would mainly take place in the next four decades. However, the proportions of the six predominant HLZs in Central America would not change significantly (see Chart 26).

CHART 26
CENTRAL AMERICA: HLZ AREA, 2005 AND PROJECTIONS UP TO 2100
(In millions of hectares)



Source: ECLAC, CCAD/SICA, UKAID, DANIDA, 2012c.

It is estimated that in the land-use change with B2 scenario, the tropical wet forest would become more predominant than it is currently, rising from 44% of total area in 2005 to just over 70% by 2100. By contrast, in the land-use change with A2 scenario, the tropical dry forest would see the largest increase in surface area, increasing from 11% to 39% of total area. These two HLZs would account for almost 84% of total natural surface. The other humid life zones would see significant decreases. Therefore, both scenarios suggest different HLZ patterns, one towards drier forest ecosystems (A2) and the other toward more humid ones (B2). In both scenarios, it is estimated that there will be an increase in humid areas by approximately 2020 and a decrease in life zone diversity over the decades. Variations between countries are expected: Belize's tropical wet forest would account for 90% of total forest area in 2100 under scenario B2, while under scenario A2, tropical dry forest would account for 44%. Costa Rica would experience more homogeneous patterns in all three scenarios (LUC, B2 and A2) and would maintain greater HLZ diversity. This study evaluates the temperature and precipitation conditions associated with the various HLZs, but it remains to be analysed whether their life forms could adapt, given the speed of the projected changes in precipitation and temperature, coupled with the pressure of land-use changes. The results confirm that reducing deforestation and making progress in the protection and recovery of natural ecosystems are themselves development challenges, and indicate that climate change, especially under the more pessimistic scenario (A2), could bring greater loss of tropical forests and the services that their ecosystems provide.

The geographic distribution of these changes is important. Following are HLZ distribution maps for 2005 and with LUC, LUC with B2 and LUC with A2 up to 2100 (see Map 14). It can be seen that under B2, the surface area of the tropical wet forest would increase significantly, mostly in the northern region of Guatemala and Belize, but under scenario A2, this life zone would decrease while the tropical dry forest would increase in the same region. The same phenomenon would occur in Honduras, Guatemala and Panama.

In summary, the results suggest that the total surface area would be determined by LUC. The climate change scenarios do not estimate variation in total surface area but rather in its composition. In the LUC scenario, the decrease in surface area of all life zones is notable. In the LUC and B2 scenario there would be an increase (or a small decrease) in the tropical wet forest surface area in the majority of countries while the dry areas would decrease. Under the LUC and A2 scenario, there would be an increase in the surface area of the dry life zones, primarily for the tropical dry forest, and a decrease in the area of humid life zones. Both scenarios estimate an increase in humid life zones, primarily the tropical wet forest, nearing 2020.

In the mentioned study by ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA (2012c) were estimated the potential changes in ecosystems using the HLZ classification, since the fact that it includes temperature and precipitation variables makes it ideal for modelling the impacts of the different climate change scenarios. This is a first step, since future analyses will face the complex task of exploring the capacity of ecosystems and their member species to evolve, “move” and maintain their integrity under these changing climate conditions. Additionally, it must be remembered that degradation and fragmentation due to direct pressure from societies complicates this adaptation. These future studies can benefit from the analyses of the effects of changes in intra-annual patterns of precipitation, aridity and dry months, available in the other publications of the 2012 Technical Series.

Potential impacts on ecosystems would not only result from climate change, but also from the reaction of the human population to it. For instance, if yields of basic grains and other products decrease, the pressure to increase the area of agricultural land at the expense of forests would increase. Therefore, the measures taken by economic stakeholders should aim to reduce such pressures and to facilitate adaptation of the ecosystems to climate change; however, this will not happen in the absence of public policies, economic incentives, and multisectoral agreements oriented towards sustainability. In international climate change negotiations, forests are at the center of various technical and political debates, not only because of deforestation and degradation, their relation to greenhouse gas (GHG) emissions and their function as carbon sinks, but also because of their importance to the lives and culture of rural populations and indigenous communities, and to the efforts to improve the sustainability of economic activities, such as agriculture and the sustainability of hydroelectric power generation. For this reason, it is important to make progress in the analysis of the impact of climate change on forests, their adaptation needs and their vital role in the adaptation of societies.

Besides the threats of deforestation, degradation and climate change, the efforts to protect forests face an additional challenge: the unquestionable economic value of forests as providers of goods and services to society is not reflected in market prices or, often, anywhere at all. When an economic actor destroys or contaminates an ecosystem, a negative externality is created and is not accounted for as an economic loss. Given this situation, it cannot be expected that these services will be incorporated into the market in time to incentivize appropriate decisions regarding use and conservation. Market signals for agricultural productivity, availability of water and other factors will appear only when the assets have been depleted, which would happen even without climate change.

In recent decades, considerable efforts have been made to improve our understanding of the contribution that ecosystems provide and of how to estimate their economic value. Several countries in the region have established payment systems for environmental services, and there are now more than 550 Natural Protected Areas. Important studies on the risks of climate change, especially for forests and biodiversity, have also been carried out. Progress had been made with methods to estimate environmental losses due to extreme events. These costs have been estimated in 14 assessments of major events in Central America in recent decades.

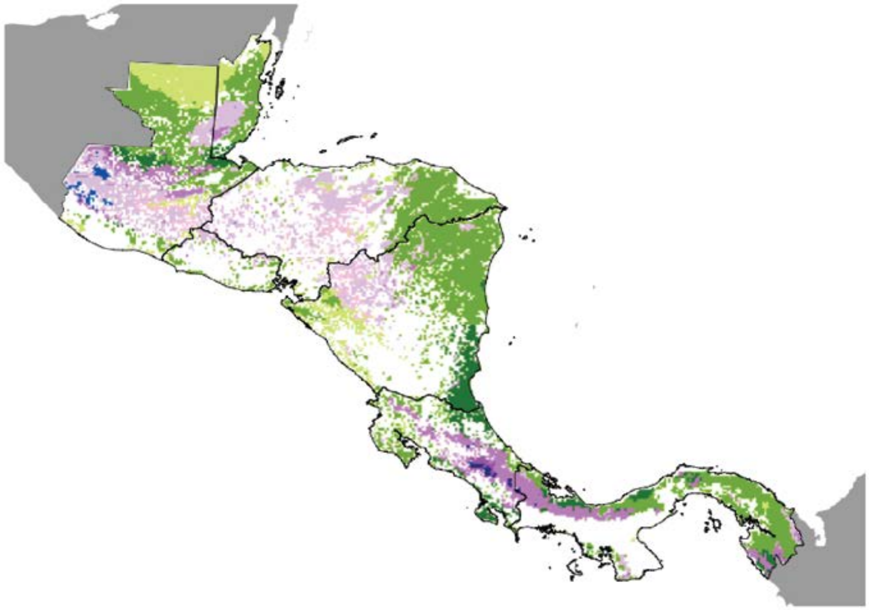
It is also important to assess ecosystems using non-market criteria, taking into account the related scientific knowledge and cultural values. This type of assessment helps to incentivize the development of precautionary measures given that the market does not send the right signals. Economic assessment analyses are useful, but have limitations because it is not always easy to assign a monetary value to certain services, especially invaluable intrinsic values, like those related to regulation, existence and culture. The challenge of developing an appropriate way of broadly evaluating ecosystems is increasingly urgent due to the threat of climate change.

In 2010, the REDD-CCAD/GIZ Regional Programme was launched in Central America. Its goal is to set the bases for creating sustainable compensation mechanisms for reducing CO_2 caused by deforestation and forest degradation. This programme works on the design of specific compensation mechanisms for each country that allow for the creation of mitigation activities in a comprehensive, permanent, sustainable and transparent form with economic, social and environmental benefits. Currently the following mechanisms are being created:

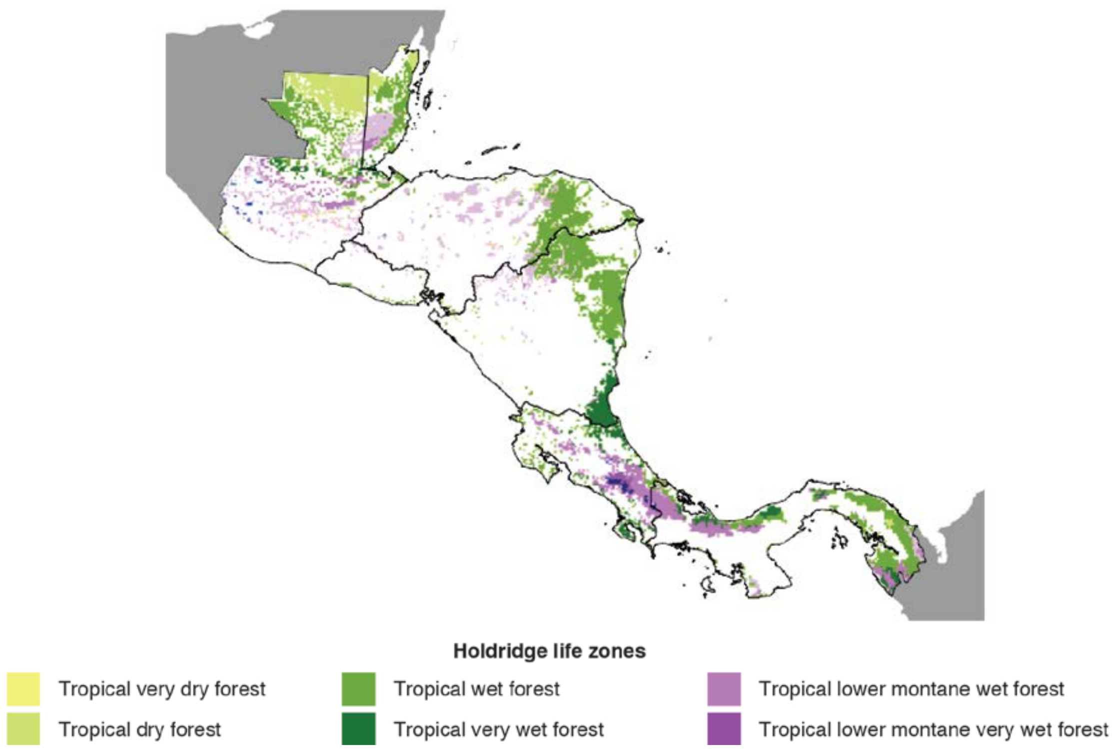
1. Panama Canal Green Route
2. Mechanism for Wetlands Protection in Costa Rica
3. Socio-environmental mechanism for Forestry Management in Honduras (MESAFH)

MAP 14
CENTRAL AMERICA: HLZ AREA, 2005 AND CLIMATE CHANGE SCENARIOS UP TO 2100

A. 2005

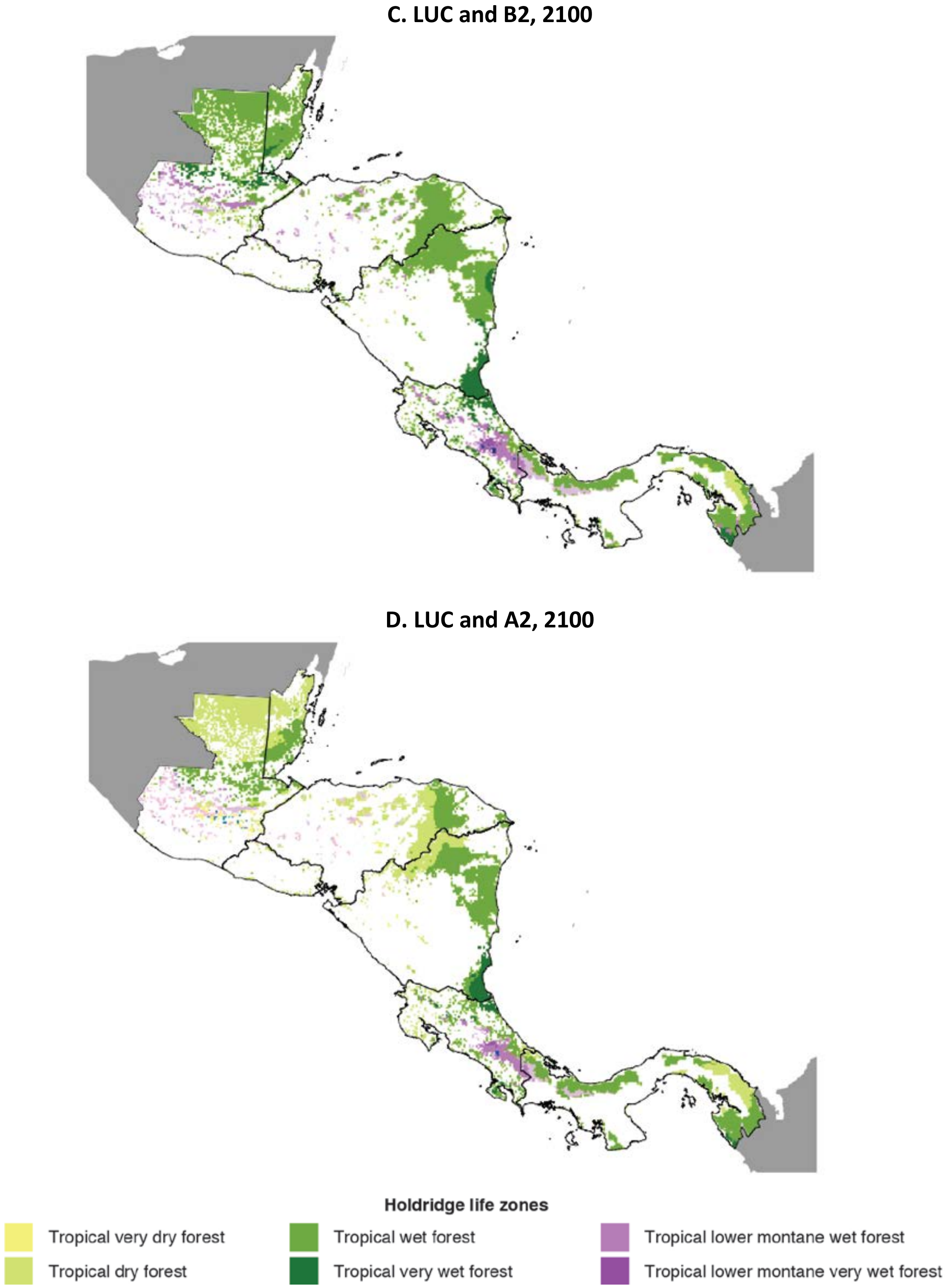


B. LUC, 2100



(continued)

Map 14 (conclusion)



Source: (ECLAC, CCAD/SICA, UKAID, DANIDA, 2012c)

The region also has the Regional Strategic Programme for the Management of Forest Ecosystems (PERFOR) which was approved in 2008 by the Council of Ministers of Environment of CCAD and CAC for a period of 15 years or more. The Regional Climate change programme (PRCC) of the United States Agency for International Development (USAID) supports the Central American region through one of its components in the development of a REDD+ financing plan for the implementation of national REDD strategies under the premises of regional technical standardization; with a focus on sustainable landscapes. Clearinghouse or the climate information system for the region is one of the most important products to develop for the programme, and efforts will be coordinated with the CRRH.

Recently, the governments of the region have begun a strong technical, political and social process to put into practice strategies to restore rural landscapes in the framework of REDD+, which has been accompanied by declarations of their commitment to this goal by governments at international forums. Guatemala and Panama recently did so with 1.2 million ha and 1 million ha respectively. The need to act in a parallel way for mitigation and climate change adaptation requires an adequate articulation of these types of actions and processes in the design of development policies for the countries of the region.

At the country level, Costa Rica has a National Strategy for the Reduction of Deforestation and Forest Degradation Emissions (REDD+ strategy), while El Salvador has a National Program for Restoration of Ecosystems and Rural Landscapes (PREP), which had an adaptation-based mitigation approach. Also in El Salvador, the creation of a project for the Preparation for the Reduction of Deforestation and Forest Degradation Emissions (REDD+) is underway with the Forest Carbon Partnership Facility (FCPF) and the World Bank for a total cost of USD 3.6 million. Guatemala has defined six REDD+ activities on a preliminary basis: incentives to improve carbon storage, incentives for the conservation of natural forests, incentives for small landowners, local communities and indigenous peoples, strengthening governability in forest regions, improved forest management and the promotion of competitiveness and legality in forest product value chains.

In Honduras, the REDD+ project (2014-2017) involves actions to help the country develop a national strategy to reduce deforestation. In Nicaragua, the ENDEREDD+ project is being implemented as a tool of the National Policy for Mitigation and Adaptation to Climate change. In the Dominican Republic, improvements have been made to the Readiness Preparation Proposal (R-PP) in line with FCPF requirements. To date, three consultation workshops have been carried out for the Emission Reductions Program Idea Note (ER-PIN). The Preparation for REDD+ project is underway in collaboration with the World Bank and has an associated cost of USD 3.8 million. [17]

[17] http://www.bancomundial.org/projects/search?lang=es&searchTerm=REDD%2B

BOX 6
RECOMMENDATIONS FOR THE ADAPTATION OF FOREST ECOSYSTEMS TO CLIMATE CHANGE

Human adaptation to climate change is clearly linked to the adaptation of the ecosystems on which humans depend, especially in regions such as Central America. Responding to this challenge will require incorporating the role of environmental services into the valuation of the efficiency and sustainability of our economic activities and taking appropriate measures outside the market to generate appropriate incentives and regulatory frameworks. It is necessary to apply the precautionary principle and establish minimum standards, considering the irreversibility of biological loss, the risk and the uncertainty.

Since climate change and the loss of habitat caused by other factors interact in this landscape, it would be advisable to expand and strengthen the system of Natural Protected Areas (there are now over 550 in the region) and biological corridors to encompass a broader bio-geographic area, to give more importance to land management and the definition of protected areas, and to strengthen the protection of climate refuges.

These efforts can be complemented with programmes in the areas of sustainable agriculture, sustainable forest use, and the rescue of native crops and wild endemic species that can resist the expected effects of climate change.

Other measures to facilitate the adaptation of forests and rural populations include programs that involve communities in the conservation and recovery of the ecosystems with which they coexist. This includes adopting appropriate technologies for sustainable livelihoods; taking advantage of traditional knowledge and diversifying sources of livelihood; improving forest management systems, including the monitoring of deforestation, forest fires, afforestation and reforestation; establishing and promoting regulations and certifying organic products and ecotourism, and promoting ecotourism or natural and "adventure" tourism managed by the owners of the areas. This will contribute to the defence of natural ecosystems, avoiding traditional tourism and real estate practices that degrade the natural attributes of these ecosystems.

Not only are there potential synergies in the protection and sustainable use of ecosystems with the GHG emissions reductions initiative, but also a number of actions related to sustainable and inclusive development, such as more sustainable agricultural production, the comprehensive management of basins and water, the rescue of native crops and endemic wild species, greater access to electric energy and payment programmes for environmental services in order to benefit the low-income rural population. All these measures need to be built into programmes and budgets.

In this sense, water is extremely important for the protection of forests and other ecosystems, and their biodiversity. The protection of forests is essential for the management of river basins. Extensive efforts are required to make more efficient use of water, reduce its contamination and recycle it in the domestic, agriculture, industry and services sectors.

Greater coordination is required with the agricultural sector in order to restore areas that are degraded and of low-productivity according to the quality criteria for primary production, production sustainability and reforestation for different uses. The expansion of agricultural areas toward natural ecosystems should be avoided. Efficiency should be improved, and rural landscapes should be managed according to conservation goals. The economic valuation of ecosystems should include their services related to agricultural production, including pollination, pest control and regulation of humidity, water flow and local climate in order to support the decisions that producers make with regard to their conservation and protection.

Environmental and urban planning is one of the fundamental strategies for achieving sustainable development and a more optimal geographic distribution of the population, its activities and natural wealth, and to prevent losses and damages due to extreme events. Natural ecosystems can reduce the vulnerability of a population to extreme weather events and can serve as complements or substitutes for investment in ”grey” infrastructure, which can have higher costs. For example, forests and coastal mangroves provide protection against storms, floods, hurricanes and tsunamis.

It is advisable to broaden and operationalise fiscal and financial policies that provide incentives to transition to higher energy and water efficiency, sustainable forest management and the recognition of the economic value of environmental services, including carbon sinks and water cycle regulation. The region has developed programmes such as the National Forest Financing Fund (FONAFIFO) of Costa Rica, the Protected Areas Conservation Trust of Belize (PACT), the Certified Forestry Incentives Programme of Panama, the Forestry Incentive Programme (PINFOR) of Guatemala, and the Smallholder Forestry and Agroforestry Vocation Incentive Programme (PINEP), also of Guatemala. Along these lines, the creation of the Mesoamerican Fund for the Payment of Environmental Services has been proposed. The goal of this fund is to contribute to sustainable development in the region and strengthen cooperation and integration for environmental management (UNEP, CCAD and SICA, 2010). It is becoming increasingly necessary to create social awareness regarding the function of ecosystems and the wellbeing associated with them.

It would be worth examining the benefits of the following: voluntary plans for the net reduction of deforestation at the national and regional levels, with financing from programmes aimed at adaptation; the Clean Development Mechanism (CDM); other markets for carbon credits through payments for environmental services; national and regional goals for ecological conservation and sustainable use of terrestrial ecosystems; and regional goals for carbon capture and storage through ecosystems. It would be beneficial to tie these conservation goals to measures aimed at improving the wellbeing of the populations, especially for those that coexist with these ecosystems. Some examples of the latter measures are the use of efficient wood stoves, provision of access to electricity and payment for environmental services.

Source: ECLAC, CCAD/SICA, UKAID, DANIDA, 2012c.

3.4 ENERGY

In the Economics of Climate Change in Central America (ECC CA) (2011) initiative, the total demand for energy was estimated. The baseline scenario of electric subsector was made according with national and regional energy prospective for the 2010-2023 period from the Central American Electrification Council (CEAC). The others energy subsectors used the prospective studies from the Central American Sustainable Energy Strategy 2020 (EESCA 2020). The following assumptions for the scenarios, for the 2024-2100 period, were taken: countries will continue to develop their renewable resources until reaching 50% of their hydroelectric potential and 90% of their geothermal potential by 2100 (based on official figures from each country). Regarding wind energy, the estimate is also conservative, but in line with current trends and interest in its development; solar and biofuel energy were not considered for the baseline scenario (ECLAC, UKaid, CCAD and SICA, 2010).

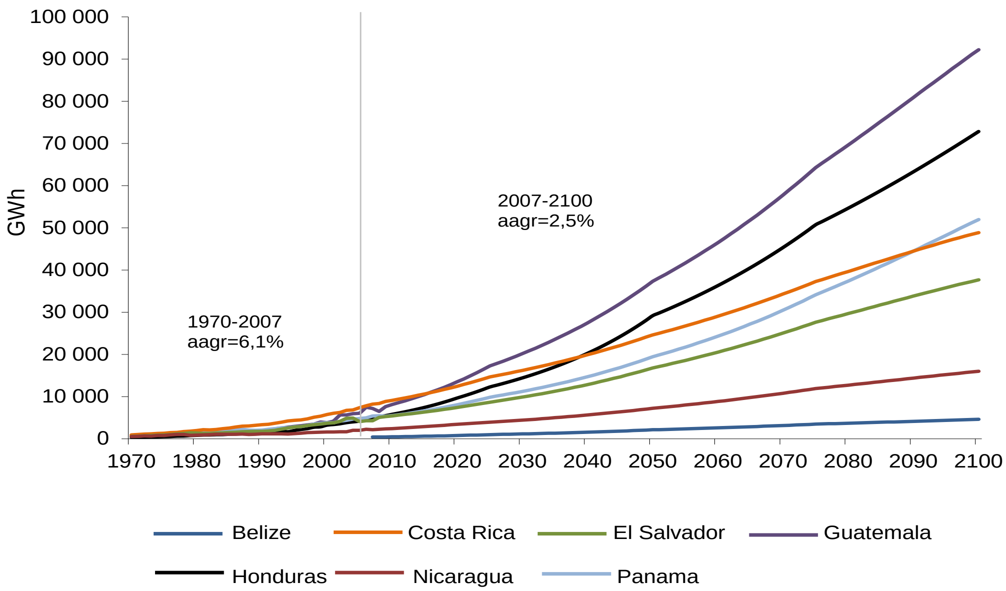
An energy matrix was designed for each country. This matrix records the flows of energy from consumers to transformation centres to production centres and/or energy importation and transport, taking into account the losses at each stage. A bottom-up model was applied following the premise of the LEAP software (Long Range Energy Alternatives Planning System). The demand for energy is modelled using a system of equations that depend on variables that drive the economic system (drivers). The residential, commercial, industrial, and transport sectors, among other, were included. The residential component was divided into urban and rural households, with two subgroups: homes with and without electricity. The end uses (lighting, cooking, refrigeration, and others) were modelled using information on energy balances and the results of certain surveys (ECLAC, UKaid, CCAD and SICA, 2010).

Total demand for energy would increase approximately by a factor of five in 2010, to 1.103 MMboed. Guatemala would continue to be the country with the highest demand, but its participation would decrease from 35% to 23%. The participation of Costa Rica, Belize and Panama would increase. Sectoral trends suggest that the participation of transport, industry and trade would increase significantly, while that of the residential sector would decrease. By the end of the century, transport would use 48% of total energy, industry, 30%, the residential sector, 11% and the trade sector, 10% (ECLAC, UKaid, CCAD and SICA, 2010).

Of the total energy demand in 2100, 934.2 MMboed would correspond to hydrocarbons and other fossil fuels, representing an increase in participation, from 50% in 2010 to 85% in 2100. Of these sources, 57% would be used for transport and 22% for electricity generation. The average annual growth rates for hydrocarbon demand are 3.6% for Belize, 2.9% for Panama, 2.6% for Costa Rica, 2.4% for El Salvador and Guatemala, 2.2% for Honduras and 2% for Nicaragua (ECLAC, UKaid, CCAD and SICA, 2010).

The baseline scenario assumes that the regional demand for electricity will grow at an annual rate of 2.5%, with variation across the countries: 1.9% in Costa Rica, 2.1% in Nicaragua, 2.2% in El Salvador, 2.5% in Panama, 2.6% in Belize, 2.7% in Guatemala and 2.8% in Honduras. In total, demand will increase by a factor of 10, from 32.366 GWh in 2007 to 324.159 GWh in 2100. Historically, Costa Rica has been the largest consumer of electricity, but during this century, it will be surpassed consecutively by Guatemala, Honduras and Panama (see Chart 27). At the end of the century, the structure of the market will be different from the current one. The residential sector, the largest consumer of electricity, will fall to third place (from 36% in 2007 to 31% in 2100), and will be replaced by the industrial sector (30% to 34% in the same period) and the commercial sector (29% to 34% in the same period) (ECLAC, UKaid, CCAD and SICA, 2010).

CHART 27
CENTRAL AMERICA: EVOLUTION OF ELECTRICITY DEMAND WITH BASELINE SCENARIO, 1970 TO 2100
(In GWh)

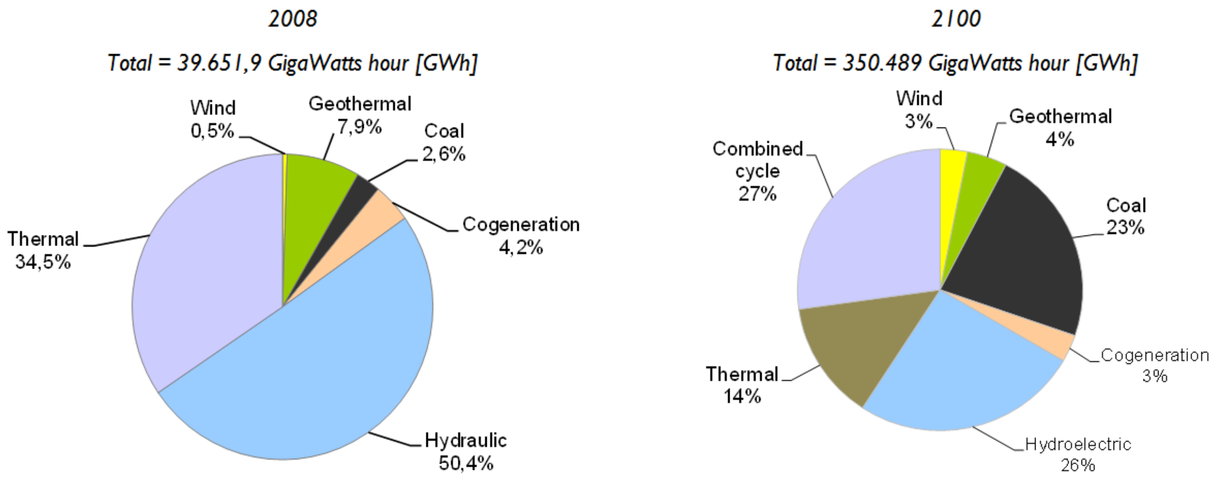


Source: Statistics from the electricity subsector, estimated from ECLAC based on official figures and the LEAP model. (Note: annual average growth rate = aagr.)

By 2100, the production of electricity using renewable sources will have been displaced by fossil fuels, the latter reaching 64% of regional generation, relative to 37% in 2008 (see Chart 28). Compared to 2008, hydroelectric generation will decrease from 50% to 26% in 2100, thermal energy from 35% to 14%, geothermal from 8% to 5% and co-generation from 4% to 3%. The following sources will grow: coal, from 3% to 23%, natural gas combined cycle from less than 1% to 27% and wind, from less than 1% to 3%. The proportion of renewable sources would decrease from 63% in 2008 to 36% at the end of the century (ECLAC, UKaid, CCAD and SICA, 2010).

Electricity deserves close attention due to the magnitude and dynamics of its emissions. It is the principal cause of industrial and residential emissions, as well as those from indirect services. These should be quantified at the same time as those from the electricity industry in order avoid double counting. The magnitude depends on consumption and the emissions factor for each national electricity system, which is determined by the type of technology and generation plants, the fuels used, annual total electricity production and relative participation of sources (ECLAC, UKaid, CCAD and SICA, 2010).

CHART 28
CENTRAL AMERICA: ELECTRICITY GENERATION, BY TYPE OF TECHNOLOGY WITH BASELINE SCNEARIO IN 2100



Source: Electricity sub-sector statistics and ECLAC estimations based on official data and ECLAC estimations, based on LEAP model.

It was possible to generate projections for the sector for 2030 using emissions inventories and analyses of the demand for and generation of energy. It was assumed that sectoral growth rates for each country could be based on the baseline and populational macroeconomic scenario. It was also assumed that there would not be substantial modifications in energy consumption patterns. Furthermore, it was assumed the electricity generation structure remains relatively stable, and, therefore, so does the emission factor of the electricity sector. The results should be seen as very basic prospective analyses, as the inventories are ten years old and since it is likely that after 2020 new technologies will be adopted more quickly. Nevertheless, the projections allow for the identification of sectors and policies that have the potential to reduce GG emissions, as well as potential co-benefits related to adaptation and sustainable development. Chart 1 presents estimates for 2030 for eight sectors, including electricity (ECLAC, UKaid, CCAD and SICA, 2010).

Under this trending scenario, total annual gross emissions could reach approximately 310 million t CO_2e in 2030, slightly lower than the estimate of 336 million tCO_2e for 2000 that was based on inventories but considering significant sectoral changes. The combined emissions of the transport, electricity, industrial processes, residential and services, agricultural and livestock, and waste sectors would have increased from 88 million tCO_2e in 2000 to more than 230 million by 2030. This would be due largely to the dynamic of fuel consumption for automotive transport and methane and nitrous oxide emissions from the agricultural sectors. Emissions due to deforestation could decrease from 74% of the total in 2000 to 25% in 2030, surpassed by emissions from the agricultural sector (31%) by 2030. The participation of other sectors, especially of transport and electricity, would increase. Without looking at deforestation, the transport and agricultural sectors would account for two thirds of total emissions, with 21% and 47% respectively. Comparing the projected emissions for Central America with estimated growth of gross global emissions, it is estimated that the former could represent 0.5% of the latter by 2030, or 310 million of 61.1 billion tCO_2e (OECD, 2008).

The trending scenario allows for the exploration of the possibilities and costs of emissions reductions for the region. The greatest opportunities for reductions lie in the sectors with the most significant contributions to the inventory: deforestation, agricultural, transport and electricity. However, technological and economics valuations must be made in order to evaluate possible mitigation measures (ECLAC, UKaid, CCAD and SICA, 2010).

ENERGY STRATEGIES AND POLICIES

With regard to regional policies, SICA and its Energy Coordination Unit (UCE) established the Sustainable Energy Strategy of Central America 2020, whose general goal is to ensure energy supply in the region, to ensure quality, quantity and diversity of sources, and sustainable development. The Regional Strategy for Efficient Lighting in Central America was created in 2013 by UNEP and the Executive Board for the Mesoamerican Integration and Development Project. A cooperation and coordination agreement was signed in 2014 between the Latin America Energy Organization (OLADE) and the Secretary General of SICA. One of the actions that was agreed to by the parties was to support efforts to develop renewable energy and energy efficiency projects in SICA countries. In 2015, the Ordinary Session of the Council of Ministers of Energy of the member countries of the Central American Integration System (SICA) approved the following projects: "Project for the Update and Implementation of Sustainable Energy Strategies in Central America 2020 and its Action Matrix" by ECLAC, "Regional Fund for Energy Efficiency Projects" by OLADE and the "Programme to Promote Geothermal Energy in Central America" by GIZ.

The United States Agency for International Development (USAID) Regional Clean Energy Initiative 2012-2017 has an associated cost of USD 9,730,421. The goal of this initiative is "to contribute to the environment of investment in clean energy in Central America, supporting the development of renewable energy generation and promoting energy efficiency and, therefore, the growth of the Regional Electricity Market (MER)".

The energy sector in Central America has designed the Sustainable Energy Strategy 2020 (ECLAC and SICA, 2007), which proposes expanding regional renewable energy sources, including hydroelectric, wind, geothermal, and imported natural gas sources. This is the first regional sectoral strategy that estimates GHG emissions, and it was approved by the Central American presidents and Ministers of Energy. The goals are as follows:

- Reach at least 90% electricity coverage in each country.
- Reduce the use of firewood for cooking by 10% by installing more efficient stoves in one million rural households.
- Reduce electricity use in the residential, commercial and industrial sectors and in public lighting by 12% using efficient lighting systems.
- Reduce residential energy use by 35% through the replacement of obsolete refrigerators with more efficient ones in 2.7 million households.
- Reduce electricity use by 10% in the industrial sector by using more efficient motors.
- Decrease the losses in electrical systems in all countries to 12%.

- Increase the regional participation of renewable sources for electricity production by 11%, favouring the construction of hydroelectric plants.
- Substitute 15% of petroleum product consumption with biofuels in public and private transport.
- Reduce GHG emissions by 20% by 2020 with respect to the trending scenario, maximizing the application of certified emissions reductions credits (ECLAC and SICA, 2007).

With greater access to technology and funding, Central America will be able to implement this strategy. The sector has shown its capacity for coordinated, long-term management in developing the network for the Central American Electrical Interconnection System (SIEPAC). Currently, the sector is working on harmonizing fuel standards within the Customs Union and on the Action Matrix for the Development and Integration of the Energy Sector in Central America.

The Central American countries have developed policies, plans and strategies related to energy efficiency and greater generation of clean energy for mitigation, as described below (UNEP-REGATTA, 2015; ECLAC, 2015a):

- Belize created the Sustainable Energy Action Plan 2014-2033, which is a tool to fulfil renewable energy and energy efficiency potential (UNFCCC, 2015).
- In Costa Rica, the Ministry of Environment and Energy (MINAE) is the authority responsible for compliance with the Energy Efficiency Law of 1994 and its decreed regulations. Tax exemptions were modified to promote the import and manufacture of efficient equipment. The Biofuel Regulations of MAG-MINAET of 2009 aim to promote the development of a national biofuel industry and equitable relations between the stakeholders or agents of biofuel activity that guarantee the sustainable development of the value chain of the national energy sector. Between 2014 and 2015, a consultation process was carried out on the aspects of development of the energy sector. This process was a main input for the creation of the VII National Energy Plan 2015-2030, which was approved in September 2015. The direction of this energy policy is based on two goals: a) promote these actions to address global climate change through citizen participation, technological change, innovative processes, research and knowledge, and b) meet the energy demands of the country through an energy matrix that ensures an optimal and continuous supply of electricity and fuel (MINAE, 2014).
- El Salvador has a National Energy Policy, which defines concrete actions based on the governmental plan for 2010-2024 and is aimed at increased energy coverage and capacity through efficiency, optimization and saving, and the promotion of sustainable use and the integration of various sectors. Regarding mitigation, a series of activities related to the efficient use of energy has been created. These activities include the adoption of the Action Plan for the Saving and Rational Use of Energy in El Salvador by the National Energy Council (CNE). The aim is to promote, strengthen and consolidate the efficient and rational use of electricity. With regard to renewable energy, there is a 2007 law titled Fiscal Incentives for the Promotion of Renewable Energy in Electricity Generation, as well as a near-complete draft of a Master Plan for the Development of Renewable Energy created by the CNE with the support of the International Cooperation Agency of Japan (JICA).
- In Guatemala, the climate change law stipulated that the Minister of Environment and Natural Resources (MARN) shall develop the National Plan for Energy for Production and

Consumption. The law establishes that the Ministry of Public Finances (MINFIN) and the Superintendence of Tax Administration (SAT) will propose the regulations to establish fiscal incentives and targeted subsidies programme for the use of clean energy in public and private transport. The 2013-2027 Energy Policy seeks to improve the living standards of the population, transform the energy matrix of the country (including greater development of renewable energy) and thus foster energy sovereignty. Along with the IADB and with the support of FIDE, the country launched the first Comprehensive Plan for Energy Efficiency which included workshops and training.

- Honduras has a Biofuel Law and a Law for Incentives for Electricity Generation Using Renewable Resources, passed in 2007. The Inter-Institutional Group for the Rational Use of Electricity was created in 2007, and the Energy Efficiency Project was developed for the industrial and commercial sectors. The Strategic Plan for the Management and Saving of Fuel and Electricity was approved in 2012.

- In Nicaragua, a law to promote electricity generation using renewable sources was passed in 2005. In 2008, a decree regarding the laws on Efficient Energy Use was presented. In 2006, another decree was presented declaring the national interest in producing biofuel and bioenergy. The country has a Strategic Plan for the Energy Sector 2012-2026, which seeks to strengthen and improve the performance of the State in the Energy Sector, guaranteeing safe, reliable and high-quality energy supply to the country, promoting effectiveness and efficiency in the Hydrocarbon sector and promoting environmentally sustainable development in the energy sector. The National Human Development Plan 2012-2016 comprises an Energy Infrastructure policy whose goal is to increase renewable electricity generation, change the generation matrix and provide electricity to rural areas. Nicaragua has a National Sustainable Electrification and Renewable Energy Program (PNESER) that aims to help reduce poverty through an increase in electricity coverage and to change the energy matrix, promoting efforts related to mitigation and adaptation to climate change.

- In Panama, the National Energy Secretariat (SNE) created the National Energy Plan 2009-2023 whose main goals are: to ensure the sustainable availability and supply of energy while meeting the national demand in the long term, to increase electricity coverage, to consolidate regional energy integration, to consolidate competitiveness plans for energy markets, to disseminate information and to provide training. The national policy for the rational and efficient use of energy was passed and implemented. Measures were adopted to save energy in government offices. It was also established that the National Department of Energy would create a National Strategic Plan for the Rational and Efficient Use of Energy. With regard to renewable energy, Panama passed a law that establishes incentives for the promotion of hydroelectric generation systems as well as other new, renewable and clean sources in 2005. A law establishing incentives for solar installations was also passed in 2013. The 2004 energy policy framework for the promotion of wind energy promotes the use of this type of energy while meeting environmental standards and respecting the rights of those affected by wind projects.

- In the Dominican Republic, an Energy Efficiency Study was carried out by the National Energy Commission (CNE) and the Dominican Corporation of State Electricity Companies (CDEE) with the technical support of the Government of Japan through its International Cooperation Agency (JICA). This survey was part of the National Energy Efficiency

Programme (PNEE) led by the CNE with the support of the CDEEE. The main goals are a) to promote the passing of the Energy Efficiency Law, b) to implement Energy Efficiency (EE) programmes in government institutions, c) to establish certification mechanisms for companies providing EE services, d) educate the population on the Rational use of energy, and e) to develop a labelling system for electric devices, among others. The National Energy Plan of the Dominican Republic (PEN) 2010-2025, the National Development Strategy 2030 and the National Climate-Compatible Development plan establish the following goals: 25% participation of renewable energy in the energy mix by 2025, and a 25% reduction in GHG emissions by 2030.

BOX 7
RECOMMENDATIONS FOR GUARANTEEING THE SECURITY AND THE SUSTAINABILITY OF THE ENERGY MATRIX AND FOR IMPROVING ENERGY EFFICIENCY

There are opportunities to improve energy efficiency and reduce the intensity of emissions associated with the use of energy: standards for automotive vehicle efficiency and emissions, industrial activities, domestic uses and general use in the city, including public transport. The expansion of hydroelectric power generation could provide the poor population with greater access to electricity, allowing it to reduce the use of firewood for domestic energy uses. It could provide the opportunity to establish sustainable and social development models for the populations living in surrounding areas, which is already happening in some of the countries of the region.

Currently, the SICA countries are working on the Central American Sustainable Energy Strategy 2030. Therefore, this is the time to create a new action matrix that includes priorities at the national and regional levels using the SDGs and the results of the COP21 as a guide. A matrix of this type will allow for improved coordination between existing donors and could be present to new financial mechanisms such as Climate Investment Funds, the Adaptation Fund and the Green Climate Fund.

The document titled "The convergence of energy policies, including carbon neutrality and strategies for meeting the goals of SE4ALL" from the next ECLAC publication (2015) was presented to the Directors of Energy and Hydrocarbons of the SICA countries, and proposes that the following activities be carried out while the new matrix is developed:

- Analyse the impacts that climate change will have on the estimates for energy generation and demand, as well as the impacts on the increases in electricity consumption due to extreme climate conditions and decreases due to a lack of electricity supply.
- Analyse the vulnerability to climate change of the infrastructure of the energy sector and the impact that this vulnerable infrastructure could have on the population.

- Evaluate the conditions under which the production of biofuel will be sustainable for its incorporation into the energy matrix and the maximum production limit, keeping in mind climatic impacts on productivity and land-use, land-use change and food production, among others.
- Create price policies that consider environmental externalities.
- Set new energy efficiency goals using the demands for energy under climate change conditions.
- Analyse the vulnerability to climate change of natural gas infrastructure and the ways in which this infrastructure could exacerbate negative environmental impacts, as well as alternatives for minimizing these impacts.
- Evaluate isolated rural communities that were previous connected to electricity, either through network extension or distributed generation, to see the impacts that these efforts have had on their capacity to adapt to climate change.
- Evaluate the impacts of climate change on production, transport and commercialization of different energy sources as well as the impact that these have on the environment.
- Research best practices regarding the multiple uses of river basins, considering a tariff structure that reflects the complete cost of each use and ensure the equity of access for all the users of the basins.

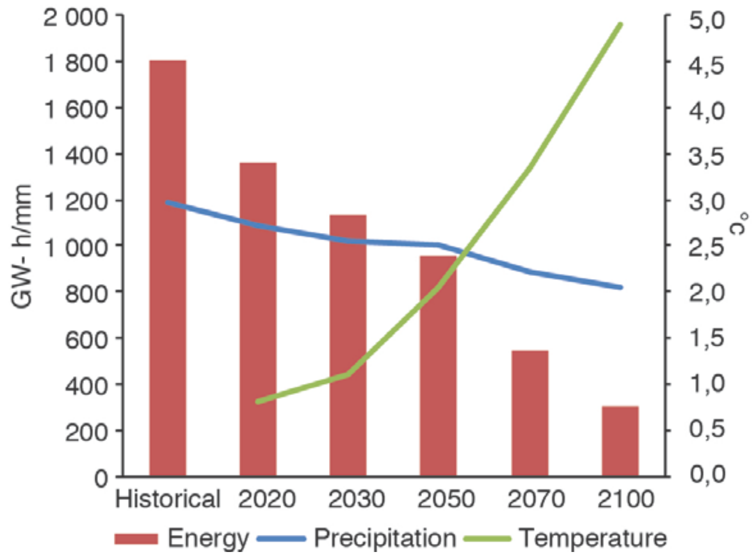
The proposal is to estimate the current energy matrix and create scenarios with potential impacts of climate change in order to have a baseline for NAMA and greater certainty or less risk of the contribution of GHG emissions reductions than that listed in the INDCs. Finally, the proposed goals of EESCA2030 and its impact on the SDGs should be evaluated in a cyclical manner. The SDGs should form part of the structure of the strategies and the results of the strategies should help, directly or indirectly, to achieve the SDGs.

Source: ECLAC (2015a).

HYDROELECTRICITY

These scenarios of potential changes in temperature, annual precipitation and intra-annual patterns suggest greater risks and uncertainty for productive activities such as hydroelectric power generation. The combined effect of the rise in temperature and the changes in precipitation will affect evapotranspiration in river basins, and thus their river flows and evaporation in hydroelectric reservoirs. A pilot study of two hydroelectric plants (Chixoy in Guatemala and Cerrón Grande in El Salvador) estimates that this chain of effects would result in reductions in electricity generation of over 20% in both plants by 2020 under the more pessimistic scenario (A2) compared to the average generation achieved during reference periods (1979–2008 for Chixoy and 1984–2009 for Cerrón Grande) (see Charts 29 and 30). By 2050, the reductions would be greater than 40% in both plants, and by the end of the century, these figures would be more than 80% for Chixoy and 70% for Cerrón Grande.

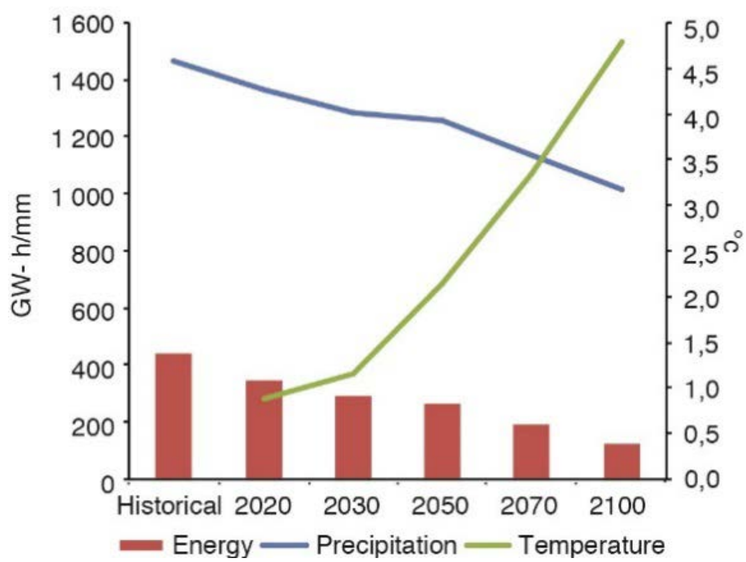
CHART 29
CHIXOY PLANT: RESULTS OF SIMULATIONS, 2020 TO 2100



Source: ECLAC, CEL, MARN, COSEFIN, CCAD/SICA, UKAID and DANIDA (2012).

Note: Historical reference period, average 1979-2008. The left axis is for energy and precipitation, while the right axis is for temperature.

CHART 30
CERRÓN GRANDE PLANT: RESULTS OF SIMULATIONS, 2020 TO 2100



Source: ECLAC, CEL, MARN, COSEFIN, CCAD/SICA, UKAID and DANIDA (2012).

Note: Historical reference period, average 1979-2008. The left axis is for energy and precipitation, while the right axis is for temperature.

Under the less pessimistic scenario (B2), there could be an increase of between 4% and 6% in electricity generated in both plants by 2020, relative to the reference period. However, from 2020 onwards, estimates are negative, with a 26% decrease for Chixoy and a 17% decrease for Cerrón Grande by 2100 (ECLAC, CEL, MARN, COSEFIN, CCAD/SICA, UKAID and DANIDA 2012).

To summarize, the expected gradual increase in temperature will affect hydroelectric power generation due to evapotranspiration in the river basin and evaporation in the reservoirs. It is important to note that the increase in atmospheric temperature could contribute to more intense rainfall events, while the increase in sea surface temperature could give rise to more intense hurricanes. Nevertheless, the greatest risks are related to rain, whose pattern in the region already shows great variability in its annual accumulation and intra-annual distribution. Future scenarios suggest a possible increase in the variability of annual accumulated rainfall, with a gradual reduction in the annual average, especially in the second half of the century. That being said, rainfall modelling involves several unknowns that still need to be identified. The current and future scenarios indicate the existence of a short-term window of opportunity which will close if it is not used to strengthen the management of basins, reservoirs and existing plants, and create new initiatives for comprehensive water management and adaptation to climate change. A summary of the recommendations resulting from this study is presented in Box 8.

The Latin American Energy Organization (OLADE), supported by the Inter-American Development Bank (IDB) and the Energy and Environment Alliance of Central America (AEA), has launched the initiative "Vulnerability to climate change of hydroelectric production systems in Central America and their options for adaptation". The goal of this study was to develop and implement a methodology for determining the vulnerability to climate change of hydroelectric production systems currently in existence or in the planning stages in the seven Central American countries. The cases selected were: Chixoy in Guatemala, Mollejón in Belize, Cerrón Grande in El Salvador, El Cajón in Honduras, Centroamérica in Nicaragua, Reventazón in Costa Rica and Bayano in Panamá. The "Generalized Streamflow Simulation System" model was used. This model controls the phenomena to be transformed using a set of parameters related to the water cycle, integrating meteorological, geomorphological and hydrological information.

Using climatic and hydrometric data available for each of the river basins, the rainfall runoff transformation hydrological model was calibrated and verified. Reference or historical information was estimated for the 1980-1999 period and is called "1990" or "current". This information was also used to estimate hydroelectric production in each condition in the current situation, and the A2, B1 and A1B scenarios from the fourth report of the IPCC were used for future estimates along with the results of four general circulation models (CM2.0, MIROC3.2, ECHAM5 and HadCM3) for the following cut-off years: 2010, which corresponds to the period 2000-2019, 2030 for 2020-2039, 2050 for 2040-2059, 2070 for 2060-2079 and 2090 for 2080-2099. The variation of the values during extreme events (landslides and drought) was also measured. In the economic analysis of climate change, discount rates of 0.5%, 2%, 4% and 12% were considered with the aim of encompassing a large range of possibilities (OLADE, IDB and AEA, 2013).

The following results were obtained from the study:

- Chixoy, Guatemala. Current production reaches 1750 GWh/year and under the climate change scenarios, average variations of +3.4% in 2010, -8.6% in 2030, -21.5% in 2050, -32.3% in 2070 and -44.8% in 2090 are expected. Current total potential is 279 MW and with climate change it is expected that there will be decreases of -3.8% by 2010, -15.9% by 2030, -23.7% by 2050, -39.3% by 2070 and -44.8% by 2090. The analysis of the economic impact of climate change on Chixoy Plan shows that cost overruns would range from $67 million to $597 million, depending on the scenario and the discount rates considered.

- Mollejón, Belize. This is the only example of a run-of-the-river plant (the others are regulation reservoirs). Current production reaches 124 GWh/year and under the climate change scenarios, average variations of +3,0% in 2010, -8.6% in 2030, -21,2% in 2050, -31,7% in 2070 and -43,0% in 2090 are expected. Current total potential is 4 MW and with climate change it is expected that there will be decreases of -25.0% by 2010, -41.7% by 2030, -50.0% by 2050, -66.7% by 2070 and -66.7% by 2090. The analysis of the economic impact of climate change on Mollejón Plant shows that cost overruns would range from $6.1 million to $66.2 million, depending on the scenario and the discount rates considered.

- Cerrón Grande, El Salvador. Current production reaches 494 GWh/year and under the climate change scenarios, average variations of -9.9% in 2010, -26.0% in 2030, -47.6% in 2050, -55.3% in 2070 and -64.6% in 2090 are expected. Current total potential is 84 MW and with climate change it is expected that there will be decreases of -37.3% by 2010, -60.7% by 2030, -75.0% by 2050, -79.8% by 2070 and -77.8% by 2090. Of the seven plants considered in the study, this one could be the most affected by climate change. The analysis of the economic impact of climate change on Cerrón Grande shows that cost overruns would range from $37 million to $360 million, depending on the scenario and the discount rates considered.

- El Cajón, Honduras. Current production reaches 1312 GWh/year and under the climate change scenarios, average variations of -0.1% in 2010, -14.4% in 2030, -35.2% in 2050, -44.9% in 2070 and -51.8% in 2090 are expected. Current total potential is 273 MW and with climate change it is expected that there will be decreases of -11.1% by 2010, -22.2% by 2030, -42.1% by 2050, -45.3% by 2070 and -51.6% by 2090. The analysis of the economic impact of climate change on El Cajón shows that cost overruns would range from $77 million to $827 million, depending on the scenario and the discount rates considered.

- Centroamérica, Nicaragua. Current production reaches 189 GWh/year and under the climate change scenarios, average variations of -4.1% in 2010, -20.8% in 2030, -37.2% in 2050, -45.0% in 2070 and -55.6% in 2090 are expected. Current total potential is 44 MW and with climate change it is expected that there will be decreases of -28.8% by 2010, -43.9% by 2030, -59.8% by 2050, -65.9% by 2070 and -74.2% by 2090. The analysis of the economic impact of climate change on Centroamérica Plant shows that cost overruns would range from $12.7 million to $151.2 million, depending on the scenario and the discount rates considered.

- Reventazón, Costa Rica. This plant is currently under construction, but its production would reach 1,578 GWh/year and under the climate change scenarios, average variations of +3.7% in 2010, -0.3% in 2030, -5.0% in 2050, -8.4% in 2070 and -14.7% in 2090 are expected. Current total potential is 217 MW and with climate change it is expected that there will be decreases of -1.8% by 2010, -8.3% by 2030, -14.0% by 2050, -20.1% by 2070 and -23.5% by 2090. The analysis of the economic impact of climate change on Reventazón Plant shows that cost overruns would range from $22 million to $244 million, depending on the scenario and the discount rates considered.
- Bayano, Panama. Current production reaches 551 GWh/year and under the climate change scenarios, average variations of +1.9% in 2010, -4.6% in 2030, -16.6% in 2050, -23.7% in 2070 and -37.9% in 2090 are expected. Current total potential is 127 MW and with climate change it is expected that there will be decreases of -11.8% by 2010, -18.1% by 2030, -29.1% by 2050, -37.5% by 2070 and -49.6% by 2090. The analysis of the economic impact of climate change on Bayano Plant shows that cost overruns would range from $18 million to $205 million, depending on the scenario and the discount rates considered.

The decrease in precipitation in the majority of the basins of the region, combined with the gradual increase in temperature in all basins, will have a significant effect on future hydroelectric generation since these factors will affects the amount of resources available. The first effect of higher temperatures will particularly affect those plants that currently have low indices of rainfall, while the second will affect those plants where the surface of the reservoir is at a higher elevation relative to the available resources. Apart from the obvious decrease in available resources, the effects of climate change are also seen in an increase in the duration of the period of low water levels, which magnifies the effect of climate change on the decrease of firm potential in the different plants analysed (OLADE, IDB and AEA, 2013).

The Sustainable Development Goals of the UN look at the topic of renewable energy. Goal 7, "Guarantee access for all to accessible, safe, sustainable and modern energy", with the goals of guaranteeing universal access to accessible, reliable and modern energy services and substantially increasing the percentage of renewable energy in the mix of energy sources by 2030. Goal 9 is to "Construct resilient infrastructure, promote inclusive and sustainable industrialization and promote innovation". Supporting hydroelectricity is part of the goal of developing reliable, sustainable, resilient and high-quality infrastructure, including regional and trans-national infrastructure, and is also part of the goal to facilitate the development of sustainable and resilient infrastructure in developing countries with greater financial, technological and technical support to the least developed countries. This also meets Goal 13, "Adopt urgent measure to fight climate change and its effects" (UN, 2015).

BOX 8
RECOMMENDATIONS FOR ADAPTATION TO HYDROELECTRIC GENERATION

Currently, maximum power generation occurs in months when the flow of water entering the reservoir is greater than the flow through the turbine. The filling period in both plants lasts approximately five months, from June to October. This pattern would change for both plants under scenario A2, which estimates a general decrease in precipitation. This estimate is based on the assumption that operating rules prioritize filling of the reservoir over power generation during the rainy season. The plants would therefore generate more power during the emptying stage of the reservoir, between November and May, although the total annual output would be lower.

Power generation would gradually decrease due to a decrease in reservoir storage capacity due to sedimentation. It is recommended that this factor be studied in order to calculate loss of generation capacity, and to create alternative generation plans or reservoir recovery plans that include recovering forests in river basins and other measures for comprehensive river basin management.

In order to adapt to changing conditions, it is essential to have all the information needed to make decisions. It is recommended that meteorological station coverage be improved in the river basins in order to meet the minimum number recommended by the World Meteorological Organization (WMO). Firstly, most of the stations are located in the lower areas of the basins, which makes it difficult to identify rain patterns at higher altitudes and thus complete water balance calculations for the basin. Including evaporation as a parameter when calculating balance would provide information that could help reduce this type of loss in reservoir operation. This study has evaluated the effects of climate change based on the moving averages of temperature and precipitation changes, where the values estimated for cut-off years correspond to the average values for ten-year periods.

In the short term, it is recommended that a historical analysis of climate variability, as well as estimates for precipitation scenarios over the next two decades, be carried out, in order to predict possible changes in variability between dryer and more humid years. In order to improve water balance results, it is recommended that models that include land use and population growth be used in the short term, taking into account their probable effects and the resources needed to address them.

Similarly, it is also recommended that the effect of increasing temperatures on power generation in dry periods be analyzed. Such effects might already be present, and therefore require attention in order to devise urgent adaptation measures. Analyses of operations should also consider the role of future reservoir projects with regard to adaptation to climate change, taking into account routine operations of both the reservoir and the plant, and emergency measures in case of excess or lack of water flow.

Operational analyses should also consider the role of future reservoir projects in adaptation to climate change, both for the daily operation of the reservoir and plant, and emergency measures to address excess or absence of water flow, considering not only the plants, but also the management of each river basin.

It is recommended that the efficiency of all systems that use water be improved to prepare for eventual decreased availability and that river basins be managed properly to prevent soil erosion and reservoir sedimentation. In order to do this, initiatives relating to forest conservation, reforestation, appropriate land use and irrigation are needed.

It is recommended that evaporation parameters be included in the calculation of reservoir balance. The results of the simulations suggest that proper reservoir operation could reduce this type of loss, and, therefore, further research is recommended. In the same vein, it is recommended that seasonal water-storage systems be implemented to compensate for the decrease in water flow during periods of low water levels.

To increase power generation in both basins, it is recommended that operating models of the plant reservoirs be reviewed in order to optimize power generation in the face of scenarios of reduced water flow and probable increases in water flow variability in the short term. The silting processes of the reservoirs should be studied in order to quantify the decrease in plant generation capacity, and to devise alternative energy production plans and restore reservoirs.

It is recommended that this analysis be applied to other hydroelectric plants in the region, particularly to those of strategic importance. It will be important to study the effect of the climate change scenarios on run-of-river and daily regulation reservoirs, and especially the effect on power generation during periods of low water levels.

Source: ECLAC, CEL, MARN, COSEFIN, CCAD/SICA, UKAID and DANIDA (2012); and ECLAC, COSEFIN, CCAD/SICA, UKAID and DANIDA (2012d).

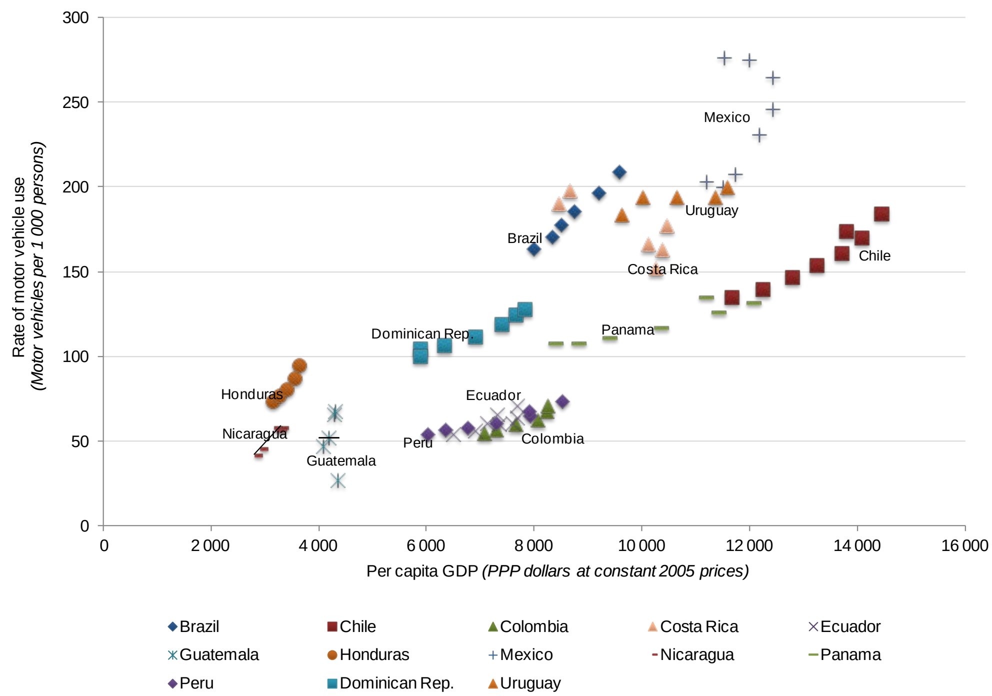
URBAN PUBLIC TRANSPORT

Many Latin American countries have seen a rapid increase in the rate of automobile ownership. Chart 31 shows the relationship between this rate and GDP per capita for a group of Latin American countries for the 2003-2010 period. In all countries with the exception of Costa Rica, the rates of automobile ownership have increased, some faster than others. Some countries have experienced a decrease in GDP per capita, but nevertheless their rate of ownership continues to increase. Guatemala, which had a GDP per capita of $4,345 in 2008 and $4,311 in 2010, saw its rate increase from 27 to 68 vehicles per thousand inhabitants. In Costa Rica, the relationship is negative: the GDP per capita grew from $8,462 to $10,546 from 2003 to 2010, but the rate of vehicle ownership decreased from 190 to 177 vehicles per thousand inhabitants over the same period.

The rest of the Central American countries and the Dominican Republic generally show a positive relationship between GDP per capita and rate of vehicle ownership. In Honduras, the GDP per capita was $3,143 in 2004 and increased to $3,631 in 2008, while the rate of ownership rose from 74 to 95 vehicles per thousand inhabitants. GDP per capita in Nicaragua increased from $2,815 to $3,299 between 2003 and 2008 while the rate of ownership rose from 42 to 58 vehicles per thousand inhabitants. Toward 2010, the GDP stagnated ($3,256 in 2010), which led to the stagnation of the rate of ownership at 57 vehicles per thousand inhabitants.

In Panama, the GDP per capita was $8,383 in 2004 and increased to $12,067 in 2010, while the rate of ownership rose from 108 to 132 vehicles per thousand inhabitants. Finally, in the Dominican Republic, the GDP per capita was $5,886 in 2003 and increased to $7,818 in 2009, while the rate of ownership rose from 105 to 128 vehicles per thousand inhabitants.

CHART 31
LATIN AMERICA: RELATIONSHIP BETWEEN THE RATE OF MOTOR VEHICLE USE AND PER CAPITA - GDP, 2003-2010
(Motor vehicles per 1,000 persons and PPP dollars at constant 2005 prices)



Source: ECLAC, 2014, using the World Bank database: Indicators of World Development

With the information available for each country, it was observed that there was a greater increase in the rate of vehicle ownership than in the growth of GDP per capita in Guatemala, Honduras, Mexico and Nicaragua, and a greater rate of GDP per capita growth than growth in rate of vehicle ownership in Costa Rica, Panama and the Dominican Republic. These rates of ownership for Latin America are lower than in other regions of the world, where rates reach up to 800 vehicles per thousand inhabitants in the United States. However, it is expected that the rate will continue to grow in the region.

The increase in the dependence on private transport in urban areas in Central America, combined with an increase in petrol consumption, is causing a complex network of negative externalities such as the costs associated with accidents, traffic, increased travel time and reduced worker productivity. The construction of infrastructure also tends to elevate CO_2 emissions and increase air pollution, which has significant impacts on the health of the population (ECLAC, 2014).

Temperature increases in cities with atmospheric pollution is an important aspect of climate change, since climate conditions directly affect the accumulation and spread of pollutants. Two of the most harmful pollutants are ozone and particulate matter; both are sensitive to the climate, but ozone is especially so. Ozone is a secondary pollutant formed in the atmosphere through reactions between primary pollutants such as nitrogen oxides and volatile organic compounds in the presence of solar light (radiation). The high number of people aged 65 and over being hospitalized for respiratory illnesses, asthma and chronic obstructive pulmonary disease is linked to the increase in the concentration of ozone. During several heat waves in London in 2003, 2005 and 2006, an additional 6,000 deaths were attributable to ozone levels and 5,000 deaths were directly related to temperature.

Central American cities do not have similar studies due to a lack of health data and, in some cases, a lack of atmospheric monitoring. The cities of the region need special attention as the population has grown disproportionately; this trend, combined with economic factors, increases levels of pollution. The main sources of emissions are obsolete automobiles and the use of low-quality fuels (Swisscontact, 2000). In order to improve air quality in Central American urban areas, atmospheric monitoring stations have been built, and measures, such as using un-leaded fuel, have been implemented to reduce the emission of pollutants. Costa Rica banned the use of leaded petrol in 1996 and established annual vehicle inspections, thus managing to reduce levels of metal in the atmosphere by 60% (Onursal and Gautan, 1997).

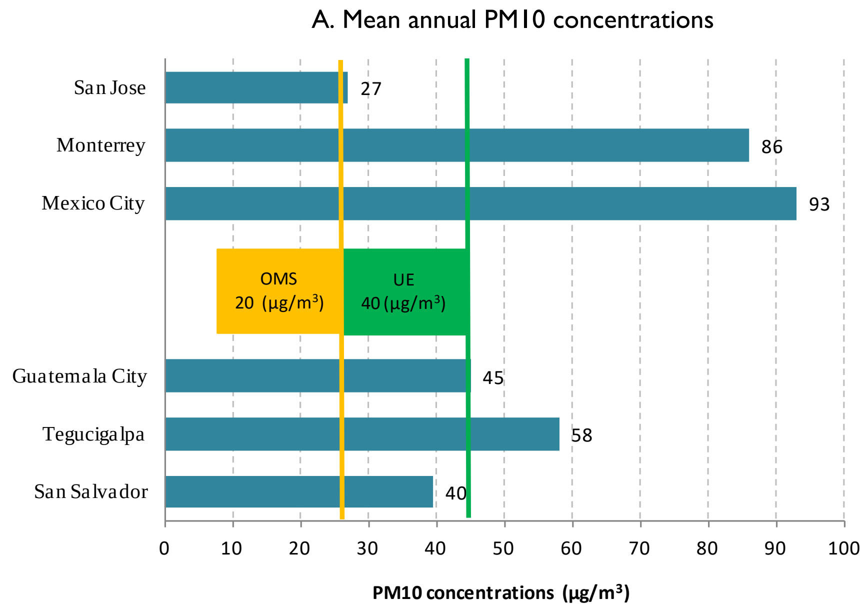
According to the records of PM10 and PM2.5 concentrations, levels are already high in cities such as San José, Monterrey, Mexico City, Guatemala City, Tegucigalpa and San Salvador according to the standard set by the World Health Organization (WHO). The levels in these cities (with the exception of San José) even surpass the level recommended by the European Union (see Chart 32).

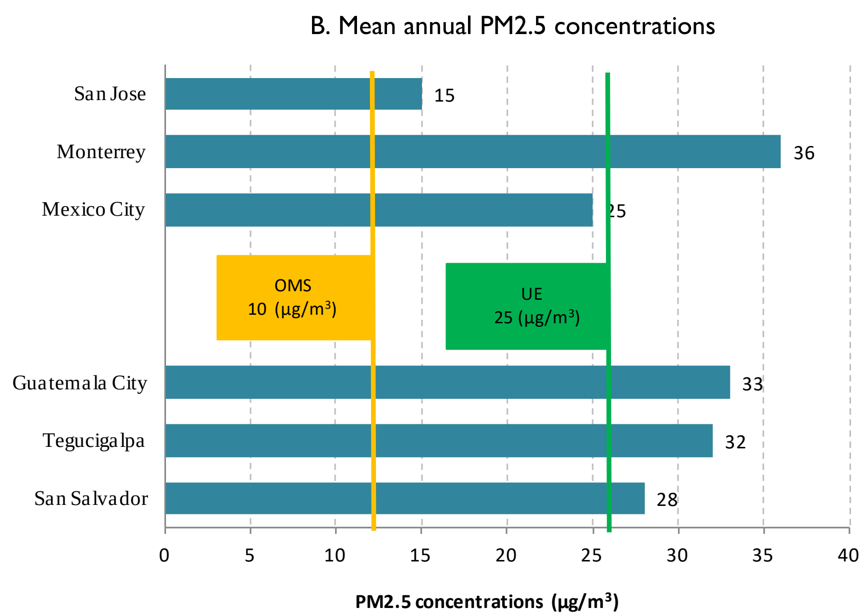
These externalities and the possible co-benefits of a sustainable focus highlight the opportunity for policies and public-private investment to facilitate the development of urban public transport systems that are accessible, fast, safe and clean, and which provide a better alternative to the vast majority of the population that cannot aspire to a private means of transport. This would benefit the population and society as a whole by reducing travel time, reducing emissions of local pollutants and GHGs, and the labour-related losses and damages caused by such problems as respiratory illnesses (ECLAC, 2014).

According to the initial estimates of the sectoral origin of GHG emissions nearing 2030, one of the sectors to consider is transport. The development style of this sector in the region has been characterized by segmentation in the modes of public and private transport, and by expenditure on transport according to income levels.

This can be seen in the trend of petroleum consumption presented in Chart 33. The figure shows the total cost on energy for transport as a proportion of each quintile, and the cost of energy for transport as a proportion of the total expenses of each quintile. The left column indicates that the quintile with the highest income, V, spends the most on petrol, accounting for 72% in El Salvador, 68% in Nicaragua, 62% in Costa Rica and 60% in Mexico. Quintile IV follows with a proportion between 16% and 21%. The lowest quintile accounts for less than 3% of petrol costs for these countries.

CHART 32
SELECTED CITIES: PM10 AND PM2.5 CONCENTRATIONS





Source: ECLAC, 2014, on the basis of World Health Organization (WHO), Ambient Air Pollution Database, May 2014.

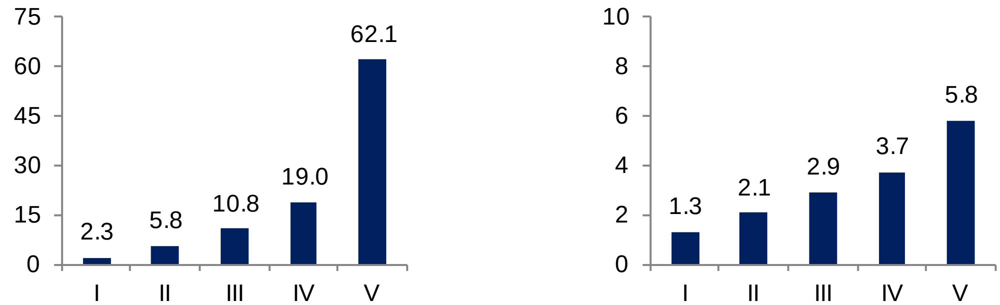
Note: The concentration data for San Salvador, Mexico City, Monterrey and San José are for 2011; for Guatemala, 2012; and for Tegucigalpa, 2013.

The highest quintiles also spend a larger proportion of their total expenditure on energy for transport. Quintile V represents 9% in Nicaragua, 8% in Mexico, 6% in Costa Rica and 4% in El Salvador. This is related to the concentration of private automobiles in medium- and high-income groups. Chart 34 shows that in Costa Rica and Mexico, 60% and 58% respectively of Quintile V are owners of an automobile. In El Salvador, 38% of quintile V owns an automobile and 21% in Nicaragua.

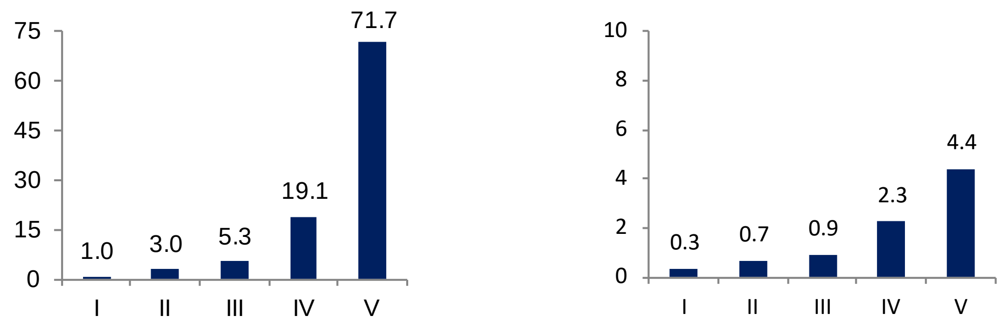
CHART 33
SELECTED COUNTRIES: COMPOSITION OF HOUSEHOLD EXPENDITURE ON TRANSPORT FUELS (GASOLINE, DIESEL AND BIODIESEL) BY QUINTILES

(Proportion of total expenditure on transport fuels relative to the transport expenditure, by income quintile) *(Proportion of total expenditure on transport fuels relative to the total expenditure, by income quintile)*

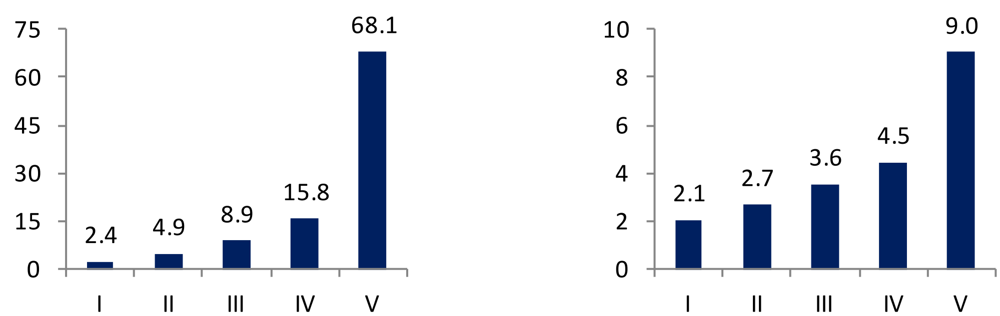
B. Costa Rica



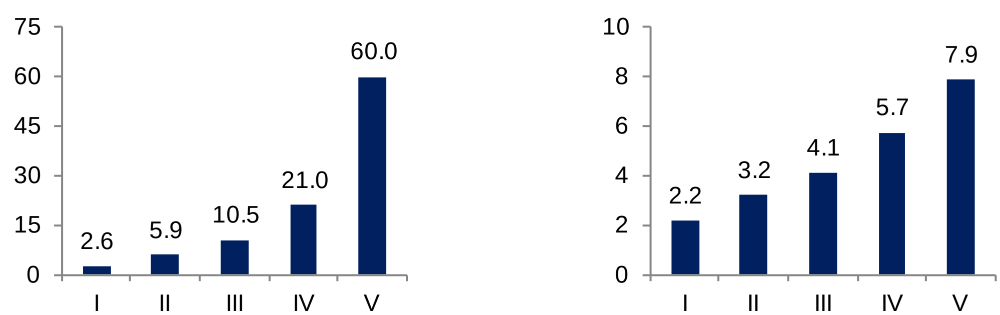
C. El Salvador



D. Nicaragua

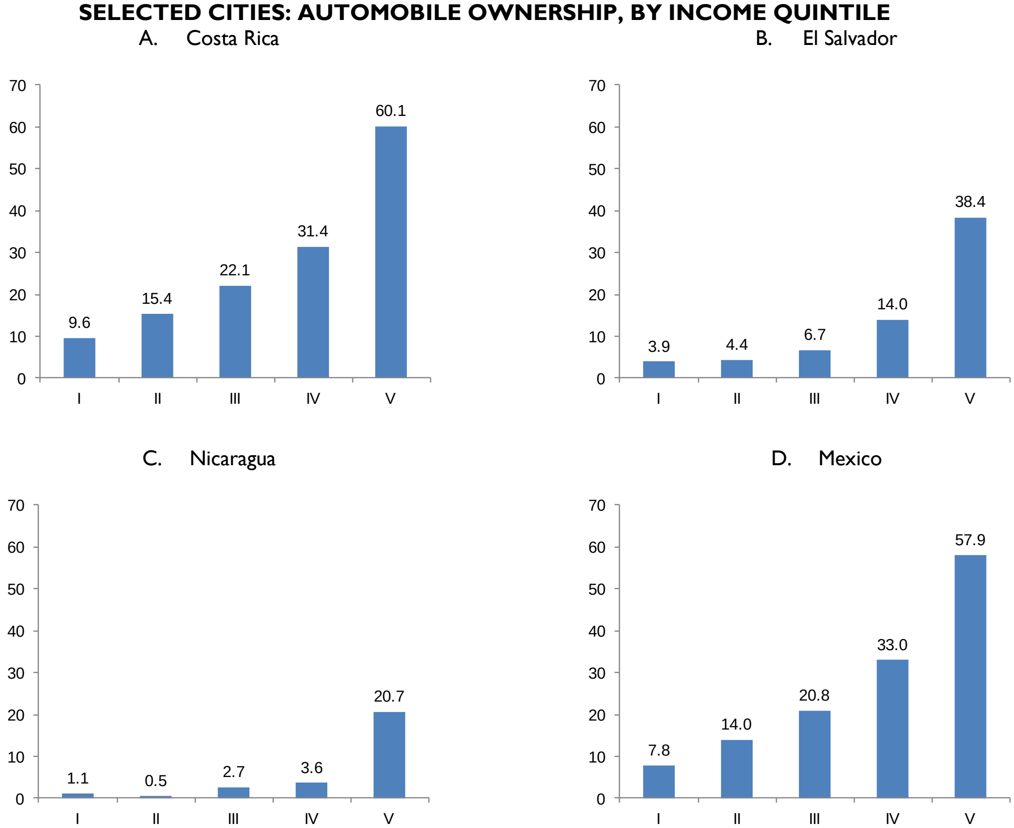


E. Mexico



Source: ECLAC, 2014, using the following surveys: Costa Rica: National Household Income and Expenses Survey; El Salvador: Household Income and Expenses Survey, 2005-2006; Mexico: National Household Income and Expenses Survey, 2012; Nicaragua: Quality of Life Household Survey, 2009.

CHART 34
SELECTED CITIES: AUTOMOBILE OWNERSHIP, BY INCOME QUINTILE



Source: ECLAC, 2014, using the following surveys: Costa Rica: National Household Income and Expenses Survey; El Salvador: Household Income and Expenses Survey, 2005-2006; Mexico: National Household Income and Expenses Survey, 2012; Nicaragua: Quality of Life Household Survey, 2009.

Conversely, the lowest quintiles spend the smallest percentage of their total expenses on petrol Quintile I spend 2% of total costs on petrol in Nicaragua and Mexico, 1% in Costa Rica and 0.3% in El Salvador. Of this same quintile, 10% have an automobile in Costa Rica, 8% in Mexico, 4% in El Salvador and 1% in Nicaragua. Therefore, the consumption of petrol is associated with the ownership of private vehicles, which are concentrated in the medium and high quintiles.

The topic of transport is located within some of the sub goals of the Sustainable Development Goals (SDGs) of the United Nations: Goal 9, regarding infrastructure, since investments in infrastructure (transport, irrigation, energy, and information and communication technology) are fundamental for the achievement of sustainable development and empowering communities. Goal 11, "Make cities and human settlements inclusive, safe, resilient and sustainable", has a sub-goal to provide access to safe, accessible and sustainable transport systems for all and to improve road safety, especially through the expansion of public transport. And finally, Goal 12, "Guarantee sustainable production and consumption modalities", where a sub-goal mentions re-evaluating inefficient subsidies to fossil fuels that promote anti-economic consumption through the elimination of market distortions (UN, 2015).

BOX 9
RECOMMENDATIONS FOR URBAN PUBLIC TRANSPORT

The high levels of contamination that fall above recommended parameters suggest the importance of an urban development strategy with the implementation of public policy measures that allow for the reduction of emissions of both local and international pollutants that have an effect on health.

Resolving the problem of climate change would be an advancement in the construction of a more equal society with more social inclusion and a public-private matrix that satisfies the needs of the new emerging classes of the region. In terms of development, society will be more resistant to climate shocks and at the same time will be in better shape to instrument mitigation policies. There are close ties between climate change adaptation and mitigation that can be taken advantage of in the framework of sustainable development: "Social equality, environmental sustainability and economic dynamism with an innovative approach are not mutually exclusive. The great challenge is to find the synergies among them".

The proper risk management that Latin America and the Caribbean needs requires the identification of these synergies with the view to instrument adaptation and mitigation processes in the context of sustainable development and in the framework of a global climate change agreement that recognizes the existence of common but differentiated responsibilities and differing capacities.

Some options for public policy measures to reduce emissions could be:

- Investment in sustainable infrastructure, such as rapid bus transit and networks for non-motorized transport, with criteria for efficiency, quality and safety, and which allow for a shift in urban mobility;
- Incentives to decrease the use of private transport through the application of regulations or economic instruments;
- Improve the quality of fuels such that impacts on air quality and the amount of greenhouse gases can be minimized;
- Improve information systems through bigger and better air-quality monitoring systems, which can help to issue early warning to decision makers;
- Inter-regional coordination so that macroeconomic and sector policies go beyond contributing to the economic development of the region and guarantee environmental sustainability and the wellbeing of the population; and
- Changes in the relative prices of fuels and of automobiles, so that the negative externalities can be internalized.

Some of these measures are already in place in the region. For example, approximately 45 cities in Latin America have chosen to implement rapid bus transit systems. Some countries of the region are also making significant efforts in the application of different tax measures that can contribute to tax collection and, at the same time, have a positive effect on the environment. Among these measures, the ones worthy of mention are related to automotive vehicles and fuels.

Source: ECLAC 2014a and 2014b, 2015b; Rodriguez and Vergel, 2013 and Hernandez and Antón, 2014.

3.5 HEALTH

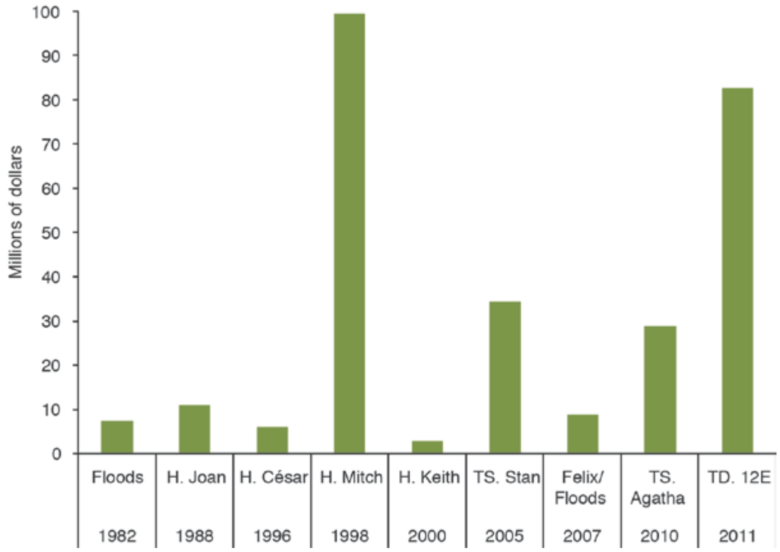
Historically, Central American countries have faced both the direct and indirect health effects of hydro-meteorological phenomena. In recent years, there has been growing concern regarding the increasing intensity and number of these events due to climate change. Besides their immediate effects, natural disasters also have serious secondary effects that affect public health due to floods, destruction of crops and the re-location of those affected to small unsanitary spaces (Noji & Toole, 1997). This is in addition to the existing poor living conditions including housing, public health and environmental infrastructure, which place the health of the population in a high state of vulnerability even without climate change.

Of the approximately 41 million inhabitants of Central America, two thirds live in settlements that combine poverty with unsanitary conditions and deficient basic sanitation and health services (FAO-ETEA, 2008). In fact, some diseases related to poverty, such as malaria, dengue, intestinal parasitic infections, Chagas disease, leptospirosis and leishmaniasis, are also associated with changes in climate (Hotez and others, 2008). At the same time, Central America is home to a mosaic of ecological niches that are ideal for the transmission of diseases associated with the region's orography and climate, since the isthmus is narrowly bordered by the Atlantic and Pacific oceans.

Chart 35 illustrates the economic losses caused to the Central American health sector by the most significant disasters. The most devastating hurricane in Central America was Mitch (1998), which left approximately 30,000 people dead or missing, and caused significant economic loss, destroying housing, bridges, roads and a large part of coffee and banana plantations (Cupples, 2007). The damage caused by EHEs to the infrastructure for communication, sanitation and basic services such as lighting, potable water and health services can create favourable conditions for the spread of multiple infectious diseases, such as cholera, dengue and diarrhoea (Schultz and others, 2005). The flooding of crops causes food shortages while contaminating the soil. The affected population can develop mental health disorders, such as post-traumatic stress disorder and depression (WHO, WMO and UNEP, 2008).

Research on the potential damage to health caused by climate change requires that, when the effects of climate are observed using epidemiological methods, other variables be considered, such as determinants of disease and vulnerability of the population studied. Therefore, epidemiological scenarios associated with climate change need to be created, and these scenarios need to consider three interrelated variables: climate variables that are related directly or indirectly to health, variables related to the aetiology of each disease, and variables of the population's vulnerability to climate change. Some studies include demographic variables; others develop complex indices to reflect climatic anomalies in different scales, which is why they incorporate ecological and social information to explain the mechanisms and the relationship between climate conditions and disease.

CHART 35
CENTRAL AMERICA: ECONOMIC LOSSES IN THE HEALTH SECTOR CAUSED BY DISASTERS
(Millions of year 2008 dollars)



Source: ECLAC, several years.

The co-publication by COMISCA, CCAD and ECLAC from the study "The economics of climate change in Central America: evidence of climate-sensitive illnesses" (ECLAC, COMISCA and CCAD, 2012) considers the direct and indirect repercussions of extreme meteorological events and changes induced by the climate. The study reviews the related literature from scientific indexed journals and other non-indexed documents in order to compile more background information for future research. The illnesses considered are: dengue, malaria, diarrhoeal diseases (DD), acute respiratory diseases (ARD), Chagas disease, leishmaniasis and leptospirosis.

The potential impacts of climate change on health in Central America include growing stress due to heat, and changes in the patterns of diseases such as malaria, dengue and cholera. Malaria continues to be a serious health risk in most of Central America, including the entire territory of El Salvador (PAHO, 2002). This analysis confirms that several countries have begun studying climate and health: Guatemala, Nicaragua, Panama and El Salvador have focused on dengue; Belize and Panama, on malaria; and Guatemala and Belize, on Chagas disease. The research carried out in Costa Rica is particularly worth mentioning, as in addition to having appropriate health and meteorological information systems, its national communications report progress in the analysis of health as it relates to climate change. Some projections suggest probable decreases in malaria during its transmission season in areas where a decrease in rainfall is expected. Nevertheless, in Nicaragua, it is expected that there will be an increase in the incidence of the disease. In Guatemala, the potential impact of climate change on acute respiratory infections, acute diarrhoeal diseases and malaria was studied. It was found that these diseases might not continue to follow their traditional seasonal patterns. In Panama, an early warning system that analyses the incidence of the dengue-transmitting mosquito allows the health sector to run its community vector control programme and other activities to reduce the number of cases. A recent study in Costa Rica analysed dengue, malaria, asthma, heart disease, diarrhoea and parasitic diseases according to vulnerability in terms of sensitivity, exposure and resilience.

GUATEMALA: EFFECTS OF CLIMATE, CLIMATE VARIABILITY AND CLIMATE CHANGE ON HUMAN HEALTH

This study was carried out in the framework of the First National Communication on Climate Change and includes an evaluation of the potential impacts of climate change on public health in Guatemala. Firstly, the study considers that human health is the result of interactions between many factors, such as (1) human biology, (2) the environment, (3) socioeconomic situation, (4) habits, traditions, and lifestyles of people and communities, and (5) the condition of socio-healthcare infrastructure, particularly health services.

The study focused on three diseases: acute diarrheal diseases (ADDs), acute respiratory infections (ARIs), and malaria (MA).

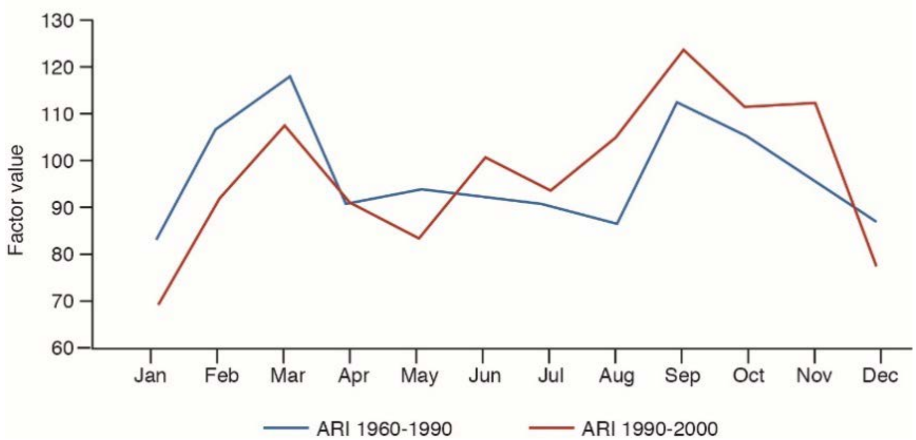
The study found that the diseases considered will not follow their historic seasonal patterns and that epidemic episodes will occur outside the normal season. With regard to ARIs, the periods 1960-1990 and 1990-2000 were analysed, looking at the number of reported cases of illness and the climate variation in each period (see Chart 36). In the period 1960-1990, ARIs showed a bimodal behavior with a sharp peak in March and another peak in September-October. It is possible to see an increase in frequency at the start of the rainy season (June and July) but also a delay in the occurrence of the epidemic episode typically seen at the end of summer (blue line). In a climate change scenario, this disease would not follow its historic seasonal pattern; instead, there would be epidemic episodes or notable decreases in incidence outside the normal season (red line).

Impacts are more pronounced during ENSO years (Glantz, 1998; Epstein, 1999) as the frequency of cold waves and the thermodynamic features of the air masses that follow change. The occurrence of warmer and dryer periods is another consequence of ENSO in Guatemala.

The impacts of climate change on human health are reflected in (MARN, GEF and UNDP, 2001):

- An increase in mortality and morbidity indices.
- An increase in infectious and non-infectious, vector-borne and non-vector-borne diseases (malaria, dengue, schistosomiasis).
- An increase in malnutrition and dehydration indices due to difficulties accessing water and food.
- Damages to public health infrastructure.
- Psycho-somatic effects caused by climatological phenomena.

CHART 36
PACIFIC COAST: IMPACT OF CLIMATE VARIABILITY ON THE BEHAVIOR OF ACUTE RESPIRATORY INFECTION (ARI)



Source: MARN, GEF and UNDP, 2001

PANAMA: EARLY WARNING SYSTEM FOR DENGUE

The Gorgas Memorial Institute for Health Studies (GMI), the Empresa de Transmisión Eléctrica S.A. [Electric Transmission Company], the Ministry of Health and the National Census and Statistics Institute, advised by the Climate and Health Unit of the Institute of Meteorology of Cuba, have created a Mosquito Infestation Index (INDINF), applying the Bultó-Index (BI) mathematical-statistical model to predict the likelihood of infestation of the *Aedes aegypti* mosquito in the district of Panama in the next three months.

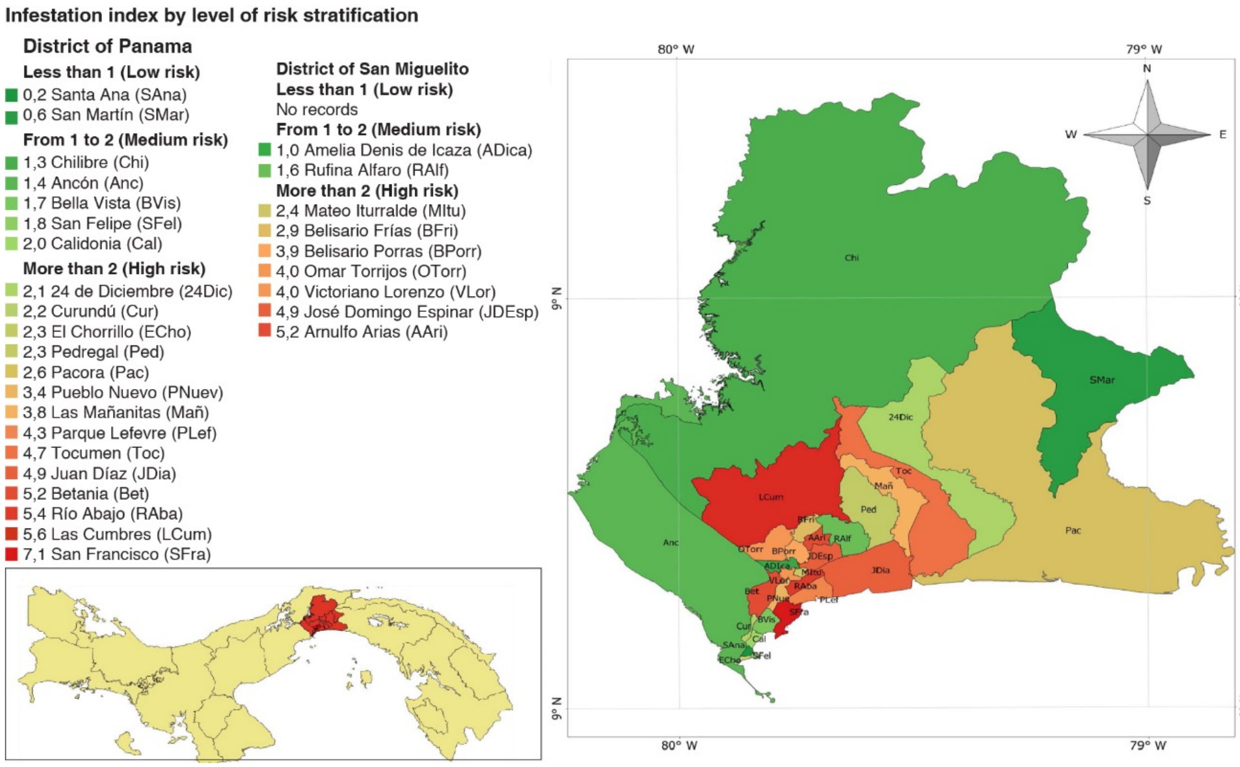
INDINF is an observational, descriptive and retrospective index that combines historical entomological and climatic variables with geographical information technology. Time series of entomological variables (mosquito infestation index) and climatic variables (atmospheric pressure, rainfall, maximum and minimum air temperatures, monthly thermal oscillation, relative air humidity, wind speed at ten meters, vapour pressure, number of days of precipitation and insolation, i.e. hours of sun) were used.

The entomological variables are obtained from the Entomological Survey carried out every four months by vector control inspectors and/or vector technicians. In April 2011, 73,123 properties were inspected; of these 912 had positive results, resulting in an index of 1.2%.

A monthly report provides the indices of observed infestation and predictions per month and quarter, as well as monthly georeferencing for the capital district. Map 15 shows infestation index predictions for August 2012 for the districts of Panama and San Miguelito, where the red areas represent the areas of highest risk. According to this report, a decrease was predicted relative to July values since the BI predicted less humidity, warmer temperatures and lower-than- normal rainfall values. The infestation index prediction depends on past behaviour, as well as the BI and MEI (Multivariate ENSO Index) measured by the U.S. National Oceanic and Atmospheric Administration (ICGES, ETESA, MINSA e INEC, 2010, and ICGES, ETESA and MINSA, 2012).

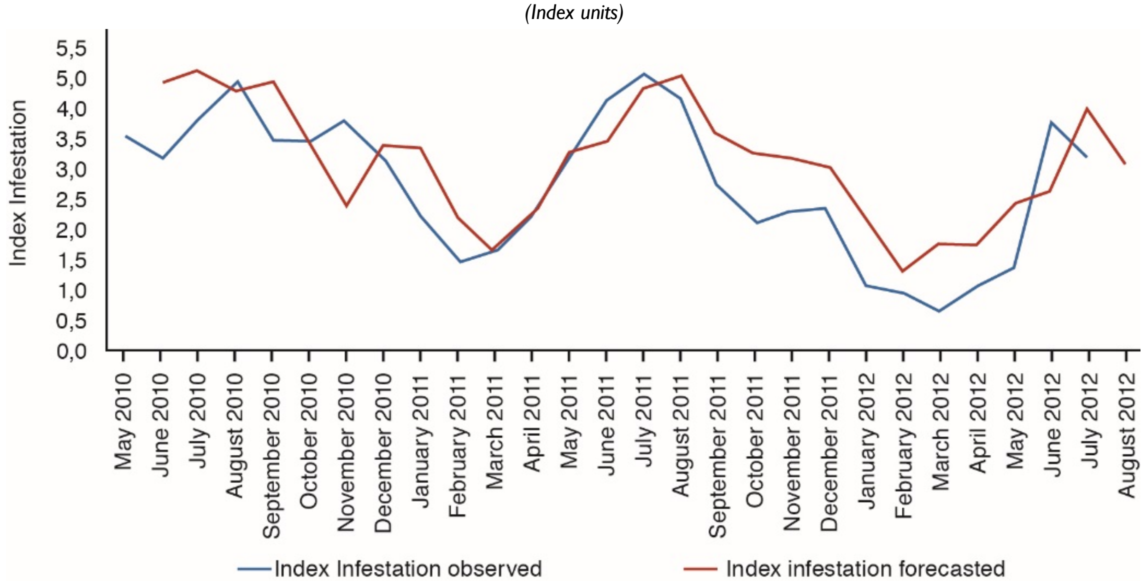
Thus, it has been possible to predict *Aedes aegypti* infestations by month and quarter in the district of Panama, which allows the National Health System to react with health interventions that reduce the risk of dengue in the country. The results show that predicted infestation index values follow the same trend as observed values. For the majority of the year, the predictions were slightly higher than observed values, as can be seen in Chart 37.

MAP 15
DISTRICTS OF PANAMA AND SAN MIGUELITO: INFESTATION INDEX FORECASTING, AUGUST 2012



Source: ICGES, ETESA, MINSA and INEC (2010), and ICGES, ETESA and MINSA (2012).

CHART 37
PANAMA DISTRICT: COMPARISON OF FORECAST AND OBSERVED INFESTATION INDEX, MAY 2010-AUGUST 2012
(Index units)



Source: ICGES, ETESA, MINSA and INEC (2010), and ICGES, ETESA and MINSA (2012).

COSTA RICA: EFFECTS OF CLIMATE, CLIMATE VARIABILITY AND CLIMATE-CHANGE ON HUMAN HEALTH

The National Institute of Meteorology (IMN) and the Ministry of Health (MINSA), with the support of the United Nations Development Programme, carried out a study on the effects of climate, climate variability and climate change on human health in Costa Rica. The goal of the study was to characterize a group of diseases according to the sensitivity and exposure of the population (INM and Ministry of Health of Costa Rica, 2008)(IMN and Ministerio de Salud de Costa Rica, 2008) . Thus, a relationship was established between climate, climate variability, climate change and the areas, regions or sectors most likely to suffer damages or losses.

To evaluate vulnerability to the prioritized diseases, quantitative methods were used to analyze sensitivity in order to establish a relationship between climate elements and historical records of rates or number of cases, and economic costs. Exposure to diseases was assessed through spatial identification of the area and population groups with greater disease incidence, and their relationship to climatic regions.

Four groups of diseases were identified using data available for different time periods: vector-borne diseases (Dengue, 1993--2006, Malaria, 2004-2006); cardiorespiratory diseases (asthma, 1998-2006, heart disease, 1990-2006); gastrointestinal diseases (diarrhoea, 1996-2006) and parasitic infections (abdominal angiostrongyliasis, 1995-1999). There are two groups that are most vulnerable to these diseases: vector-borne diseases such as dengue and malaria are most common in the economically active population between 15 and 45 years of age, while the other diseases present primarily in dependent persons, such as infants and the elderly. For this reason, the impacts on vulnerable groups affect national development since they cause absenteeism at school and work due to illness.

Climate, its variability and its change are not solely responsible for disease incidence, but they do explain a percentage that could be worsened by the effects of global warming. Future climate change scenarios predict an increase in extreme meteorological events that can be linked to the impacts of ENSO in Central America, and a 2°C to 6°C increase in temperature at the national level. Regarding dengue and malaria, the increase in temperature would affect the metabolism and physiology of mosquitoes (feeding rate, reproductive frequency), which could mean a greater risk of contracting these diseases in the entire country, especially in areas that are already high-risk. Regarding diarrhoea, a global increase of 1°C increases the number of cases of diarrhoea in developing countries by 5% (Cantero and Fonseca, 2007). However, above all, changes in rainfall will cause water imbalances that facilitate the propagation of viruses and bacteria that cause diarrhoea in children and adults (Cantero, 2007).

With regards to asthma, greater exposure to elevated environmental humidity and high temperatures could be harmful to the population. Finally, the estimated precipitation scenarios for the areas most affected by abdominal angiostrongyliasis could help decrease the risk of contagion in the population since the dry environment will limit the development of intermediate hosts for the parasite.

TABLE 11
SUMMARY OF FEATURES OF VULNERABILITY

Disease	Exposure		Sensitivity	
	Vulnerable group	Vulnerable area (most vulnerable region and canton)	Correlation with climate change	Economic impact[a]
Dengue	Population group between 15 and 44 years. Economically active population	North Pacific and Caribbean region (Orotina)	Increase in environmental temperature and precipitation	$630 000 (¢346 million)
Malaria		Caribbean region (Matina)		$154 000 (¢85 million)
Asthma	Children under 9 years, adults over 65 years	Central Region, North Pacific and Central Pacific (Alajuela Centro)	Increase in environmental pollution, heat waves and humidity	$53 000 000 (¢29 billion)
Cardiovascular	Adults over 65 years with cardiac or respiratory deficiencies, hypertension and obesity	North Pacific, Central Pacific, and Central region (Atenas)	Increase in stratospheric ozone, in temperatures and heat waves	Data not available
Diarrhoea	Children under 5 years and adults over 65 years	Central region, North Pacific (San José Centro)	Water imbalances	$9 000 000 (¢5 billion)
Abdominal angiostrongyliasis	Children between 1 and 5 years, as well as the school-aged population	North area (Upala)	Water imbalances that affect the development of plagues of molluscs and rodents	$162 300 (¢89 million)

Source: IMN and Ministerio de Salud de Costa Rica, 2008

[a] Annual average cost of healthcare for patients (dollars at current exchange rate of ¢550 per $1), based on average cost of visit, number of affected persons and the average number of visits per person.

In summary, the region has valuable experience in the research, treatment and prevention of tropical diseases, including vector-borne diseases. Dengue records, for example, show the existence of endemic areas with seasonal patterns, mainly in urban centres; however, studies relating this disease to climate variables are scarce.

The region has an active malaria monitoring system. This has led to a low mortality rate and efficient medical attention during outbreaks in certain years. There is also a significant amount of information available on vector distribution and its link to environmental degradation.

The incidence of acute diarrheal diseases has a long history in the region. It is an illness associated with poverty that is concentrated in the infantile population. Although various studies try to understand the seasonal variations of this illness, there are no analyses that estimate changes under different temperature and precipitation scenarios.

Food and nutritional security, stress and anxiety episodes, and skin conditions following hydro- meteorological events have received little attention; dehydration, heat strokes or stress, and various cardio respiratory diseases related to atmospheric pollution and the increase in temperature in large cities have not been studied either.

The Council of Ministers of Health of Central America and the Dominican Republic (COMISCA) established a framework of regional strategies and guidelines, and its institutions have begun different national initiatives. This framework was based on the climate change mandates established by the presidents of the SICA countries, especially since 2008. For example, Strategic Result 9 of the Regional Agro-environmental and Health Strategy (ERAS), which involves cooperation between the Ministers of Agriculture, Health and Environment, defines four lines of action regarding research and analysis of the negative effects of climate change on health, the creation of plans and programmes needed to attend to these effects, the participation and support of the Ministries of Health and other important stakeholders in the evaluation of the vulnerabilities of the national health systems, and the development of a proposal for the creation of a Climate and Health Observatory (CAC et al, 2009). The Regional Climate Change Strategy (ERCC) establishes a strategic area for public health as well as different lines at action aimed at institutional strengthening and the design of public policies that help to mitigate the effects of climate change on health (CCAD, SICA, 2010).

During this same period, the Ministries of Environment and Treasury of the seven Central American countries, with their integration agencies, CCAD and COSEFIN of SICA, and SIECA, and with the help of ECLAC, implemented the Economics of Climate Change in Central America (ECC CA) initiative. This was done to alert ministers and other key stakeholders from different sectors to the vulnerability of the region to climate change by producing various technical analyses and evaluations and supporting the discussion and creation of response policies. Through various activities hosted by ERAS and the Council of Ministers of Health, results regarding the potential impacts on various sectors were shared, and a dialogue was begun on the implications for health.

It was decided with ES/COMISCA to hold a "Technical meeting for the analysis of potential impacts of climate change on the incidence of climate-sensitive illnesses in Central America" in April 2012, along with the technical group of Directors of Epidemiology and Monitoring and its officials in Information Systems (COTEVISI). At this meeting, each country presented its progress in the analysis of the relationship between health and climate, and the statistical tools used. The results of phase II of the ECC-CARD initiative relating to this topic were presented. The technical work done by the Pan American Health Organization (PAHO), National Institute of Public Health of Mexico (INSP), the Gorgas Institute in Panama and the Cuban Institute of Meteorology (INSMET) was also presented. A work proposal was prepared for the Council of Ministers.

Based on this, COTEVISI, ES/COMISCA, ECLAC, ICGES, INSP and INSMET created a short-term work plan and began the design of a project within the framework of the Economics of Climate Change in Central America initiative. At the end of the meeting, it was agreed to a) propose a work plan on "Health and Climate Change" in the framework of COMISCA and its technical group, COTEVISI. The Gorgas Institute, INSP, INSMET, PAHO and ECLAC would be invited to assist this group as technical advisors of the initiative, without excluding the option of inviting executive secretaries such as CCAD, CAD and other regional, national and international specialists to the technical meeting as required by the corresponding agendas; b) to start technical analysis and dialogues on response options, as well as capacity building within the framework of the ECC-CARD initiative, and to form (as a part of the initiative) a Thematic Regional Group for the health sector to be led by COTEVISI; and c) prepare a medium-term work proposal to expand on the analysis already carried out on historical trends of other high-priority diseases, initially including malaria, ARIs, leptospirosis, leishmaniasis and Chagas; and to progress with prospective analysis using future scenarios of climate change.

In its XXXVI Meeting of June 2012, COMISCA analysed the proposal that arose from the technical meeting and instructed the ES COMISCA to gradually establish the "Health and Climate Change in Central America" initiative to generate technical evidence to support decision making at COMISCA. This was to be done in direct coordination with the Directors of Epidemiology that make up COTEVISI and the Regional Health Situation Room, inviting the Gorgas Institute, INSP of Mexico, PAHO and WHO, and ECLAC as advisors and coordinating this effort with the ECC CA initiative with the support of ECLAC. These bodies were instructed to begin short-term technical activities to prepare historical databases and start analysis using a common methodology. They were also instructed to prepare a medium-term work plan. ES COMISCA was instructed to identify financing opportunities in coordination with ECLAC.

The Ministers of COMISCA, in their XLI Meeting, established that climate change and health need to be addressed in a coordinated and intersectoral way, complementing the efforts of different agencies and promoting the use of climate forecasts in the region for prevention and planning actions in the health sector (COMISCA, 2014a). During this meeting, the 2014 SICA Regional Health Policy was also approved. This policy establishes the building through consensus of a regional position on critical health topics, such as the effects of climate change. It also establishes the need to articulate and coordinate initiative that arise in the regional environment to promote intersectorality and to address social determinants of health (COMISCA, 2014b).

It is important to point out that, besides the Ministries of Health and Environment, there are consolidated public sector research groups, such as the Gorgas Memorial Institute of Health Studies (GMI) in Panama, the National Meteorological Institute (IMN) of Costa Rica and the university sector, especially in the field of vector-study. Likewise, international institutions such as the Mesoamerican Initiative for Public Health, INSMET, the University of Miami and the University of Michigan, among others, have collaborated in important studies.

BOX 10
RECOMMENDATIONS FOR THE ANALYSIS OF CLIMATE-SENSITIVE ILLNESSES

According to the review that has been carried out, in order to advance the research on the impact of climate change on human health in Central America, it is advisable to:

- Promote a regional initiative to support research on climate change and health; this initiative can coordinate consolidated research teams in various disciplines and establish partnerships with different sectors.
- Analyse the implications of temperature, precipitation and the evolution of each country's demographic structure on studies of climate and health. In this sense, it would be ideal to consider future temperature and precipitation trends so as to predict health risks, and to incorporate ecological niche modelling to analyze the changes in species distribution due to climate change. This last aspect requires greater attention in the research of Vector-Borne Diseases (VBDs).
- Not only evaluate the effects of climate change on the most vulnerable populations, but also analyze the establishment and spread of this vulnerability, so as to create specific proposals to help reduce it. Costa Rica and Panama have both made advances in assessing the problem and creating programs to address it.

- Carry out studies that include conditions of social and environmental vulnerability such as poverty, inequality, lack of access to health services, institutional response capacity and environmental degradation.
- Standardize approaches and methodologies in order to carry out valid comparisons and better understand the results.
- Recommendations for Disease analysis:
    - For vector-borne diseases like Chagas, leishmaniasis and climate-sensitive zoonoses, consolidate databases in order to carry out epidemiological studies related to climate at the regional and national levels, taking into account climate change scenarios and the geomorphologic and socioeconomic similarities between countries.
    - Given the importance of the cohort study of dengue in Nicaragua, expand and replicate it in other countries of the region in order to find causal associations between disease transmission and climate variables and social vulnerability.
    - Since it is known that diarrheal diseases are directly related to water quality, analyze their incidence following hydro-meteorological events.
    - Carry out studies on the adverse effects of air pollutants on the health of vulnerable groups such as children and the elderly in cities and broaden the network of atmospheric monitoring stations.
    - Evaluate the impact of climate on agricultural production and food and nutritional security.
- Broaden studies on the impact of climate change in national communications, taking into account ecological, hydrological and agricultural regions as well as other relevant areas of analysis.
- Take into account conditions of social and environmental vulnerability that could alter biodiversity and ecosystems, as well as impact human health. These relationships are generally seldom studied.
- Treat the projections of climate change models and the different aspects of ENOS as tools to create regional policies on disease control. It will be necessary to carry out interdisciplinary studies involving research teams, health sector personnel and the community in order to develop adequate response measures.
- Strengthen systems for collection and analysis of epidemiological data. Researching the effects of climate change on health requires at least 30 years of retrospective data series, which is why the ability to carry out direct evaluations is limited and why climate models must be used to estimate changes in climate and diseases. Use epidemiological methods that:
- Delimit the determining factors of the disease and the vulnerability of the population under study, describe the geographical area from which the health data comes, adequately assign meteorological data to the population of interest, include a plausible biological explanation that relates climate parameters to the disease, and remove time trends and seasonal patterns in the time series analysis before assessing the possible link between climate and health.

Source: ECLAC, COMISCA and CCAD (2012).

3.6 FISCAL POLICY

The initial estimate of the economic valuation of climate change in Central America shows a significant impact on the economy as a whole, and a marked difference depending on the trajectory of global emissions. This shows its importance to fiscal and economic policy.

This estimate is based on the measurable impacts of certain extreme events on the agricultural sector, water and biodiversity, and can therefore be considered an initial, partial costing. The baseline macroeconomic scenario "without climate change" can be used to identify the impacts on these sectors caused by temperature and precipitation. The two trajectories valuated in monetary terms represent the costs associated with the impact of climate change. The valuation of the cost in monetary terms allows for the estimation of changes or decreases in GDP trajectories in the baseline scenario. In economic studies of climate change, it is standard to use the VPN of the cumulative cost flow over a period, i.e. its value or percentage relative to current GDP.

The initial costs estimated for A2 rise after 2050 in the majority of sectors, and in general are quite high at the end of the century. The estimated initial cumulative cost by 2100 under scenario A2 with a discount rate of 0.5% is equivalent to $73 billion in today's dollars, or $52 billion in year 2002 dollars, i.e. approximately 54% of the GDP of the region in 2008 to VPN. (With a discount rate of 4%, the equivalent value is 9% of regional GDP in 2008 at VPN, showing the importance of the discount rate used).) The estimated cumulative cost under scenario B2 by 2100 would be equivalent to $44 billion in today's dollar and 31 billion in year 2002 dollar, i.e. approximately 32% of GDP in 2008 with a discount rate of 0.5% (With a discount rate of 4%, the equivalent value is 6% of regional GDP in 2008 at VPN).

The estimates indicate that costs are higher under scenario A2 than under B2, and that they tend to increase at a higher rate after 2050, when the effects of greater emissions levels would lead to greater increases in temperature. In this regard, an international agreement that stabilizes and reduces global emissions would help to reduce the impact. The estimates are also higher than those for developed countries under scenarios B2 and A2. The estimates confirm that the costs of climate change will be unequal and non-linear and will grow over time. They also show that the continuous increase in temperature and changes in precipitation will have an increasing amount of negative effects for all economic activities. Furthermore, they suggest that there will be irreversible thresholds past which costs will increase disproportionately and that effective management of risk will be essential in the response to this phenomenon.

In this summation of costs, those costs associated with the livestock sector and the consumption of water in the industrial sector are not included due to the limitations on measuring the relationship between climate change and production in these sectors. It is important to reaffirm that there are serious limitation to an economic valuation of biodiversity and that the relationship between climate change and flood, hurricane and storm frequency has not yet been determined. For these intense events, it is assumed that a 5% increase in intensity would imply the fewer impacts and emissions of scenario B2. An increase of 10% would be sufficient to lead to scenario A2. There are several factors still not included in this valuation: health services, hydroelectric power generation and energy consumption, infrastructure, tourism, marine and coastal areas, and the multiple indirect impacts on other areas such as industry and the services sector. Progress needs to be made in the evaluation of impacts on key ecosystems such as forests, and due to other extreme events, such as drought. Therefore, the calculations presented are a conservative, initial estimate of the economic impact.

It is important to state that Central American economies have made structural changes and shown instability in their macroeconomic dynamics in the last two decades. The characteristics of this growth pattern are a result of various factors with multiple, different origins: economic, social and political, with national differences. These factors manifest themselves in the volatile behaviour of some macroeconomic aggregates or in more significant proportions (e.g. investment-to-GDP). Besides the macroeconomic context, there is a high level of uncertainty regarding key variables such as technology, the relative prices of energy, water consumption and biodiversity. Therefore, the cost estimates here are merely indicative.

Even with just this initial evidence, fiscal policy has a large role to play within national policies to address climate change. There is an urgent need for a sustainable fiscal policy that accounts for the current impacts of extreme events and the growing effects of climate change, and that creates a framework of incentives for the transition to economies that are environmentally sustainable and resilient to climate risks.

These climate phenomena are affecting public finances in various ways, such as through the increase in the number of emergencies, and the instability of agricultural production and hydro-electric power generation. They could also give rise to greater demand for the expansion and modification of social services, and the relocation of populations and economic activities. The affected populations would demand compensation for their losses, the cost of which would fall on the State given the low level of insurance coverage in the region. This partial list of pressures on public finances caused by climate change suggests that its economic impact should be seen as a serious contingent liability, which in the long run will become far less "contingent".

In economic terms, climate change is a global externality. The Stern Report has called climate change the greatest market failure in the history of humanity, as a large part of climatic costs still have no "market price" (Stern, 2008). Given that the market cannot solve these problems, collective action led by the State (i.e. the combination of public institutions and structures for decision-making and action) is required. Proactive measures must be implemented in order to reduce the negative effects, so that future impacts can be lessened. Financial and insurance mechanisms as well as fiscal-stimulus programmes must be created in order to lessen the impact in general and align fiscal incentives with the transition towards an economy that causes less damage to the environment.

Despite the immediate challenges of fiscal sustainability, the Ministers of Finance/Treasury of Central America have begun to pay attention to climate change at the regional and national levels, through their Council of Ministers of Treasury/Finance of Central America and the Dominican Republic (COSEFIN). The region has experience in swapping debt for climate change programme financing, with budget line "labelling" systems in order to identify investment in adaptation and is now creating proposals for national funds for climate change, domestic carbon markets, climate change requirements in sectoral plans as part of public budget planning, disaster contingency funds and investment in infrastructure adaptation. Officials from the region are receiving training in econometric analysis that relates fiscal issues to climatic risks, fiscal sustainability and subsidy analysis, expenses and fiscal incentives.

It is important to mention the current initiative by the Ministers of COSEFIN to establish a catastrophic insurance mechanism for Central America, and to incorporate their countries, according to the needs of each, into the Caribbean Catastrophe Risk Insurance Facility (CCRIF) of the Caribbean, through a partnership between the two regions. This is a huge progress in and of itself and establishes guidelines to motivate sectoral ministers to implement comprehensive risk management and insurance measures. In 2014, the Presidents of SICA recognized the importance of this effort.

The two regional strategies approved in recent years, ERCC and PCGIR, establish mandates for the Ministers of COSEFIN on external financing and on the incorporation of risk management into public investment with economic evaluations of said risk and financial protection mechanisms for subsidized and fair investment for "uninsurable" groups. In December 2011, not only did the President urge greater cooperation and financing from the international community, but they also committed themselves to reallocating, where possible, resources for risk reduction and adaptation to climate change to the rehabilitation and reconstruction of the region.

BOX 11
RECOMMENDATIONS FOR FISCAL POLICY

Possible measures were identified during ECC CA discussion:

- Build the capacity to design fiscal sustainability policies that reduce climate risks and incentivize production and resilient and sustainable infrastructure, including the analysis and revision of subsidies, taxes and exemptions.
- Create and apply standards for investment projects in order to strengthen the climatic resilience with the ministries responsible for infrastructure in sectors such as health, education, transport/roads and energy (especially hydroelectric), including an economic valuation of climate risk from the design phase.
- Establish outlines and training for the creation of programmes and sectoral budgets to increase climate resilience, integrating it into results-based budgeting when applicable.
- Develop programmes for insurance and comprehensive risk management in the agricultural sector and previously-identified sectors at the national level and consider options for regional initiatives.
- Design and accredit national mechanisms for the management and administration of international climate financing.
- Expand mechanisms and capacities to take advantage of different sources of financing for adaptation and emission reduction, and valuate the services provided by ecosystems.
- Contribute to the construction and governance of international financing mechanisms that acknowledge the situation in developing countries, which are highly vulnerable to climate change, and respond to their needs and opportunities.
- Analyse the potential impact of climate change on fiscal income due to its direct effect on productive sectors and its potential effects on the global economy.
- Analyse the potential impact on health spending and on transfer programmes for poor populations as well as the direct impacts on the population, and establish adaptation

priorities, such as agricultural extension, investment in infrastructure adapted to climate change and extreme events of greater intensity, climatic data recording systems and productive insurance.

- It is advisable to broaden and operationalise fiscal and financial policies that provide incentives to manage forests in a sustainable manner and recognize the economic value of environmental services, including carbon sinks and water cycle regulation. The region has developed programmes such as the National Forest Financing Fund (FONAFIFO) of Costa Rica, the Protected Areas Conservation Trust of Belize (PACT), the Forestry Incentives Programme of Guatemala and the Certified Forestry Incentives Programme of Panama.
- Include dynamic incentives in fiscal policies, combining regulation with price signals and, in some cases, steps in time that favour economic players, productive processes and sectors whose activities reduce socio-environmental externalities, develop greater water, electricity and hydrocarbon efficiency, and reduce GHG emissions.

Source: ECLAC, CCAD/SICA, UKAID and DANIDA (2011).

3.7 TRADE POLICY [18]

Since the 1960s, when the General Treaty for Central American Economic Integration (TGIEC) was signed, the Central American countries have sought to increase the level of commercial integration of their economies, moving toward a more competitive insertion in international markets and taking advantage of the patterns of commercial and productive complementarity in the markets. The TGIEC had as its fundamental goal to unify the economies of the region and jointly boost the development of Central America in order to improve the quality of life of its inhabitants.

As of the 1990s and once the Protocol to the TGIEC (known as the Guatemala Protocol) was ratified, the region accelerated its progressive incorporation into the general framework of the World Trade Organization (WTO) and became a member in 1995. [19] The context in which the Central American integration process unfolded at the time implies not only the consolidation of a regionalist vision as a platform for the wellbeing of its people, but also a change in the position on trade policy within the countries, with greater emphasis on the opening of markets and insertion into the global economy.

This brought about the creation of Free Trade Agreements (FTAs) with important strategic alliances within the region and with large international players, such as the United States, the European Union, Mexico and Chile. Through this regional policy position, the Central American countries have created legal certainty to their trade relations and third-party investments and have managed to carry out more than 80% of trade in Central America with partners of a signed FTA.

The efforts to penetrate international markets carried out at the regional level have led to a broad portfolio of trading partners for Central America that is based on exports that gradually

[18] This section is a summary of the document titled "International Trade and Climate Change in Central America", created by the Economic Intelligence Board of SIECA, a partner of ECC CARD (SIECA, 2015b).
[19] All the Central American countries ratified their membership at different times in 1995, with the exception of Panama, which joined in 1997. For more information, see: https://www.wto.org/spanish/thewto_s/whatis_s/tif_s/org6_s.htm

become more diversified. Nevertheless, there is a definite need to continue with the efforts to achieve vertical diversification which implies the domestic manufacture of goods with added value, especially related to processing, marketing and other related services (SIECA, 2014).

Almost one third (29.9%) of exports from the region was destined for the intra-regional market, while the remaining 70.1% was destined to foreign markets (SIECA, 2015a). This clearly puts into context the importance of international trade for Central American economies, not just for their relationship with third markets, but also for the intra-regional market whose participation in the total of trade has been dynamic in recent history.

Current circumstances of regional trade policy are developing in a context in which the facilitation of trade corresponds to one of the priority elements in the development of support policies for foreign trade. The Central American Strategy for Facilitation of Trade and Competitiveness with Emphasis on the Coordinated Border Management (CBM), which was approved as part of the follow up to the Trade Facilitation Agreement discussed in the Bali Round during December 2013, is the reference for countries in this particular agenda.

The Council of Ministers for Economic Integration of Central American (COMIECO), aware of the urgency of improving performance in the management of trade procedures in the current era, approved the Central American Strategy for Facilitation of Trade and Competitiveness with Emphasis on the CBM in October 2015. The aim of the CBM model is to promote coordination between public and private sector agencies to improve collection, control and border security, and to facilitate the transit of goods and people, all within a framework of effective control and efficient use of resources.

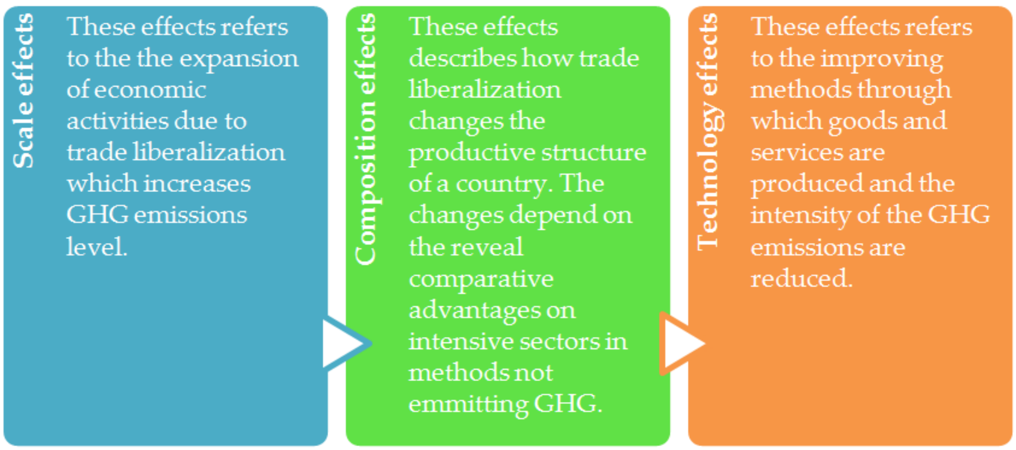
International trade, as with all human activity related to production, has a direct impact on GHG emissions, and at the same time, emissions reduction policies have consequence on the trade performance of countries (UNCTAD, 2015). According to the WTO/UNEP, there are three channels by which opening of trade affects GHG emission levels: effects of scale, of composition and technological (see Figure 2).

The effects of scale basically arise from the growth of trade activity in the region, which increased from $130.5 million in 1960 to $101.6194 billion in 2015. The increase in the exchange of goods in Central America brings with it an increase in the volume of economic activity and with that, changes in the emission of polluting gases.

The effects of composition are related to the form in which international trade in Central America has changed the regional productive structure. Nearing 2014, 44% of the total exports of the region were consumer goods, and 52% were intermediate goods, while 28% of imports were consumer goods and 58% were intermediate goods. The prevalence of intermediate goods in the composition of the supply and demand for goods in Central America needs a comprehensive analysis of the comparative advantages in each sector and its intensity of GHG emissions.

Finally, the technological effects of trade on the emissions of contaminating gases correspond to a set of intangible externalities that nevertheless have important implications on the final composition of the goods. The internationalization of productive processes through the insertion in global value chains (GVCs) allows economies to participate in different parts of the chain related to production, commercialization, distribution or customer service. Through greater insertion in GVCs that intensively use environmentally-friendly technologies, Central American countries have the opportunity to create capacities for the development of new production methods that allow for the reduction of emission intensity, thus limiting the carbon, water and environmental footprints of regional exports.

FIGURE 2
EFFECTS OF INTERNATIONAL TRADE IN CLIMATE CHANGE



Source: SIECA (2015b), WTO/UNEP (2009).

The facilitation of trade and the transition to environmentally sustainable economies correspond to two lines of action that stipulate concrete measures to mitigate the impact of trade activity on the environment while promoting competitive insertion into international markets.

The facilitation of trade encompasses all the aspects and factors that speed up and facilitate trade flows through the simplification and standardization of document, procedures and information flows related to international trade (Echeverría, 2007).

Current shortfalls in management in border countries is one of the factors that most affects logistical performance in Central America. It is estimated that the combined cost of the shortfalls in border management increases the final price of products in the region by up to 12% (COMIECO, 2015). The increase in product price in intra-regional trade could lead to basic food products being inaccessible for the most vulnerable segments of the population.

Furthermore, the obstacles and bottlenecks present in the transit of goods over land mean an increase in the impact that transport services have on GHG emissions. According to the IPCC, in 2010, transport services accounted for 14% of GHG emissions, as international trade is one of the main areas in need of these services. Speeding up the movement of goods by land transport and diversifying the forms of transport of goods would not only reduce the final cost of the goods, thus providing greater access to the population, but would also minimize the collateral effects of transport on the environment.

Through concrete measures to facilitate trade, Central American countries can ensure greater agility in the flow of goods that are important for food and nutritional security (FSN), and can have smaller impacts on the transportation costs matrix associated with the movement of goods.

Similarly, the transition to environmentally sustainable economies involves a mix of policies, regulations and institutions that allow for an evolution toward environmentally-friendly productive activities and consumption patterns, and that ensure dignified conditions for future generations.

The trade policy of a nation tends to respond to changes in the consumption patterns of its trade partners and the Revealed Comparative Advantage (RCA) for individual industrial sectors. In Central America, the RCAs traditionally identified lie in agro-exports, the textile and clothes making industry, the assembly of electronic components and tourism. However, the promotion of new productive structures that are environmentally friendly would satisfy the increasingly high standards for quality of Central American trade partners, allowing for a diversification of the portfolio of partners in the region and facilitating the insertion of goods into the GVCs.

This insertion in the GVCs as a consequence of modification to structures and forms of production would allow the region to improve its levels of competitiveness, increase its market share in goods, and, finally, decrease the regional contribution to GHG emissions. Additionally, sustainable and environmentally-friendly Central American products are a market opportunity for the region. Central America products and services can stand out in the world and compete in segments of the market and links of GVCs that create greater added value for internal economies.

Is it necessary to further consider that the transition toward sustainable productive structures that allow for the migration toward products and services that have a smaller impact on the environment can be considered an implicit requirement for entry into high-income markets, whose sense of responsibility and worry for the future of the planet leads them to demand more rigorous production and environmental standards given the current circumstances of climate change.

To create the right conditions for this transformation, Central America should have comprehensive policies and reforms that manage to combine economic incentives tied to new green industries with a robust regulatory framework that controls and ensures compliance with the standards that ensure the required changes.

Technology transfer is another transversal component that would facilitate the design of trade policy actions that support the transition to sustainable production. The intensive use of appropriate technologies will allow for an evolution to goods and services production systems that are more in line with the reality of global warming, thus reducing the GHG footprint resulting from trade activities.

Finally, the development of sectoral FSN policies is essential for ensuring the availability of foods in Central America, as it is a region exposed to the impacts of climate phenomena on harvests and the productivity of the cultivation of mostly basic grains, the effects of which are magnified for socially vulnerable populations. The link between regional FSN and the dynamics of foreign trade is a close one due to the increasing efforts to open markets to different trade partners by the Central American countries, which has modified food supply and demand.

Actions are required at the regional level to promote these meta objectives by making use of regional cooperation as a platform in order to disseminate successful experiences in Central American countries and jointly carry out programmes to facilitate addressing identified problems in a regional manner.

BOX 12
RECOMMENDATIONS FOR TRADE POLICY

The following are some strategic actions that could be carried out from the regional perspective:

Facilitation of trade:

- Implement the Central American Strategy for the Facilitation of Trade and Competitiveness with emphasis on the CBM approved by the COMIECO, which will allow for the reduction of costs associated with intra- and extra-regional trade, improving the competitiveness of Central American exports and speeding up the movement of goods. Given that the number of micro, small and medium-sized businesses (MIPYME) in the region is significant, reforms of this type allow for an increase in potential to face an ambitious integration in the intra-regional market, taking advantage of the geographical closeness. Since this strategy includes the CBM, it can include adaptation to sanitary and phytosanitary control procedures of goods linked with FSN to ensure the quick transit of these goods through border crossings in the region.
- **Adapt the safeguard mechanisms of the FTAs**: the safeguard mechanisms established in the FTAs allow countries to modify import tariffs during times of contingencies associated with national security. Despite being a useful mechanism that has the potential to address food crises, the procedures to unilaterally activate the mechanism can require a period of time that will not work in critical situations. Making adaptation to national approval mechanisms for safeguards would improve the response capacity of the region in such situations.
- Diversify the modes of transport for goods: the deficits in road infrastructure in the region, combined with the complexity of border crossing procedures, place a heavy burden on transport systems and international goods transit systems, thus increasing the costs of trade and the impact of transport services on the environment. Diversifying the modes of transport for goods by making use of short-distance maritime routes for intra-regional trade represent an opportunity to improve performance. When measured by grams of CO_2 per ton/kilometre, air transport and land transport using trucks emit more than maritime transport, which is more efficient (ECLAC, 2013). Investment in port infrastructure is required according to the needs for regional trade and the positioning of the region as a logistical hub.

Sustainable productive transformation:

- **Certification of exports based on GHG emissions and/or environmental footprint:** Certification verifies the sustainable nature of the productive process of the origin of the inputs used in the making of the final good, becoming a seal of approval that a person other than the producer or consumer can provide to validate certain characteristics of the final product to be sold. Although there are already environmental footprint and carbon-neutral certification programmes at the national level, primarily for individual businesses, the reach of these programmes needs to be expanded in order to improve accountability of the footprints of the exported products. This is an opportunity to innovate, reach greater energy efficiency, diversify and add value, and gain international competitiveness (ECLAC, 2013).

- **Standardize or coordinate methodologies for the measurement of footprints:** The certification of exports could have a greater impact on markets if a standardized methodology at the regional level is established. This could be used to develop a regional brand.

- **Build capacities to identify GHG emission and environmental footprints, prioritizing the main exports and products oriented to specialized markets:** The correlation between the development of international trade in Central America and the intensity of GHG emissions should be studied to clearly understand the ideal framework of policies to balance the needed insertion into international markets with the protection of the environment and the reduction of damages to the environment and GHG emissions.

- **Supporting trade regulations:** The Central American technical regulations that govern labelling, safety and quality of products for intra-regional trade are the ideal regulations to provide support to the efforts to move toward processes that are less GHG-emission intensive. The adaptation and creation of regulations that support the efforts to certify GHG or environmental footprints and social responsibility is a regional opportunity to position the intra-regional market as a platform for fair and sustainable trade.

- **Strengthening of sustainable value chains:** regional value chains (RVCs) are the set of production, commercialization and distribution activities of goods and services, in which two or more economies participate directly in the links of the chain, with cross-border interaction in one or more stages of the complete chain. Through programmes for technical assistance, research and socialization of best practices, the chains can be strengthened in their adaption to climate change and their environmental sustainability.

Source: SIECA (2015b).

4. CONCLUSIONS

Central America is one of the regions of the world most exposed to climate phenomenon. Its societies and ecosystems are particularly vulnerable to the adverse effects of climate change, with evidence of many of the characteristics of vulnerability identified in the United Nations Framework Convention on Climate Change. In Chapter 27 of its Fifth Report, the IPCC reported a wide range of climate effects on Central America, including changes in temperature and sea level, coral bleaching, delays in the start of the rainy season and greater irregularity in, and intensity of, rainfall. The report also considered scenarios involving changes in hydrological conditions, temperature increases, food production and security, hydroelectricity and health (Magrin and others, 2014). In its previous SREX report, the IPCC had reported that there was medium confidence that anthropogenic influences had contributed to the intensification of extreme precipitation at the global scale, and to drought in some regions, including Central America, due to decreases in rainfall and/or increases in evapotranspiration (IPCC, 2011).

Climate change is also exacerbating socioeconomic vulnerabilities in Central America and will increasingly affect its economic progress, given that factors that depend on the climate are very important to production activities such as agriculture and generation of hydroelectric power. At the same time, it is estimated that Central America produces only a minimal portion of global greenhouse gas (GHG) emissions: less than 0.3% of emissions without land-use change, and less than 0.8% of net total emissions (ECLAC, CCAD/SICA, UKAID and DANIDA, 2011).

Climate change could be considered a phenomenon that will only have an effect in the distant future. The pressure of existing social and economic issues as well as budgetary constraints could be used as arguments for postponing the implementation of much-needed measures. However, the growing impacts of extreme events, such as Tropical Depression 12-E in 2011 and the intensification of drought conditions in recent years, demonstrate the need to break the vicious cycle of the cumulative effect of losses and damages and of the reproduction of vulnerabilities to climate events in post-disaster reconstruction.

Significant measures are required in order for this reconstruction and for public investment to be undertaken differently than in the past. Incentives and requirements need to be established for to vulnerability reduction and adaption to both current climate variability and estimates for climate change in the coming future. These measures can include integrating programmes for improved housing, human settlements, infrastructure and equipment with criteria for preventing disasters into poverty-reduction strategies; establishing laws, programmes and incentives for the design and renovation of housing and settlements that are adapted to local climatic and extreme events conditions and efficient in the use of water; reforest coastal areas, hillsides and areas prone to landslides; adopt the lines of action proposed in the Sendai Framework for the Reduction of Risk of Disasters (2015-2030) in order to promote a culture of prevention and disaster-risk reduction; and further develop national policies on this topic and incorporate them in national development plans and in sectoral strategies, plans and projects.

In many ways, the key indicators of adaptation are related to water: equitable access to this resource and greater efficiency of its use. Central American societies need to become wise and bold managers of their water resources, distributing it judiciously amongst multiple demands. This effort is extremely important for improving the quality of life of the population and for protecting forests and other ecosystems. The conservation of forests and the restoration of rural landscapes are essential for the management of river basins, for reducing erosion, landslides and floods, and for the production of hydroelectric power. Extensive efforts are required to make more efficient use of water, reduce its contamination and recycle it in the domestic, agriculture, industrial and services sectors. Given that transnational river basins cover 40% of the territory of Central America, one of the complex challenges that the region faces is creating an effective transnational institutional framework for the sector and its management.

Protecting food security in the face of climate change, especially access to basic grains, and making the transition to more sustainable and inclusive agriculture is a major challenge that cannot be put off if rural and urban people living in poverty are to be protected. With a few notable exceptions, most countries have experienced a decapitalization of the rural economy and the dismantling of programmes for land titling, outreach, post-harvest loss reduction, and improving market access and capacity building. Greater attention must be paid to improving the quality of life in rural areas and to supporting the production and value chains of basic grains and other foods, the reduction of post-harvest losses, the protection and promotion of native varieties and local, indigenous and national capacities, which are underappreciated sources of resilience and adaptation to climate change.

The response to climate change in the agricultural sector will need to be closely coordinated with policies aimed at reducing deforestation, protecting biodiversity and managing water resources. Due to the complementarity of production and the intra-regional trade of food, there is an opportunity to improve the resilience of the region to food emergencies by the coordination of actions through the integration system. At the farm and local level, opportunities exist to diversify and strengthen sources of income for producer families with an orientation towards sustainability, including payment for environmental services provided by their sustainable management of river basins and forests, harvesting of non-timber products, GHG emission reduction bonds, cultivation and processing of organic products, such as organic shade-grown coffee, for "green" markets and domestic and international fair trade mechanisms. Credit and incentives could be created that support adaptive and sustainable production in the face of climate change, including measures to improve the efficiency of water use and reduce the use of inputs that emit GHGs and other pollutants. Agricultural insurance and other risk management instruments could be strengthened and funds for contingencies and risk reduction increased.

The adaptation of human beings to climate change is clearly linked to the adaptation of the ecosystems on which they depend. Meeting this challenge will require further valuation of environmental services and taking non-market measures to create appropriate incentives and regulatory frameworks. It is necessary to apply the precautionary principle and establish minimum standards, considering the irreversibility of biological loss, the risk and the uncertainty. Reducing deforestation and degradation and restoring rural landscapes will generate benefits in many aspects of the development agenda per se, even without considering climate change. It is advisable to expand and strengthen the system of Protected Natural Areas (of which there are more than 550 in the region) and of biological corridors, so as to cover broader bio-geographical areas and to broaden the definitions of protected areas and climate “refuges”. It would be beneficial to link these conservation measures with ones aimed at improving the wellbeing of the populations that live in or depend on these ecosystems. Some examples measures with such cobenefits include the use of efficient wood stoves, access to electricity and payment for environmental services. It is becoming increasingly necessary to create heightened social awareness regarding the functions of ecosystems and how the wellbeing of human populations depends on them.

These efforts can be complemented with programs relating to agriculture, the sustainable use of forests and the protection of local crop and endemic wild varieties that are resistant to anticipated climate effects. The adaptation of forests and rural populations could be supported with programmes that strengthen the capacities of communities to conserve and regenerate the ecosystems with which they coexist. This includes adopting appropriate technologies for sustainable livelihoods; taking advantage of traditional knowledge and diversifying sources of livelihood; improving forest management systems, including the monitoring of deforestation, forest fires, afforestation and reforestation; and establishing and promoting regulations and certifications of organic products and of ecotourism.

It is advisable to expand and make operational fiscal and financial policies that provide incentives for the transition to higher energy and water efficiency, sustainable forest management and the internalization of the economic value of environmental services, including carbon sinks and water cycle regulation. The region has developed programmes such as the National Forest Financing Fund (FONAFIFO) in Costa Rica, the Protected Areas Conservation Trust in Belize (PACT), the Certified Forestry Incentives Programme in Panama, and the Forestry Incentive Programme (PINFOR) and the Smallholder Forestry and Agro Forestry Vocation Incentive Programme (PINEP) both in Guatemala.

Recently, the governments of the region have begun a concerted effort, with technical, policy and social dimensions to restore rural landscapes in the framework of REDD+. Costa Rica has a National Strategy for the Reduction of Deforestation and Forest Degradation Emissions (REDD+ strategy), while El Salvador has a National Program for Restoration of Ecosystems and Rural Landscapes (PREP) and has begun a project for the Preparation for the Reduction of Deforestation and Forest Degradation Emissions (REDD+). In Honduras, the REDD+ project (2014-2017) involves actions to help the country develop a national strategy to reduce deforestation. Nicaragua is implementing the ENDEREDD+ Project. Guatemala and Panama have declared their willingness to carry out projects under the framework of REDD+ at international forums.

Environmental land-use management is essential in order to achieve sustainable development and to improve the distribution of the population, its activities and infrastructure so as to reduce the significant damages and losses resulting from cumulative extreme events and climate change. Natural ecosystems can reduce the vulnerability of a population to extreme weather events and can serve as complements or substitutes for investment in "grey" infrastructure, which can have higher costs. For example, forests and coastal mangroves provide protection against storms, floods, hurricanes and tsunamis.

The region is highly dependent on imported fossil fuels with extensive pollution effects. The transition to an energy matrix based on local and renewable sources could improve energy security, save foreign currency reserves and reduce the adverse effects of fossil fuel consumption. A new action matrix could be developed outlining national and regional priorities at the national and regional levels and referencing the SDGs and the results of the COP21. The current energy matrix and scenarios which consider the potential impacts of climate change could contribute to baselines for NAMAs to better consider the risks regarding potential contributions to GHG emissions reductions of the sector.

A well-designed expansion of hydroelectric power generation based on sustainability and inclusion principles could provide people living in poverty with greater access to electricity and contribute to the social and sustainable productive development of populations living in the areas surrounding the power plants. There are opportunities to improve energy efficiency and reduce the intensity of GHG emissions and other contaminants with new norms and measures for vehicles, industrial and domestic machinery and equipment. More appropriate waste management could generate multiple benefits such as reduced pollution, increased raw material for production, power generation through methane capture at landfills and better drainage of water during extreme hydro-meteorological events. Important opportunities exist to develop sustainable infrastructure systems, such as rapid urban transport systems to provide the population with a safe, quick, modern, clean and high-quality service, and with co benefits in improved health, productivity, equality and social cohesion. This investment might be linked to changes in the relative prices of fuels and of automobiles, so that negative externalities are internalized.

The Central American region is vulnerable to a number of climate-sensitive illnesses, including vector-transmitted diseases (VTDs) such as dengue, Chagas, leishmaniasis, climate-sensitive zoonoses, such as leptospirosis, acute respiratory infections (AFIs), acute diarrhoeal diseases (ADDs) and illnesses caused by atmospheric pollutants and the impact of climate on food security and nutrition. Thus, a regional initiative to analyse the diverse impacts of climate change on health would be very useful. This initiative could coordinate research teams in various disciplines and establish partnerships with different sectors. The estimates of climate change models and the different elements of ENSO should be analysed with data from strengthened epidemiological information systems to generate prognostic tools and other evidence for national and regional public policies.

Technological change is an essential component of climate change adaptation and the transition to environmentally sustainable economies, both in terms of accessing modern technology and recuperating and using traditional and local knowledge and technologies, especially those of indigenous peoples and rural communities. It is recommended that an intersectoral work programme to generate better evidence for climate change policies be created between national and regional institutions for education and science, technology and innovation. Partnerships between universities, research centres, businesses, civil organization, volunteers and the United Nations could be strengthened. Since the climate is a global public good and the risk associated with climate change is high, access to adaptation and mitigation technology needs to be negotiated within a "special" or "exceptional" agreement of the WTO conventions for developing countries.

The Council of Ministers of Finance/Treasury of Central America, Panama and the Dominican Republic (COSEFIN) has given attention to climate change. The region has experience in swapping debt for climate change programme financing and with budget line "labelling" systems in order to identify investment in adaptation. Proposals have been prepared for national funds for climate change, domestic carbon markets, catastrophe insurance plans, disaster contingency funds and investment in infrastructure adaptation. However, further strengthening of the capacity to design fiscal sustainability policies that reduce climate risks and provide incentives for robust and sustainable infrastructure and production is required. New standards for investment projects need to be developed and applied, and guidelines and training need to be provided for the development of sectoral programmes and budgets. Programmes for insurance and comprehensive risk management are required at the level of the whole public budget and for producers in key sectors, such as agriculture. National mechanisms for the preparation of projects and the administration of international climate financing need to be designed and accredited.

Climate change can lead to both trade risks and opportunities for the region. Other countries could implement compensatory measures, such as a tax on the carbon content of imported goods or payments for GHG emission rights resulting from production, transportation and other stages of the life cycle of exports from the region. Other measures could include higher tariffs or carbon taxes on international transportation. These measures could imply greater costs for exports and a loss of competitiveness due to the energy intensity or carbon content of their productive processes and transportation.

At the same time, this trend could bring trade opportunities if relatively clean and low-carbon production systems are developed and/or if smaller distances to market can reduce the emissions associated with transportation. There are important efforts being made to expand the capacity of the region in this type of production, but programmes to measure the water and carbon content and the ecological footprint of exports are urgently needed, in order to benefit from the growing market for such products; benefits would be especially effective if they accrued to producers who are currently live in poverty.

In this regard, Central American trade policy could benefit from implementing the Central American Strategy for the Facilitation of Trade and Competitiveness with an emphasis on the Coordinated Management of Borders (CBM), adapting the safeguard mechanisms of FTAs to modify import tariffs when the importing country finds itself in a situation of food insecurity, and diversifying the modes of transport of goods by using short maritime routes for intra-regional trade to improve performance and reduce emissions. Nevertheless, such a trade strategy requires a transformation in production towards greater sustainability, that would require technological changes and certification of exports based on GHG emissions and/or environmental footprint, technical regulations for labelling standards, safety and quality of the products for intraregional trade and the strengthening of sustainable value chains.

Proactively addressing the challenge of extreme events and climate variability and change is of utmost importance. If this is not done, the current generation will suffer greater losses and damages due to extreme events, and future generations will bear a very high cost of adapting to climate change. The region has developed diverse evidence of the multiple effects of climate variability and the potential impacts of climate change on various sectors. This analysis suggests that the costs of inaction in the face of extreme events and the cost of the impacts of climate change at "present day" values are too high for immediate and ambitious measures not to be taken. Since climate change involves a market failure, it cannot be treated as the exclusive responsibility of environmental institutions. Rather, it should be seen as a central economic threat with serious fiscal implications. Climate change presents a series of multisectoral challenges that need to be tackled jointly by diverse stakeholders, including the public and private sectors, citizens and civil society organizations, academia, integration institutions and the international community.

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ACRONYMS AND ABREVIATIONS

AAGR	Average Annual Growth Rate
ACE	Attribution of Climate-related Events
ADDs	Acute Diarrheal Diseases
AEA	Energy and Environment alliance of Central America
ARI	Acute respiratory infections
ARI	Acute Respiratory Infection
BCIE	Central American Bank for Economic Integration
BI	Bultó-Index
BI	Bultó-Index
BPI	Biodiversity Potential Index
CAC	Central American Agricultural Council
CATIE	Tropical Agricultural Research and Higher Education Center
CBM	Coordinated Border Management
CCAD	Central American Commission for Environment and Development
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CCSI	Climate Change Severity Index
CDEEE	Dominican Corporation of State Electrical Companies
CDM	Clean Development Mechanism
CEAC	Central American Electrification Council
CEL	Executive Hydroelectric Commission of Rio Lempa
CEPREDENAC	Coordination Centre for the Prevention of Natural Disasters in Central America
CIAT	International Center for Tropical Agriculture
CICAFE	Coffee Research Center, Costa Rica
CIMHAC	Central America Centre for Meteorological and Hydrological Integration
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	French Agricultural Research Centre for International Development
CNE	National Energy Council, El Salvador/Dominican Republic
COMIECO	Council of Ministers for Economic Integration of Central American
COMISCA	Council of Ministers of Health of Central America

COSEFIN	Council of Ministers of Finance/Treasury of Central America and Dominic Republic
COTEVISI	Technical Commission on Surveillance in Health and Information Systems
CRED	Centre for Research on the Epidemiology of Disasters
CRRH	Regional Committee on Hydraulic Resources
CSA	Climate-Smart Agriculture
CSC	Central America Dry Corridor
CUT	Land-use change
DANIDA	Danish International Development Agency
DFID	UK Department for International Development
ECADERT	Central American Strategy for Rural Territorial Development
ECAGIRH	Central American Strategy for the Integrated Management of Water Resources
ECC CA	The Economics of Climate Change in Central America
ECLAC	Economic Commission for Latin America and the Caribbean
EESCA	Central American Sustainable Energy Strategy
EM-DAT	Emergency Events Database
ENCC	National Climate Change Strategy, Costa Rica / Honduras
ENCCP	National Climate Change Strategy of Panama
ENDE	National Strategy for Avoided Deforestation, Nicaragua
ENSO	El Niño Southern Oscillation
ERAM	Regional Environmental Framework Strategy
ERAS	Regional Agro-environmental and Health Strategy
ERCC	Regional Climate Change Strategy
ER-PIN	Emission Reductions Program Idea Note
FAO	Food and Agriculture Organization of the United Nations
FAR	Fractional Attributable Risk
FCAC	Central America Climate Forum
FCPF	Forest Carbon Partnership Facility
FEWSNET	Famine Early Warning Systems Network
FNS	Food and Nutrition Security
FOCARD-APS	Forum on Potable Water and Sanitation of Central America and the Dominican Republic
FONAFIFO	National Forest Financing Fund, Costa Rica
FTA	Free Trade Agreements
GHG	Greenhouse Gas
GIZ	German Agency for International Cooperation
GLOBIO3	Global Biodiversity Model

GMI	Gorgas Memorial Institute for Health Studies
GTCCGIR	Technical Group on Climate Change and Integrated Risk Management
GVCs	Global Value Chains
HLZ	Holdridge Life Zones
HURDAT	Atlantic hurricane database
IBP	Potential Biodiversity Index
ICO	International Coffee Organization
IDB	Inter-American Development Bank
IFAD	International Fund for Agricultural Development
IMN	National Meteorological Institute, Costa Rica
INDINF	Mosquito Infestation Index
INSMET	Cuban Institute of Meteorology
INSP	National Institute of Public Health of Mexico
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
JICA	International Cooperation Agency of Japan
LEAP	Long Range Energy Alternatives Planning System
MA	Malaria
MAG	Ministry of Agriculture and Livestock , Costa Rica/ El Salvador
MAGA	Ministry of Agriculture, Livestock and Food and the Ministry of Guatemala
MAGFOR	Ministry of Agriculture, Livestock and Forestry, Nicaragua
MARENA	Ministry of Environment and Natural Resources, Nicaragua
MARN	Ministry of Environment and Natural Resources, Guatemala
masl	Metres above sea level
MbA	Mitigation based on Adaptation
MEI	Multivariate ENSO Index
MER	Regional Electricity Market
MIDA	Agricultural Development Ministry, Panama
MINAE	Ministry of Environment and Energy, Costa Rica
MINFIN	Ministry of Public Finance, Guatemala
MINSA	Ministry of Health, Costa Rica
MIPYME	Micro, Small and Medium Businesses
MSA	Mean Species Abundance
NAMA	Nationally Appropriate Mitigation Actions
NCAR	National Center for Atmospheric Research
NDF	Nordic Development Fund

NOAA	National Oceanic and Atmospheric Administration
OLADE	Latin American Energy Organization
PACA	Central American Agricultural Policy
PACAGIRH	Central American Action Plan for the Integrated Management of Water Resources
PACT	Protected Areas Conservation Trust, Belize
PAHO	Pan American Health Organization
PCGIR	Central American Policy for Integrated Risk Management
PEGIRH	State Policy for Integrated Risk Management, Honduras
PERFOR	Regional Strategic Program for Forest Ecosystem Management
PINEP	Smallholder Forestry and Agroforestry Vocation Incentive Programme, Guatemala
PINFOR	Forest Incentive Programme, Guatemala
PNCC	National Climate Change Plan, Guatemala
PNESER	National Sustainable Electrification and Renewable Energy Program, Nicaragua
POLSAN	Food and Nutritional Security Policy for Central America and Dominican Republic
POR-FRUTAS	Regional Policy for Fruticulture Development
PREP	National Program for Restoration of Ecosystems and Rural Landscapes, El Salvador
RAAN	North Atlantic Autonomous Region, Nicaragua
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RTC	Regional Technical Committee
SAT	Superintendency of Tax Administration, Guatemala
SDGs	Sustainable Development Goals
SICA	Central American Integration System
SIECA	Secretariat for Central American Economic Integration
SIEPAC	Central American Electrical Interconnection System
SIINSAN	National Food and Nutrition Security Information System
SNE	National Energy Secretariat, Panama
SREX	Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SWH	Significant Wave Height
UKAID	United Kingdom Department of International Development
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
UTSAN	Technical Assistance for the Food and Nutrition Security Technical Unit
VBDs	Vector-Borne Diseases
WCRP	World Climate Research Programme
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

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