

# The Economics of Climate Change in Central America

## Interim Report – Executive Report<sup>1</sup>

### Key Messages

*The seven countries of Central America will be seriously affected by climate change. They are highly vulnerable to this process given their geoclimatic exposure that produces a high variability in precipitation and high vulnerability to extreme events even in the absence of climate change. In addition the region exhibits serious socio-economic and environmental vulnerability linked to a long term pattern of development* which is characterized by more than half of the population living in poverty; problems of access to food and potable water; insufficiencies in the coverage of healthcare, education, social security and in access to capital and productive credit, as well as their economies' exposure to global economic conditions. In the political sphere, the region has moved beyond past decades of armed conflict and has established electoral democracies, but continues to face tasks related to the consolidation of democracy and the development of citizen participation.

At the same time, *Central America has valuable treasures that must be preserved for their contribution to development today and for future generations.* These treasures include ecosystems rich in biodiversity, such as forests, coral reefs and mangroves, among others, all of which provide the population with multiple services. These ecosystems are already experiencing the ravages of the existing, unsustainable pattern of development and will be further affected by climate change. These countries' relatively young population is also regarded as a treasure, given their cultural, ethnic and linguistic and life-style diversities. Investment is need in these treasures, even more so due to climate change, to protect the ecosystems and permit the human population develop their potential and respect their diversity, including local communities and indigenous peoples.

The IPCC Fourth Assessment Report establishes that the rise in median atmospheric and oceanic temperatures, declining ice and permafrost coverage and rising median sea levels are unequivocal evidence that the climate system is warming. There is a 90% degree of certainty that global warming in the 20th century is due to the observed increase in anthropogenic greenhouse gas concentrations.

The Central American Isthmus has experienced in recent years higher levels of climatic variability. Recent decades have witnessed significant changes in precipitation and a rise in median surface temperatures. There has been a trend toward declining precipitation especially in western Central America, and temperatures have risen by between 0.7 °C and 1°C. The principal climatological events that affect the region,

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<sup>1</sup> Document whose circulation is limited and for the use of the Steering Committee of Central American Environment and Treasury Ministers (SC), the Regional Technical Committee (RTC), ECLAC, and project teams. Revision 1 based on comments from the Ministers of the Environment, RTC and negotiators. It does not necessarily represent the positions of any of the governments or institutions involved.

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hurricanes and floods, have almost doubled in frequency in the past two decades and they have grown more intense. The climate will increasingly affect the region's economic and environmental evolution and will largely determine its development during the current century.

In the context of Central American initiatives for developing a strategy to deal with climate change, the project "The Economics of Climate Change in Central America" is being carried out by the Ministries of Environment and Treasury of the seven countries, the Central American Development and Environment Commission of the Central American Integration System (CCAD/SICA), the Economic Integration System of Central America (SIECA) and the Economic Commission for Latin America and the Caribbean (ECLAC). The national and regional institutions have a mandate to carry out economic studies on climate change from the Central American Presidential Climate Change Summit Declaration of 2008. The project seeks to alert decision makers and key actors in the region, especially those in the economic and social spheres, about the urgency of confronting the phenomena, and to promote dialogue regarding national and regional policy options and potential actions. Its specific aim is to conduct an economic assessment of the effects of climate change in Central America based on various developmental scenarios and emissions trends relative to the potential costs and benefits of either a lack of response (i.e. a business-as-usual approach) or public-policy adaptation and mitigation options for preventing, reducing and limiting adverse impacts.

The project is part of a global network of national and regional studies on the economics of climate change. This initiative was motivated by the Stern Report of 2007 which made a global economic assessment of this phenomenon and found that the costs of inaction will be higher than those of taking early and proactive measures to mitigate global emissions of GHGs. This global network and the regional Latin American network, including regional experts and members of the IPCC, have developed methodological guidelines to adapt the analysis to the national and regional scales and to the situation of developing countries.

Recognizing that climate change will have multiple impacts, the Central American study covers economic sectors, such as agriculture and energy, as well as other key fields of impact, such as water resources, extreme events, poverty and vulnerable populations, health, marine-coastal areas, biodiversity and ecosystems. It aims to identify the direct impacts in these sectors and make an economic assessment of these impacts to the extent possible. These components are in different phases of execution and some are programmed to begin in early 2010. For this reason, the results herein reported are preliminary and subject to revision. This interim report was prepared upon request of the Protempore President of the Central American Environmental Ministers' Council.

It is important to recognize the considerable uncertainty involved considering the long term nature of the future scenarios developed and the need to integrate diverse "levels" of analysis, including the climate and macroeconomic "business as usual" scenarios, the impact studies for different sectors and areas of concern, and their economic costing. In this respect, it is important to consider these results in terms of their tendency and magnitudes, not as precise figures. In addition, each "level" and area of analysis have different methodological challenges and the potential feedbacks between sectors and fields of analysis are yet to be explored. The project will also explore options for adaptation, mitigation and the transition to low carbon economies, whose respective

advantages and disadvantages could vary between countries and depending on the international agreements yet to be made. Precisely due to this varying and uncertain context, the project aims to provide a diverse analysis no necessarily tied to the position of one country in particular.

Even so, the initial results presented in this document suggest various fundamental issues: first, that the effects of climate change in Central America under a scenario of growing emissions and global inaction, IPCC scenario type A2, are significant and will grow over time, with a certain degree of heterogeneity at the country level. Second, that the cost of global inaction, particularly of high emitting countries, is greater than that of an equitable and inclusive international accord that significantly reduces global emissions and recognizes the shared, albeit differentiated responsibilities of each country, and in which developing countries are supported in adopting adaptation and voluntary mitigation measures in a framework of sustainable development. From an economic viewpoint, it is more efficient to take action than to leave the problem to future generations, even before considering the ethical implications of such an attitude. Third, the results confirm that climate change is the greatest market error ever experienced because we have not been able to internalize in the economy the value of the climate as a global public good or that of many social and environmental impacts from climate change. Beyond the work of economic assessment, ethical decisions are required relative to the multiple inequities implicit in the differentiated responsibilities for historic accumulated emissions, and the differentiated impacts, with the populations that least contributed to the problem suffering most. Another required decision regards the value that we assign to the needs of future generations and the ecosystems upon which we depend for vital services, and which we could all too easily lose before the economy sends appropriate signals.

The results of this initial phase of the study indicate:

**Temperature<sup>2</sup>:** Under scenario B2 through the year 2020, the countries of Central America could register an increase in the median annual temperature ranging from 0.2 °C to 0.7 °C above the average observed between the years 1980 and 1999. Through 2050, the figures could be between 1.2 °C to 1.6 °C. To 2100, the anomaly would range from 1.9 °C to 3.7 °C. The **average** of the three applied models projects an average increase of 2.2 °C to 2.7 °C by country with a regional average of 2.5 °C. The IPCC estimates that with B2, the global temperature could rise between 1.4 °C to 3.8 °C with a best estimate of 2.4 °C for 2090-2099 relative to 1980-1999. The regional results would appear to be compatible with these global ones.

Under scenario A2 to 2020, the countries of the region would experience increases in median annual **temperatures** of between 0.4°C and 0.9 °C, a range of 1.4 °C and 2.3 °C to 2050, and 3.4 °C to 5.2 °C through 2100, considering each model separately and above the average observed between 1980 and 1999. The **average** of the three applied models anticipates by 2100 an average variation range of between 3.6 °C and 4.7 °C per

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<sup>2</sup> The Intergovernmental Panel on Climate Change (IPCC) has established four families of scenarios and developmental storylines. This study recommends the use of scenarios A2 and B2 and four general circulation models, three of which are used for the reported average. See Section II for more information.

country, and a regional average of 4.2 °C. The IPCC estimates that with A2, the global temperature could rise between 2.0 °C to 5.4 °C with a best estimate of 3.4 °C for 2090-2099 relative to 1980-1999. The regional results would appear to be above those expected at the global level.

**Precipitation.** There is even greater uncertainty as to the trajectory of precipitation levels. Under global emissions scenario B2 using the average of three models, by 2100 precipitation could fall by 3% in Panama, 7% in Guatemala, between 11% and 13% in Costa Rica, Belize, El Salvador and Honduras, and 18% in Nicaragua. An average 11% reduction is expected for the region. Scenario A2 at 2100 indicates possible reductions in precipitation of 6% in Panama, of 14% in Nicaragua and between 19% and 23% in Costa Rica, Belize, El Salvador, Guatemala and Honduras. For the region precipitation is expected to fall by 18% on average.

#### **Business-as-usual (BAU) trend scenarios 2008 to 2100:**

**Population.** Demographic projections from CELADE indicate that the population of Central America will grow from 38 million in 2005 to 50 million in 2020, 68 million in 2050 and could peak at 73 million in 2075, before gradually receding to 69 million in 2100. The age structure would change toward a pyramid with a larger percentage consisting of adults over 60 years of age. The pace of that transition would vary by country with the fastest variation in Costa Rica and Panama. Guatemala would have the greatest percentage of youth during the 21<sup>st</sup> century.

**Economy.** The project prepared a macroeconomic baseline scenario without climate change in which economic growth would be relatively stable and remain within the ranges observed over the past two decades with a greater degree of ties with the global economy and rates of investment similar to those registered between 1990 and 2008. Annual GDP growth by country in this “business as usual” (BAU) scenario to 2100 is estimated for Belize at 3.6%, Costa Rica 3.1%, El Salvador, Guatemala and Honduras 3.2%, Nicaragua 3.1% and Panama 3.5% with a 60% probability within the framework of the macroeconomic analyses carried out.

**Land-use change.** This baseline land-use-change scenario without climate change used an average of three GEO 4 scenarios with the International Futures model. The results suggest that between 2005 and 2100 the region will lose a third of its forests and 80% of pasture land, savannah and scrub, a loss largely explained by an approximately 50% expansion of the amount of land dedicated to crops and livestock. Almost all of that change would occur by 2050, with a risk of losing an estimated 1010 Mton of total carbon stock in the region, equivalent to 30% of the stock estimated for 2005.

#### **Climate change effects to 2100 in initial sectors/areas of concern studied:**

**Water resources.** In the baseline scenario without climate change, currently under development, initial estimates suggest that demand for water in the region will grow at an average annual rate of 2.8% for the period 2008 to 2050, and 3.1% from 2051 until 2100, considering demand from the urban, agricultural and industrial sectors. In addition to the pressures generated by urban sprawl and economic growth, water demand and availability will be impacted by rising temperatures and variations in precipitation. Pressures on water resources are expected to be greatest in Guatemala,

Honduras and Nicaragua. On an aggregate basis, demand for water could grow 12% above the trend scenario until 2050 and then by 19% to 2100.

**Agricultural Sector.** Agriculture is one of the main motors of the region's economy, accounting for 18% of GDP including agro-industrial output. It stands to be one of the sectors hardest hit by climate change. According to initial aggregate estimates for the region as a whole, the climate change scenario A2 to 2100 would induce the overall agricultural production index to decline by approximately 9%, with the livestock index registering a significant reduction of 13%. Maize production could possibly increase over the near term with yields of slightly greater than 2 ton/ha, but it would then begin to trend lower with production possibly receding to 1.4 ton/ha around 2100. Average bean harvest productivity could decline from more than 0.7 to less than 0.1 ton/ha in 2100. Rice output would tend to reduce from an historical average of 3.5 ton/ha to between 2 and 1 ton/ha. This initial analysis does not capture the large diversity of situations between and within countries, and further analysis will be carried out at a less aggregate level.

**Biodiversity.** Central America is home to 7% of the planet's biodiversity as well as great geological, geographic, climatic and biotic diversity. With climate change, using the A1B scenario, the region's Potential Biodiversity Index would fall between 27 and 48% to 2080, depending on each country's biodiversity. Nicaragua, El Salvador and Honduras are the countries to be most affected. The regional average loss would be 38%.<sup>3</sup>

**Extreme events.** Central America has a register of 248 extreme events associated with climatological phenomenon between 1930 and 2008. The most frequent events are floods, storms, avalanches and mudslides, followed by droughts, with 85% and 9% corresponding to these two categories out of the whole count. The disasters of greatest impact, among those measured, are associated with tropical hurricanes which particularly affect the Atlantic coast. In the last three decades, the number of disasters registered has increased by 5% annually relative to the number registered in the seventies. There is a consensus that the increased intensity of hurricanes and tropical storms is associated with climate change, and that this intensity could grow by between 5% and 10% during this century compared to the average of the past four decades with the most significant effects likely in Belize and Honduras, followed by Costa Rica and Panama. If it is confirmed that the increased number of hurricanes registered in the last decades is also due to climate change, the costing will have to take this into consideration.

### **Economic Valuation**

The economic valuation of climate change in Central America is based on a bottom up analysis, which so far includes the agricultural sector, water resources, biodiversity and certain extreme events. Starting from the baseline macroeconomic scenario without climate change, the potential effects of temperature and precipitation variables on these sectors and areas of concern are analysed, and an estimate is then made of the related costs in each one relative to the baseline scenario. By making cost valuations in

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<sup>3</sup> The potential biodiversity index includes species and ecosystems diversity and infers the probability of finding more or less diversity within a region based on a series of relevant variables. It does not necessarily coincide with the actual number of species and ecosystems present.

monetary units it is possible to estimate changes or reductions in economic output. For the economy of climate change studies in Latin America it was agreed to express the accumulated cost over a specified period into the future in terms of the net present value as a percentage or absolute value of GDP of a specified year in the current time.

**Table 1: Initial estimate of costs to Central America in four areas under scenario A2\* (net present value as a percentage of 2008 GDP)**

	0.5%		2%		4%	
	discount rate		discount rate		discount rate	
<b>Impacts</b>	<b>2050</b>	<b>2100</b>	<b>2050</b>	<b>2100</b>	<b>2050</b>	<b>2100</b>
Agriculture	5.41	19.10	3.99	8.61	2.82	4.01
Biodiversity	4.45	21.00	0.95	9.54	0.29	0.54
Water resources	2.26	14.93	1.54	6.23	0.98	2.37
Extreme events	3.23	17.98	2.08	7.18	1.21	2.52
<b>Total</b>	<b>15.35</b>	<b>73.01</b>	<b>8.56</b>	<b>31.56</b>	<b>5.30</b>	<b>9.44</b>

\*For biodiversity the scenario A1B was used due to technical requirements.

The initial estimated costs under scenario A2 for the areas of concern analysed grow significantly more beginning in 2050 and reach extremely high levels by the end of the current century. The initial estimated cost measured in this exercise for these four areas of concern in Central America to 2100 is equivalent to about 70% of the region's GDP in 2008 at net present value and a 0.5% discount rate, or equivalent to about 103 thousand million current USD or 69 thousand million USD at 2002 prices. Costs to the agricultural sector grow at an accelerate pace beginning in 2070, primarily due to additional costs to the livestock sector, which double beginning in 2050. Based on initial results, measurable costs to the water sector will remain relatively low until 2030, at less than 1% of current GDP, and costs will increase rapidly between 2070 and 2100, with negative effects for all the countries in the region. The limited measurable costs in biodiversity, relative to the index used, will grow exponentially beginning in 2050. With an extrapolation from 2080 to 2100, these costs will be equivalent to 20% of the current GDP of all the countries of the region. These costs are also probably undervalued due to the use of the A1B scenario. In the case of extreme events, the high end estimate of an increase of 10% in intensity, based on the literature review, was associated with the high end A2 scenario. It is important to reiterate that this estimate is initial and based on only four areas of concern and what is measurable in terms of economic costs. In 2010, the project will expand this analysis and complete the costing of the B2 scenario. This work does not pretend to estimate the total costs of climate change. Nevertheless, even this initial estimate is significant and of concern.

### **An initial proposal for the exploration of policy options**

Despite the context of climate change, public policy decision makers may be tempted to respond with an inertial or “business as usual” logic, rolling out responses to emergency situations, with inadequate adaptive or *ad hoc* approaches that generate more vulnerability and magnify risks over the medium and long terms. The challenge is to establish national, regional and international agreements, and “best evidence” based policy discussions to support more proactive responses.

**Adaptation.** The challenge for Central America is of great concern because it will require a redoubling of efforts to reduce poverty, inequality and socioeconomic and environmental vulnerability as well as increasing the resilience and adaptive capacities of societies and specific populations to climate change. At the same time, there will be limits to adaptation with losses and damages that will not have a solution even with abundant financing. Thus, without a timely and significant global effort to reduce emissions and the concentrations of GHGs, particularly by the countries most responsible, the costs of adaptation and non-resolvable impacts for these countries will increase, even though they have only contributed to the problem in a very minor degree. This scenario would imply a high carbon world economy with countries subjected to more and more adverse effects of climate change.

In the best case scenario, with a significant and early reduction in emissions, adaptation will imply not only efforts to adapt to direct impacts on countries, but also to changes in the global economy, principally regarding a possible transition to a low-carbon economy, including such possible measures as a global tax on carbon content or carbon-content based import barriers or tariffs. Essential to this effort is the transfer of resources from the developed countries to developing ones and international cooperation for financing and innovation, development and diffusion of adaptation and mitigation technologies appropriate for developing countries, including the use of local and indigenous technologies.

Based on the initial results of the study, an initial proposal for policy options to be explored during the rest of the project can be made, oriented toward adaptation (though not exclusively). This proposal must be analysed and validated by final results and through discussions with national and regional experts and national decision makers. This framework can be summarized as follows:

***Due to variability in precipitation and water availability, problems that will grow with climate change, Central American societies need to become audacious managers of their water resources***, ensuring its sustainable and efficient use both for the human population in terms of its food security, health and productive activities, as well as for ecosystem functions, including the regulation of the water cycle and the survival of these ecosystems and their biodiversity in the face of climate change. Water is a strategic resource with a high inter-national attribute, due to the more than twenty major water basins shared by more than one country in the region. Thus, one of the working hypothesis is that this could be one area with great necessity and potential for implementing a regional strategy. Success in this field will condition the options in others, such as the expansion of hydroelectric power generation, relatively lower in carbon emissions.

***Food security will be threatened by climate change, especially basic grains***, thus threatening the wellbeing and livelihoods of many of those living in poverty, including small scale producers and urban consumers. Responses can include changing public policy to strengthen the applied research, technological transition, credit, insurance, investment, training and extension work provided to the agricultural sector and agroindustrial to support more sustainable practices. Possible adaptation measures include changing the land under cultivation, crop types and varieties, efficient water-use and conservation practices, soil retention and measures to increase soil fertility and water absorption, and agro-forestry. In terms of regional cooperation, measures could include inter-country coordination of productive capacities and the promotion of intra-regional food trade in the context of national food security policies and the sharing of good practices in agricultural technologies and sustainable rural development. Another option involves creating a network of regional centers to support technological change, innovation and capacity building for the adaptation of agriculture that ensures the participation of local producers and indigenous peoples and their knowledge and practices.

***The protection of natural ecosystems and their biodiversity, including forests, mountain and river systems, marine coastal zones, including coral reefs and mangroves, is essential to sustaining the multiple services they provide the human population and other living beings. These ecosystems are and will be severely affected by climate change, and so, need to be given priority in adaptation strategies.*** They contribute in diverse ways to productive, distributive and consumptive activities, providing water resources, food, pollenization of agricultural crops, tourism, medicines and construction materials. Their economic value is unquestionable, but this is not completely reflected in market prices.

***A significant part of ecosystem services are not given an economic value, and it is not probable that such a value will be assigned in time to get the correct signals through the market to motivate appropriate decisions about their use and preservation. The signals given by declining agricultural productivity or water availability will arrive when these resources are already very seriously depleted, even without climate change.*** Preserving these ecosystems is essential, by reducing the pressure of the human population and promoting their adaptation (such as by creating better connectivity between protected areas) and by way of using options for mitigation of emissions or payment for other environmental services to protect these ecosystems.

***Reinforce efforts to enhance social well-being and quality of life as well as to reduce poverty.*** Central America needs to step up efforts to invest in its peoples' capacities and to progress toward the Millennium Development Goals, especially for those living in poverty, efforts that need to include the strengthening of public services in the areas of healthcare, education, training, technical extension, insurance and credit for producers. Part of the challenge is to promote more sustainable patterns of consumption within the population, including high and medium income groups, and to bolster civil defense networks, response capacity and adaptation to extreme events. In the framework of the transition to low-carbon economies and sustainable societies, work to actively integrate people living in poverty in programs promoting energy efficiency (lighting, efficient wood stoves, electrification) and conservation of natural treasures (payment for environmental services, emission reduction bonds, efficient water use, banks and trading of native seeds, traditional technologies).



***Strengthen scientific, innovation and technology development systems, integrating indigenous and local actors and their knowledge and experience.*** Technological change is essential to climate change adaptation and the transition to low-carbon economies. Such change requires access to appropriate “modern” technologies and the recovery of traditional and local ones, both of which must be broadly disseminated and employed. It may prove necessary to insist on access to and financing for adaptation and mitigation technologies under some type of “special” regime or “exception” to WTO agreements for developing countries, recognizing climate’s quality as a global public good and the high risk associated with climate change. In the same vein, indigenous peoples, *campesino* populations and other economic actors of the region can contribute their local practices, varieties of products, and the knowledge they conserve to sustainable economic development and to environmental protection and the preservation of biodiversity. This technological transition requires a new generation of technical norms of various types that extend to infrastructure design, energy and water efficiency requirements in transport machinery and vehicles, irrigation, housing and human settlements, among others.

***Adopt farsighted fiscal policies.*** There is an urgent need for proactive responses to climate change. Otherwise, future generations will bear much more onerous mitigation and adaptation costs. The current study shows that the cost of climate change impacts will eventually become too great if we fail today to act in a proactive manner. Since climate change is a question of market failure it cannot be left exclusively up to environmental institutions, but instead must be recognized as a central and transversal economic problem.

Climate change will most likely affect public finance and policy due to greater emergencies provoked by extreme events. It will increase the need to improve transport, hydroelectric, bridge and port infrastructure, to adjust social services and to relocate populations and economic activities. As a result, there is indispensable need to adopt fiscal policy that integrates the environment, especially climate change, as a transversal issue.

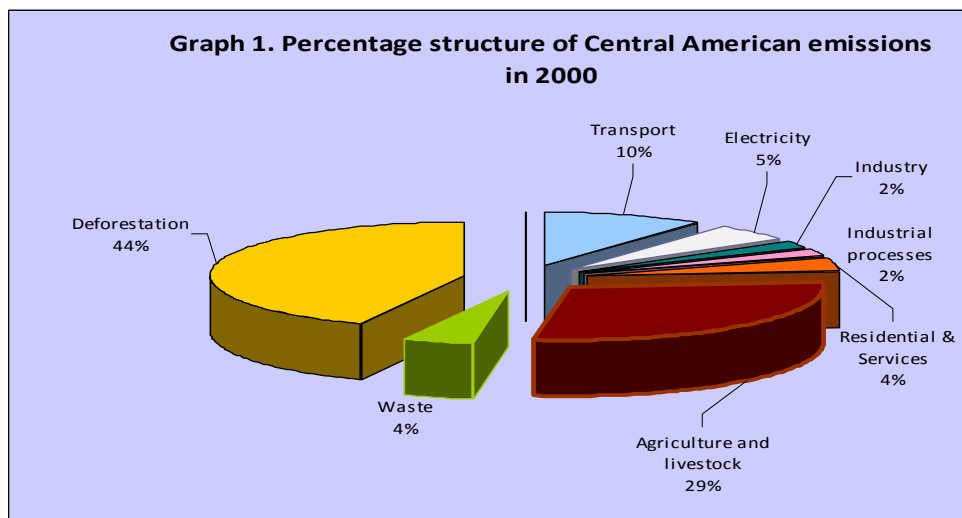
While the current economic crisis is a threat of great proportions, it can be seized as an opportunity to reformulate national development strategies so as to incorporate responses to climate change. In a context of slowing economic growth it is necessary to create financial mechanisms to permit a proactive response to the impact of climate change, and to align fiscal incentives to support the transition toward an economy that is less harmful to the environment and low in carbon.

**Mitigation/low-carbon economies.** On the matter of emission reductions, it is estimated that in 2030 Central America will continue to produce less than 0.5% of the planet’s GEI emissions,<sup>4</sup> and yet it is already disproportionately experiencing, and will increasingly suffer, the ravages of climate change. At the same time, the global economy must lower its carbon intensity. This change will generate an agenda for the competitiveness of the region and its insertion in the global economy, particularly because its economies are already quite open. Instead of strictly limiting the mitigation focus to GEI emission reduction, the challenge for Central America will be to maintain its aspirations to provide a better quality of life for its people by making the move to low-carbon economies and sustainable societies.

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<sup>4</sup> Assuming that emissions from changes in land use will remain at 2000 levels.

In this framework, the following graph shows that the most significant source of emissions in Central America is deforestation, with Honduras emitting 37 million TCO<sub>2</sub>e due to land use change, followed by Nicaragua and Guatemala with 17 and 13 million TCO<sub>2</sub>e, respectively, while those of Costa Rica, Belize and Panama are insignificant or negative. The second emitting sector is agriculture due to methane emissions from enteric digestion, manure management on cattle farms and rice cultivation; nitric oxide emissions come from the denitrification of crop land arising from the use of nitrogen fertilizers. Third are transport emissions, basically those generated by gasoline or diesel driven internal combustion engines. Electric power generation based on fossil fuels has a relative regional weight of 5%. With the exception of Belize, Costa Rica has the lowest level of national emissions as the country is largely powered by hydroelectric sources. Industrial emissions, which are mostly attributable to the decarbonation of limestone in the cement industry's production of "clinker", are notable in all the countries. Methane emissions from the handling of urban/municipal waste contribute 4% of total emissions.

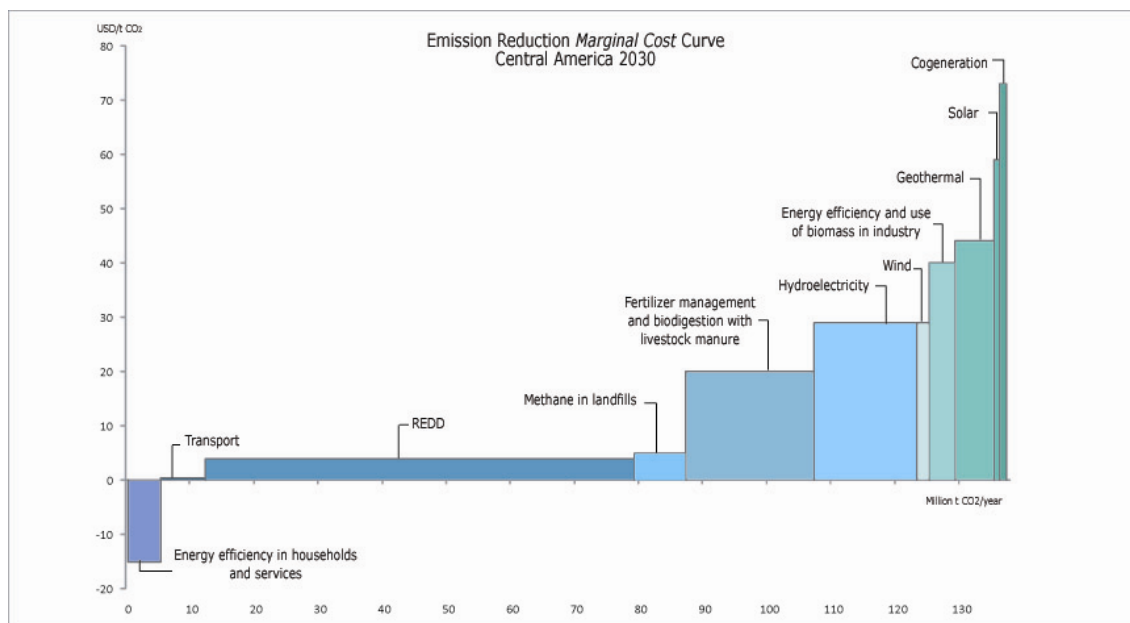


When considering a future “business as usual” scenario of the region’s emission projecting current trends, the study identified mitigation options beginning with consideration of each sector’s volumes and technological characteristics. Then, based on proposed scenarios for the average per ton cost of lowering CO<sub>2</sub> emissions in each sector, a horizon of incremental or marginal costs was established, considering a scenario of potential reductions below the business as usual scenario. Graph 2 depicts the sequential relation between average costs and potential emission reduction estimated to 2030, which can be interpreted as a “curve” of the marginal costs of emission reduction for the region.

The technical analysis of results of this initial exercise suggest a series of mitigation or decarbonization options in energy efficiency, transport, REDD, methane in sanitary landfills, agriculture and livestock, and electric power generation. Energy and REDD are probably the main mitigation option fields that offer the people of Central America the greatest potential benefits. This initial exercise was made at the aggregate level for the whole region to illustrate this technical analysis. These aggregate results do not necessarily coincide with what would be national abatement curves, which could be prepared in the future. This exercise will be strengthened by the final results of the

various sectoral studies underway and with the discussions with national and regional experts. The results of international negotiations and the possible institutional frameworks will have to be considered, along with the need to ensure that any such initiatives complement those aimed at reducing poverty and vulnerabilities and increasing the adaptive capacities of local populations and indigenous peoples that could be involved.

**Graph 2. Marginal cost mitigation curve**



Two more policy options can be derived from this exercise:

***Guarantee the security and sustainability of the energy matrix and improve energy efficiency.*** The region has developed a severe dependency on highly polluting, imported, fossil-fuel based energy sources. There are multiple benefits to be gained from moving toward an energy matrix geared toward renewable and local energy sources, both to enhance energy security and to lower adverse effects on human health and GEI emissions. The Central America energy sector has produced its Sustainable Energy Strategy 2020 with various future scenarios and an Action Matrix that is regularly updated. Despite the short term dependency on imported hydrocarbons, this strategy proposes a transition towards regional energy sources that are renewable and less polluting relative to the business as usual scenario, and includes hydroelectricity, wind and geothermic power sources and the importing of natural gas to reduce the dependency on coal, bunker and diesel fuels. With access to financing and technology, the region could implement its Sustainable Energy Strategy. At the same time, reactivating the expansion of hydroelectric projects creates an opportunity to establish models that support the social and sustainable development of communities in the neighbourhood of the projects, with a number of cases being developed currently in the region. Finally, the Central American energy sector has a proven record of managing the sector in a coordinated and farsighted manner, with the establishment over a number of decades of the integrated regional electric power grid (SIEPAC). Opportunities also exist for improving energy efficiency and lowering emissions related to energy use.

***The protection of natural ecosystems and their biodiversity, including forests, coral reefs and mangroves, is vital to sustaining the multiple services that they provide the human population,*** as was already identified in the adaptation proposals. Reducing deforestation to net zero would involve a significant effort, should be made in a way that it benefits the people of the region, particularly those living in these ecosystems, as well as making major contribution to the global effort to reduce emissions. Nevertheless, it requires a series of complex transformations, the adoption of international agreements and increased emissions reductions, and an analysis of the benefits and costs of diverse options for markets and international financing.

At the national and regional level, an effort to execute adaptation measures separate from mitigation endeavors may prove to not be very practical for countries with limited fiscal and investment resources, despite the fact that international negotiations tend to maintain these two spheres as separate issues. It is possible that at the national policy level, a better option would be to adopt **sustainable adaptive strategies linked to measures designed to move toward low-carbon economies** employing an array of management tools and implementation timelines that can generate virtuous cycles of sustainable development-oriented adaptation/mitigation. Examples of public policy options that are nominally classified as mitigation that could generate adaptation and wellbeing co-benefits, include ensuring the participation of populations living in poverty in programs for the protection of natural ecosystems, including forests, through payments for environmental services, or in energy-efficiency initiatives such as energy efficient lighting or appliances, efficient wood fuel stoves and rural electrification and ensuring their access to other technologies appropriate to adaptation and the transition to low-carbon economies.

Finally, two policy areas are of a transversal and regional nature:

***Central America enjoys an important advantage in its integration system, which should be strengthened and used to coordinate the climate change response effort.***

Without ignoring the diversity of national conditions, there are various areas in adaptation in which it would be advantageous to work as a region, such as the integral management of water resources, food security and probably science, technology, and innovation as well as continuing the work in energy and environmental issues. In the field of mitigation, the probable trend toward the establishment of sectoral emission-reduction programs could lower transaction costs if they were created by a number of countries or on a regional level. The region has established its Central American Integration System with its decision making structures and technical organisms, and a set of strategies and initiatives that are constantly evolving. These include the Regional Climate Change Strategy, the Regional Agroenvironmental and Health Strategy, the Central American Integrated Management Strategy for Water Resources, the Agricultural Policy Strategy, the Mesoamerican Biological Corridor, and the Sustainable Energy Strategy to 2020 among others.

***The transition toward a low-carbon global economy can create opportunities for promoting a regional sustainable development “brand”,*** including a possible long term goal of zero net emissions, a more accelerated transition to low-carbon service economies including a greater linkage between the sustainable use of natural resources (forests, agriculture, coastal zones) with tourism, agro-industry, and the diversification of trading partners and exports to markets with green, organic, or carbon-content preferences.