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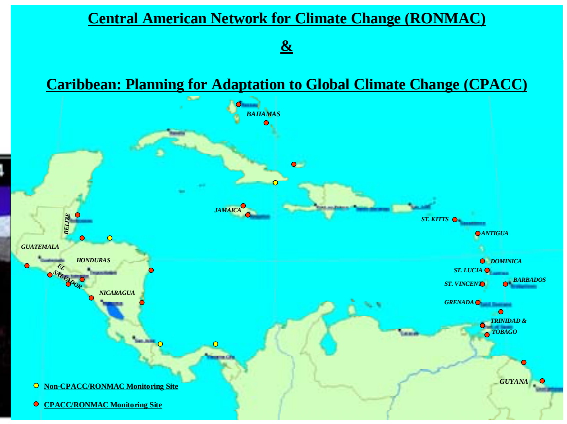
Latin America and Caribbean Region

Sustainable Development Working Paper 25

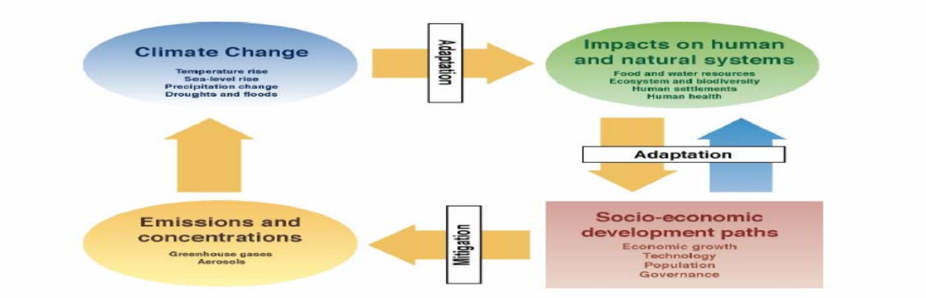
Adapting to Climate Change

Lessons Learned, Work in Progress, and Proposed Next Steps for the World Bank in Latin America



Rapid regression of the Qori Kalis glacier in Peru's Andes

Monitoring network for sea level rise in the Caribbean



Adaptation, mitigation, impacts on ecosystems and development

October 2005

By:

Walter Vergara

The World Bank

Latin America and Caribbean Region

Environmentally and Socially Sustainable Development Department (LCSES)

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Lonnie Thompson (2004)
CPACC (2002)
La Reunion preparatory workshop for Fourth Assessment Report (2005)

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Acronyms

ACCC	Adapting to Climate Change in the Caribbean Project
AGCM	Atmospheric Global Climate Model
AMIP	Atmospheric Model Intercomparison Project
CAFE	Corporate Auto Fleet Emission Standards
CARICOM	Caribbean Community
CAS	Country Assistance Strategy
CCCCC	Caribbean Community Climate Change Centre
CCSR	Center for Climate System Research (University of Tokyo)
CEA	Canadian Executing Agency
CEA	Country Environmental Assessment (World Bank)
CERMES	Centre for Resource Management and Environmental Studies
CIDA	Canadian International Development Agency
CORALINA	Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés (Colombia)
COP	Conference of Parties
CPACC	Caribbean Planning for Adaptation to Climate Change
CRIS	Coastal Resources Information System
DPL	Development Program Loan
EIA	Environmental Impact Assessment
ENSO	El Niño Southern Oscillation
ES	Earth Simulator
GCC	Global Climate Change
GCSI	Global Change Strategies International
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GLOOS	Global Ocean Observation System
GOF	Glacial Overflow
IDEAM	Instituto de Hidrología, Meteorología y Estudios Ambientales (Colombia)
IDI	Institutional Development Initiative
IDMSCS	National Integrated Dengue and Malaria Surveillance and Control System (Colombia)
INAP	Integrated National Adaptation Program
INS	National Institute of Health (Colombia)
IPCC	Intergovernmental Panel for Climate Change
IRD	Institut de Recherche pour le Développement
IRICP	International Research Institute for Climate Prediction
LDC	Least Developed Countries
LDCF	Least Developed Countries Fund
MACC	Mainstreaming Adaptation to Climate Change
MAR	Millennium Ecosystems Assessment Report
MBRS	Mesoamerican Barrier Reef Systems Project
MEAR	Millennium Ecosystem Assessment Report
MPA	Marine Protected Area
MRI	Meteorological Research Institute (Japan)
NIES	National Institute for Environmental Sciences (Japan)

NOAA	National Oceanographic and Atmospheric Administration (U.S.)
OAS	Organization of American States
PDF	Participatory Development Fund
PHRD	Population and Human Resources Development Fund
PRSP	Poverty Reduction Strategy Paper
RAC	Regional Archiving Centre
RONMAC	Central American Network for Climate Change
RPIU	Regional Project Implementation Unit
SBSTA	Subsidiary Body for Scientific and Technical Advice
SCCF	Special Climate Change Fund
SMP	Synoptic Monitoring Program
SPACC	Implementation of Adaptation Measures in Coastal Zones
SRES	Special Report on Emissions Scenarios
STAP	Subsidiary Bodies on Science and Technology
TFESSD	Trust Fund for Environmentally and Socially Sustainable Development
TT	Trinidad and Tobago
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UPME	Unidad de Planeación Minero Energética (Colombia)
UWICED	University of West Indies Centre for Environment and Development

Summary

This report presents a brief overview of the work on adaptation to climate change already undertaken by the World Bank in the Latin America region. It also summarizes current initiatives in the portfolio and presents recommendations for further work. The document echoes the conclusion reached in a previous report[1] concerning the priority character of adaptation in Latin America, given the region's reliance on a fragile natural resource base and the irreversible character of many of the anticipated changes.

Impacts in the region include coastal-threatening sea level increases, increased sea surface temperatures, catastrophic melting of tropical glaciers and snowcaps, destructive warming of moorlands and other high altitude ecosystems in the Andes,[2] higher frequency and extension of forest fires, the appearance of tropical disease vectors in the Andes piedmont, changes in agricultural productivity, and impacts on coastal and watershed ecosystems. Known information on these impacts is summarized in the report.

In the context of the institution (as well as other multilateral and development agencies), the region has a strong lead in the implementation and formulation of adaptation activities. The report reviews this experience. These activities are being funded primarily through the GEF. PHRD resources and carbon revenues are also being used to support efforts in adaptation.

World Bank involvement in adaptation was initiated in the Latin America region with the formulation of the CPACC (Caribbean Planning for Adaptation to Climate Change) Project in 1997, an enabling activity of regional nature. It focused on the vulnerability of the island nations of the Caribbean to the impacts of climate change. These efforts continue with MACC and the SPACC Project, now under formulation. To date, work on adaptation in the Caribbean constitutes the most comprehensive Bankwide approach, from which valuable lessons can be derived. The region has also pioneered work on adaptation in mountain habitats through the INAP Project in Colombia, due to be approved for implementation in 2005, and the proposed work in the Central Andean region.

Given the characteristics of natural resources in the region and the dependence of regional economic activities on environmental services, adaptation work should be central to the Bank's sustainable development agenda in the region. Thus, it should be significantly expanded. An expanded work program could ideally include at least the following elements:

- The Bank group could strengthen and expand its work on institutional development and technical assistance in climate change, building on work already done under the enabling activities window of the GEF.
- Better understanding of regional climate trends and projected impacts is essential for the work on adaptation. The Bank should actively support these efforts which are requisite for efficient allocation of adaptation resources. The partnership reached with the Meteorological Research Institute of Japan for the utilization of data from the Earth Simulator, is a useful example of what can be done.

[1] Responding to Climate Change. A proposed strategy for the World Bank in Latin America. Sustainable Development Series No. 19. World Bank 2004.

[2] Modeling the energy balance of glaciers in the tropical Andes. Corripio 2004; Documentos Técnicos para la Preparación del Proyecto INAP. IDEAM 2005

- Mainstreaming of climate concerns into national and regional policies is required to ensure sustainability of climate initiatives. The work in the Caribbean provides a useful, practical example for replication in the region.
- Work on ecosystem restoration (done under GEF operational programs) and on climate change adaptation needs to be made more complementary and mutually supportive.
- Synergies should also be sought between the mitigation work (largely done with carbon revenues) and adaptation opportunities in the region. The Nariva Project in Trinidad offers a useful example of integration of these agendas.
- Besides coastal systems and mountain habitats, adaptation work in the region should also cover major inland ecosystems such as watersheds, savannahs, and others.
- Climate change will have repercussions on coastal development, water supply, energy, agriculture, and health, among other sectors. A large-scale effort, already initiated to some extent in the region, needs to be launched to better understand the anticipated impacts, help strengthen adaptive capacity, and promote adaptation measures.
- Adaptation will be expensive. The region, while contributing little to the global issue, is at the receiving end of anticipated impacts. Adaptation will require considerable funding, well beyond what is available today through the GEF funds and other sources. These resources will need to be complemented with additional funding. In the meantime, several regional priorities must be carefully selected to cover a range of situations, ecosystems, and economic activities affected.

Background

Regional climate change impacts

Global climate is changing rapidly. The 2001 Third Assessment Report of the Intergovernmental Panel for Climate Change (IPCC) concluded that, with the continuing emission of GHG (greenhouse gases), the mean surface temperature may increase between 1.5 and 5.8 degrees Celsius during the next 100 years. Documentation being used in the preparation of the Fourth Assessment Report, due to be released by the year 2007, corroborates the range of the projected increase.[3] A change of this magnitude is unprecedented and will result in significant impacts to be felt at a global scale. Along with changes in mean climatic conditions, the biosphere potentially faces irreversible and catastrophic system impacts associated, for example, with the reduction of thermohaline circulation, the melting of the Greenland ice sheet (Epstein 2005), the subsidence of small islands, increases in intensity of hurricanes (Webster et al. 2005), and the elimination of permafrost in Siberia and northern Canada. Climate change is the most serious challenge being faced by the global ecosystem.

Global warming will affect all species and exacerbate the stresses already being experienced by ecosystems, as recently documented in the Millennium Ecosystems Assessment Report (MEAR 2005). Thus, climate change may further accelerate both the ongoing impoverishment of global biodiversity caused by unsustainable use of natural capital, and the processes of land degradation.

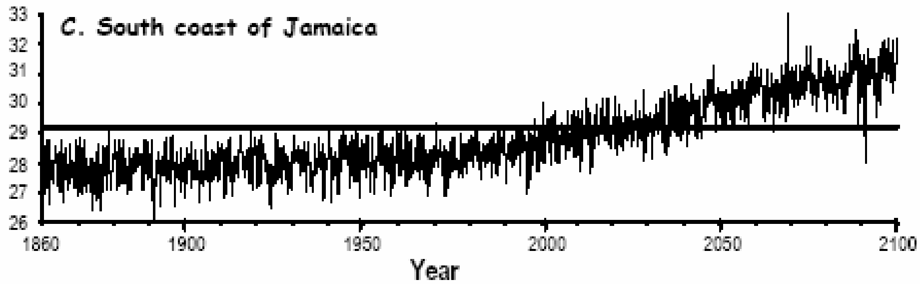
Impacts in the Latin America region are expected to be wide ranging and include coastal threatening sea level increases (Caribbean Planning for Adaptation to Climate Change [CPACC] 2001)**,** increased sea surface temperatures in the Caribbean Basin, increased intensity of weather disturbances, catastrophic melting of tropical glaciers and snowcaps, destructive warming of moorlands and other high altitude ecosystems in the Andes (Corripio 2002), higher frequency and extension of forest fires, the appearance of tropical disease vectors in the Andes piedmont, changes in agricultural productivity, and impacts on coastal and watershed ecosystems. Some of the most important regional impacts are summarized below:

Sea level and sea surface temperature increases. Projections reported by IPCC indicate that sea levels could rise, on average, about 5 mm/yr, within a range of uncertainty of 2–9 mm/yr. This is about two to five times the rate experienced over the past 100 years (1.0–2.5 mm/yr). Changes reported through the monitoring network in the Caribbean Basin range from 3 to 8 mm in three years (CPACC 2001). Of course, changes in sea level at regional and local levels will not necessarily be the same as the global average. However, anticipated sea level increases will place aquifer-based freshwater supplies under additional pressure through saline intrusion in many of the smaller islands. In addition, modeling of small islands has identified major population displacement as one of the main threats of climate change; in most Caribbean states, more than 50 percent of the population resides within 2 km of the coast (Nurse 2001). Therefore, these populations will be directly affected by sea level rise and other climate impacts on coastal zones. Thus, small islands with dense populations and a lack of interior land on which to relocate coastal communities will suffer “severe impacts.” Finally, sea level increases may result in the submergence of oceanic atolls and reefs with potential implications for national boundaries and sovereignty rights in the Caribbean Basin.

[3] The range of carbon emissions from recent non-intervention scenarios is slightly higher on the upper limit than the SRES range (more than 20 GtC). The SRES scenarios have been criticized for overestimating future emissions. However, the post-SRES literature shows an even higher emission range (IPCC, FAR workshop, February 2005).

High ocean temperatures cause corals to bleach and, if conditions are warm enough for a long enough time, to die. Nearly 30 percent of warm-water corals have disappeared since the beginning of the 1980s, a change largely due to increasingly frequent and intense periods of warm sea temperatures (The Royal Society 2005). The unprecedented increases in sea surface temperature in the Caribbean in recent years are further contributing to the pace of coral destruction. The destruction of corals has long-term implications for coastal zone protection, ecosystem integrity, biodiversity, and productivity of the tropical seas and fisheries. The unheard-of coral bleaching events registered over the last decade seem to be accelerating in frequency and intensity. For example, during the summer of 2005, the most serious bleaching ever, in Puerto Rico, was registered with up 95 percent of corals bleached in some reefs. Similar but not as serious bleaching was registered in Grenada (NOAA 2005). These events coincided with high sea surface temperatures in the Caribbean Sea during the same period.

Figure 1. Sea surface temperature and thermal threshold of corals on the South Coast of Jamaica



Source: Data generated by the global coupled atmosphere-ocean-ice model (as reported by Hoegh-Olderg 1999). Horizontal lines indicate the thermal threshold of corals at the site in degrees Celsius.

Acidification of oceans. The increase of CO_2 in the atmosphere is also resulting in an acidification of the oceans (The Royal Society 2005). The higher the concentration in the atmosphere, the higher the corresponding equilibrium concentration in the oceans will be. This in turn lowers the pH (increases acidity), and importantly for organisms that calcify, lowers the carbonate saturation status of the surface oceans. The extent and rate of change to ocean chemistry that is predicted to occur by 2100 has no precedent for at least hundreds of thousands of years and possibly much longer. Among the most affected ecosystems are corals but also all organisms that require calcification.

Impact on coastal ecosystems. Besides the impact on oceans, climate change will affect the physical and biological characteristics of coastal areas, modifying their ecosystem structure and functioning. As a result, coastal nations face losses of marine biodiversity, fisheries, and shorelines. Likewise, wetlands and mangroves are highly vulnerable to sea level rises and increases in sea surface temperature.

Specifically, in terms of coastal ecosystems, coral reefs are expected to be impacted detrimentally if sea surface temperatures increase by more than one degree Celsius above the seasonal maximum temperature. In addition, increases in CO_2 will affect the ability of reef plants and animals to calcify and thus reduce the ability of reefs to grow vertically and keep pace with rising sea levels.

Moreover, many wetlands in near-shore marine and coastal areas will be affected by changes in storm surges. These may result in large-scale translocation of populations in low-lying areas. Mangroves and coastal lagoons are expected to undergo rapid change and perhaps be lost all together as functioning ecosystems as a result of increasing temperature, sea level, and salinity conditions. Low-lying coastal areas and associated swamps could also be displaced by salt water habitats, disrupting freshwater-based ecosystems. Such changes are likely to result in the dislocation of migratory birds and aquatic species that are not tolerant to increased salinity or flooding.

The combined pressures of sea level rise and coastal development could also reduce the availability of intertidal areas, resulting in loss of feeding habitats and leading to catastrophic declines in wintering shorebirds. Migratory and resident birds and fish may lose important staging, feeding, and breeding grounds which are difficult to replace under competing demands for scarce land. All these may result in impacts on commercially important fish species, seriously affecting the sustainability of fisheries.

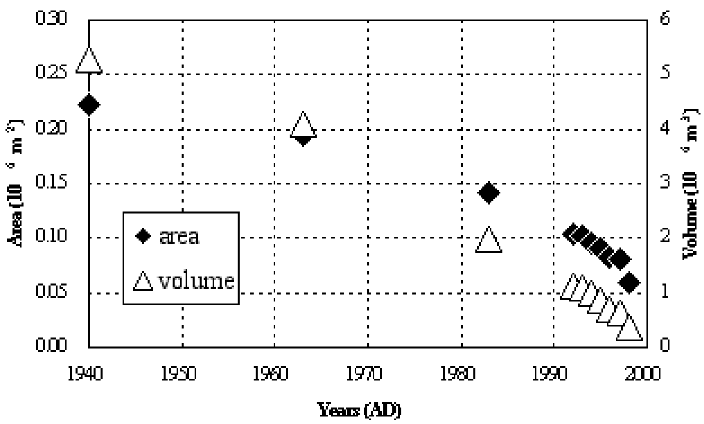
Implications for inland systems. Biogeophysical implications of sea level rise will vary greatly in different coastal zones around the world because coastal landforms and ecosystems are dynamic. For example, flooding conditions in the Pampas, in the province of Buenos Aires, would be exacerbated by any degree of sea level rise because the effectiveness of the natural drainage system would be reduced by such a rise. Some coastal sectors in Central America and on the Atlantic coast of South America, such as the river deltas of the Magdalena in Colombia, would be subject to inundation risk. Other large, flat areas—such as the Amazon, Orinoco, and Paraná River deltas—and the mouths of other rivers would also be affected. Estuaries such as the Río de la Plata would also suffer increasingly from saltwater intrusion, creating problems in freshwater supply. These effects will depend on the amount of sea level rise and the characteristics of atmospheric and oceanic circulation.

Figure 2. Glacier in the Peruvian Andes in 1980 and from the same position in 2002. Cordillera Blanca, Peru. (Photographs by Bryan and Mark Lynas)

Impacts on mountainous areas. Highland Andean ecosystems are very vulnerable to climate change impacts. In particular, glacial retreat in the Andes is occurring at an alarming rate (Corripio 2002, 2004; Francou et al. 2004**)**. Recent measurements show catastrophic declines in glacier volumes which are likely to result in substantial impacts on water flows to Andean valleys.

Many small glaciers in the Andes are expected to disappear in the near future. As an example, Francou et al. reported a model simulation to estimate the time required for the complete disappearance of the Chacaltaya Glacier (0.06 km^2) in Bolivia. This prediction was based on an average ice deficit measured during the 1983–1998 period, and on direct measurements of ice thickness with ground-penetrating radar. The modeling results predict a complete disappearance of the glacier within the next 15 years. This is an immediate impact and not a faraway event of concern only for future generations. Implications on water management are serious as most of the glaciers in the Andes are less than 1 km^2 in size and many high-elevation basins with small glaciers are likely to experience a significant decrease in water discharge in the next two decades.

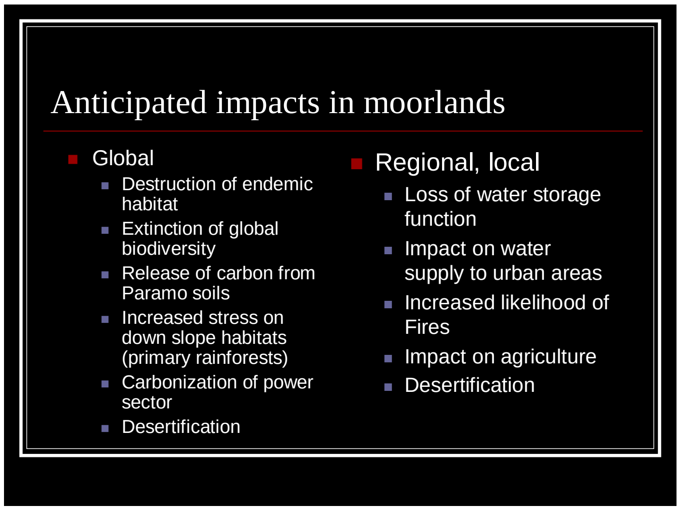
Figure 3. Retreat in volume and area of the Chacaltaya glacier (Bolivia) over the last decades (Francou et al. 2000)



At lower mountain altitudes, changes observed include loss of water regulation, increased likelihood of flash fires, and changes in ecosystem composition and resilience. Moreover, as temperature increases, there is a substantive risk of recurring glacial overflows (GOFs) caused by ice melting, placing large downstream populations and infrastructure at imminent risk. Warming is also affecting the moorlands, high altitude ecosystems with unique and abundantly diverse flora and fauna as well as a storage area for water and carbon in the soil. Recent research shows that climate change will be even more pronounced in high-elevation mountain ranges (Bradley et al. 2004). While much attention has been paid to climate change in polar regions, mountains that extend into the troposphere have been warming faster than adjacent lowlands. Thus, heavily populated, high-elevation areas in the tropics, such as the tropical Andes, are now experiencing particularly dramatic changes in climate and are likely to continue to do so in the future.

Hydrologic and ecological changes of this magnitude would result in a loss of global biodiversity ("no way up" for unique mountain species) and also in a loss of many of the environmental goods and services provided by these mountains, especially water supply, basin regulation, and associated hydropower potential. On this last point, many rivers that are used to generate hydroelectricity in the region are glacier fed. Loss of water regulation and water flows will result in a decrease in hydropower potential and consequently a gradual increase in GHG emissions from the power sector if thermal sources are used to fill the gap. In addition, many of the valleys in the Central Andes have low rainfall patterns and largely depend on the regulated flows from glaciers and snowcaps for water supply. Destruction of natural water regulation systems will contribute to a gradual process of desertification with damaging implications to ecosystems and the services they provide**.**

Figure 4. Global and local impacts caused by warming of high altitude moorlands



Impacts on health. A warmer climate will generally increase exposure to tropical diseases, health impacts from weather disturbances in the Caribbean Basin, and respiratory irritants. Hurricanes are frequently followed by increases in rates of incidence of tropical diseases. For example, the landing of Hurricane Mitch in Central America in 1988 resulted in large increases in cases of malaria, dengue fever, cholera, and leptospirosis (Epstein 2005**)**. For Caribbean islanders, Epstein reports, "respiratory irritants come in dust clouds that emanate from Africa's expanding deserts and are then swept across the Atlantic by trade winds accelerated by the widening pressure gradients over warming oceans."

Increased exposure to tropical vector diseases. In Latin America, a large portion of the population lives in mountain ranges, including large urban areas situated above 2,000 m, normally not exposed to tropical diseases. The two mosquito-borne diseases with the largest global impact on human health and well-being are dengue and malaria. The fact that both dengue viruses and the malaria parasites of the genera *Plasmodium* reproduce almost exclusively in humans but pass through an obligatory phase of their life cycle in mosquitoes, means that climate has a large bearing on their transmission and maintenance. Unlike humans, mosquitoes do not maintain their body temperature, and as such, the pathogens they bear must be able to tolerate ambient temperatures. Neither dengue virus nor *Plasmodium spp.* is able to develop in mosquito vectors when the ambient temperature is below 18–20°C. Furthermore, as temperature increases, the development time of both pathogens in their respective vectors decreases. Because a large portion of mosquitoes experiences mortality before the virus/parasite can complete development, an increase in temperature of 2°C, as predicted by the IPCC, may significantly increase the number of infective mosquitoes biting humans.

Climate change may have profound impacts on the transmission dynamics of dengue and malaria through other mechanisms besides pathogen development. Increases in temperature increase the rate at which mosquitoes digest blood meals, as well as the rate of larval development into adult mosquitoes. Both of these, in turn, may increase the frequency of vector-human contact and the epidemic potential of dengue and malaria. Furthermore, periods of intensive rainfall or drought associated with the processes of climate change have been related to increases in the abundance of larval breeding habitats of vectors, which in turn result in a pattern of dengue transmission that is highly associated with seasonal rainfall.

Climate variability. Climate variability is already a major development issue. In the region, El Niño Southern Oscillation (ENSO) and hurricanes are significant sources of climate events, frequently tied to impacts on coastal zones, agriculture, fisheries, and other sectoral impacts. Disaster relief to address these seasonal impacts uses significant development funds. Hence, the Bank has invested in disaster prevention and management in the region. Responses to weather variability are immediate in character and based on current impacts. Therefore, they attract the attention and priority of nations in the region. The linkage between these short-term climate events and the longer term and gradual climate change is key to the internalization of the issue among policy makers.

Hurricanes. There is no consensus from global modeling results for doubled CO_2 scenarios in projecting an increase or decrease in the total number of hurricanes, although most simulations project an increase in hurricane intensity. There are regional studies that show an increase in the intensity of hurricanes in the Atlantic. Global tropical cyclone statistics for the satellite era (1970–2004) have recently been analyzed (Webster et al. 2005). In each tropical ocean basin, the study examined the numbers of tropical storms and hurricanes, the number of storm days, and the distribution of hurricane intensity. The study concluded that rising sea temperatures have been accompanied by a significant increase in the energy of hurricanes. The global data indicate a 30-year trend toward more frequent and intense hurricanes.

In the Caribbean Basin, sea surface temperature has steadily increased and can possibly promote intensification of hurricanes once formed. In fact, the recent Hurricane Katrina evolved from a category 1 storm into a powerful category 5 in matter of hours as it passed over an abnormally warm pool of water in the Gulf of Mexico. An increase in the intensity of hurricanes has major implications for coastal zones in vulnerable nations. In the Latin America region this includes most countries in the Caribbean Basin. The intensification of hurricanes and its linkage to warmer sea surface temperatures also highlights the need for additional efforts in the identification and development of measures to adapt to climate change and of preparedness actions.

Figure 5. Global number and share of intense hurricanes (Saffir-Simpson scale) during 1970–2004 (Webster et al. 2005)

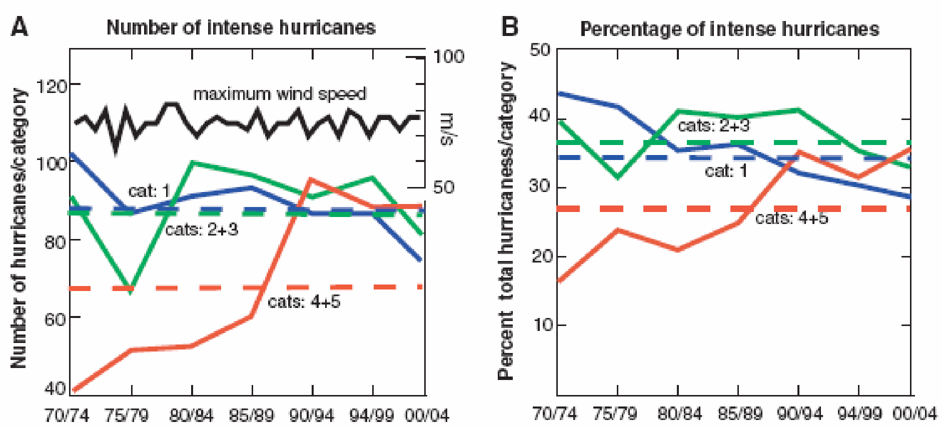
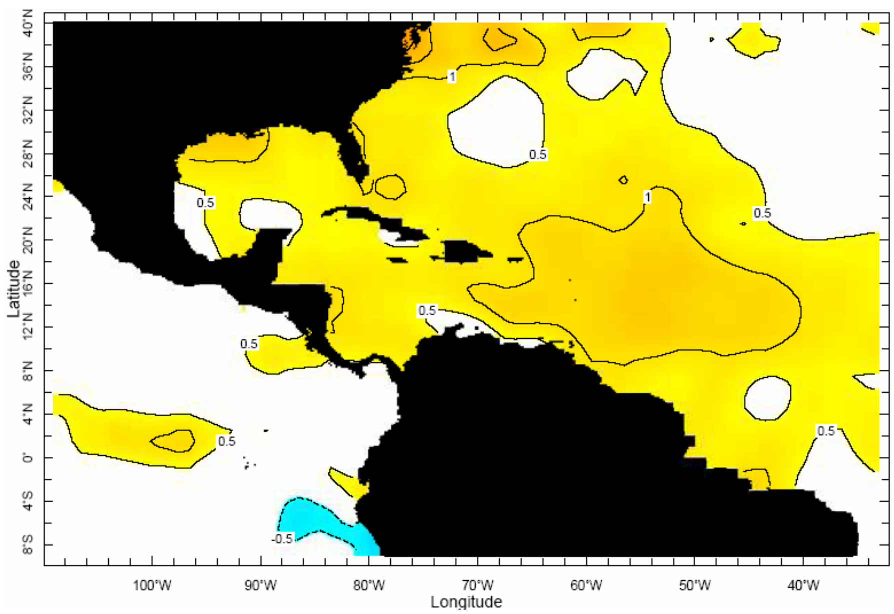


Figure 6. Sea surface temperature anomaly in the Caribbean for August 2005 (0.5 Celsius isothermals above 1961–1990 average)



Source: International Research Institute for Climate Prediction (IRICP) 2005

In summary, given the magnitude of the impacts and the irreversible character of some of the impacts from climate change, a comprehensive climate strategy for the region needs to focus on adaptation as a first priority. While adaptation is a top priority in the region, there are other activities that should complement a comprehensive agenda on climate change. This includes work on mitigation, using the sizable resources available under the Kyoto Protocol, at the World Bank, and the GEF financial resources for operational programs and institutional strengthening.[4] Funding for mitigation can also be tapped to support adaptation activities. For example, ecosystem restoration in coastal areas done in the context of carbon sequestration can serve both purposes.

The Millennium Ecosystem Assessment (MEAR)

These climate changes are taking place at a time when the stability and resilience of ecosystems are at unprecedented risk due to anthropogenic impacts induced by damaging growth, or growth attained at the expense of deterioration or sustainability of natural resources. Deterioration of the natural resource base at a global scale has been documented through the MEAR. The report was commissioned by the United Nations and its findings were released in early 2005. Summary reports were disclosed by July 2005. The report concludes:

> *"Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing*

[4] Responding to Climate Change: A proposed strategy for the World Bank in Latin America. Sustainable Development Series No. 19. World Bank 2004.

demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth."

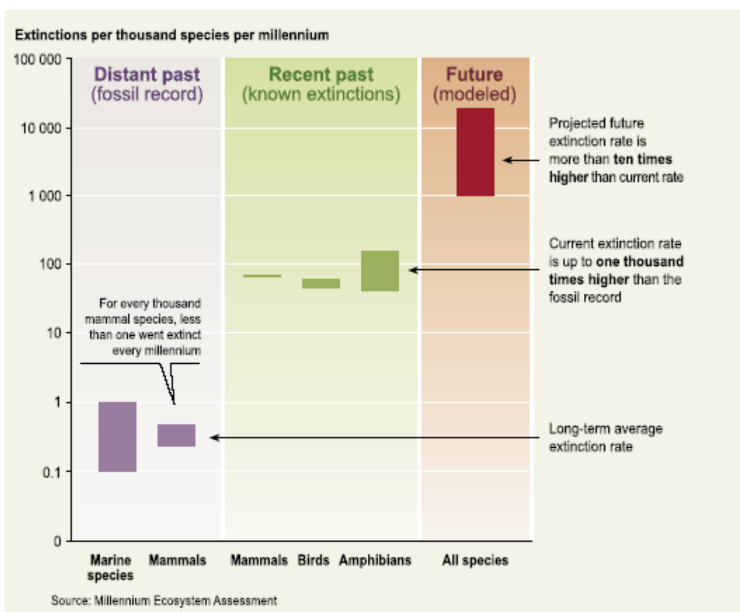
A partial accounting undertaken through regional assessments was used to reach additional sobering conclusions:

a) approximately 60 percent (15 out of 24) of the ecosystem services examined are being degraded or used unsustainably, including fresh water, fisheries, air, water purification, and the regulation of regional and local climate, natural hazards, and pests;
b) there is evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes in ecosystems;
c) the harmful effects of the degradation of ecosystem services (the persistent decrease in the capacity of an ecosystem to deliver services) are being borne disproportionately by the poor.

These changes will also affect the capacity of ecosystems to withstand damages caused by global warming and ultimately our ability as a species to adapt to these changes. This is a sobering thought. It also reveals that the current direction of development efforts is largely unsustainable.

While damaging growth is caused by one species (our own), the impacts are felt by all. The rate of extinction of species and the subsequent reduction in ecosystem resilience and complexity have been documented previously. The Millennium Ecosystem Assessment documents the rapid increase in extinction which in historical terms is also unprecedented (Figure 7). Weaker and poorer ecosystems are less likely to cope with the changes induced by global warming.

Figure 7. The rate of extinction of species



A perfect storm

The combined effects of local anthropogenic impacts and the impact of a global climate change constitute a "perfect storm," the ultimate test of the sustainability of current patterns of growth and development. Further, many of the changes being experienced in the region are irreversible in nature (glaciers cannot be rebuilt, sea level pH cannot be reversed, extinct species cannot be brought back); others, while reversible, would be extremely expensive (salinization of island and coastal aquifers). Finally, there is significant evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes in ecosystems (abrupt and potentially irreversible changes) that have important consequences for ecosystem stability and therefore for human well-being. Examples of such changes include disease emergence, sudden alterations in water quality, the collapse of fisheries, acidification of the sea to the point where it can no longer act as a net reservoir of CO_2, and permanent shifts in regional climate.

On the other hand, a series of measures can be implemented to promote adaptation to some of the changes. These measures would require modifications in the pattern of consumption or access to natural resources, changes in behavior, and ultimately a change in direction of economic development. While most of the impacts are caused by the emissions of GHG in developed nations, many damaging impacts are also expected in developing countries. What is the character of these activities and how can they be implemented?

The character of adaptation

The IPCC defines adaptation in the context of climate change as:

> "*(an) adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability.*"

For purposes of this report, adaptation is seen as (a) adjustments to the pace of use or access to the natural resource base in order to maintain reliable services from the affected ecosystem, or (b) reorganization to reduce exposure to loss or to exploit new opportunities from the affected resource (after Arnell 2004).

The scale of adaptation. The scale issues in time and space have important implications for planning and managing natural resources, posing major challenges for adaptive response to potential climate change impacts. In both senses, they highlight "problems of fit" between the climate change threat and the structure or capacity of institutions to take concrete action to address that threat.

Climate change impacts are intergenerational. The adaptation requirements are expected to increase gradually over time. The magnitude and rate of these possible impacts suggest that effective adaptation should start early and may itself require lengthy processes of technical, legislative, and social change. If the climate change threat is to be taken seriously, concerted efforts should be undertaken now to initiate such strategic processes. Mechanisms are therefore needed to extend the time horizons for adaptation planning and decision making. Without such extended horizons it will be difficult to justify and source expenditures on anticipatory action to tackle the predicted effects of climate change. In the absence of these mechanisms, policy makers and development agencies may see only the need for today's priorities and ignore the overwhelming but future threats.

Spatial scale of response is also crucial. There is a mismatch among the science of climate change (working at a global scale), the strategic analysis of climate change adaptation needs (undertaken at national or regional scale), and the capacity and mandate of a range of agencies at the local scale to decide on and coordinate specific adaptive measures. The agenda of climate change under these circumstances may seem to be imposed on the region. However, the truth is that all the impacts will be local in nature.

Nevertheless, the problems of long timescale and scientific uncertainty that complicate response to climate change risks strengthen the case for vertically integrated structures for climate change management, as emphasized in the recent Foresight Future Flooding report for the United Kingdom (Evans et al. 2004). Vertical integration of planning requires a continuity of policy and action among these scales (global, regional, local). In order to create a continuity between strategic policy relating to climate change and action "on the ground" there is a need to invest resources in local adaptive capacity, strengthen local long-term planning mechanisms, and establish genuinely cross-scale institutions to make and support what may be difficult decisions with long-term implications.

Limits to adaptation. Adaptation measures in Latin America are limited by a number of factors. These include financial limitations imposed by the available Global Environmental Facility (GEF) and other sources of funding, and the budgetary resources available in nations with many competing needs. In many instances the changes are great or the character of the changes is ultimately irreversible. Therefore, it is physically impossible to prevent the loss (i.e., the destruction of 11,000-year-old glaciers). Likewise, there may be social and political constraints (moving entire coastal populations to inland areas in advance of expected sea level rises) that would render necessary action unfeasible. Finally, capacity limits may also prevent the ability of affected groups to implement required adaptation measures.

Equity in adaptation. The impacts of climate change are being felt by and will fall disproportionately upon developing countries and the poor within all countries, and thereby exacerbate inequities in health and access to adequate food, clean water, and other resources. Populations in developing countries are generally exposed to relatively high risks of adverse impacts from climate change. In addition, poverty and other factors create conditions of low adaptive capacity in most developing countries. Many human settlements are facing an increased risk of coastal flooding and erosion, and tens of millions of people living in deltas, in low-lying coastal areas, and on small islands will face the risk of displacement. Resources critical to island and coastal populations, such as beaches, wetlands, fresh water, fisheries, coral reefs and atolls, and wildlife habitat, are at risk. The costs of adaptation are likely to be high and should ideally be borne by those most responsible for the increase of trace gases into the atmosphere.

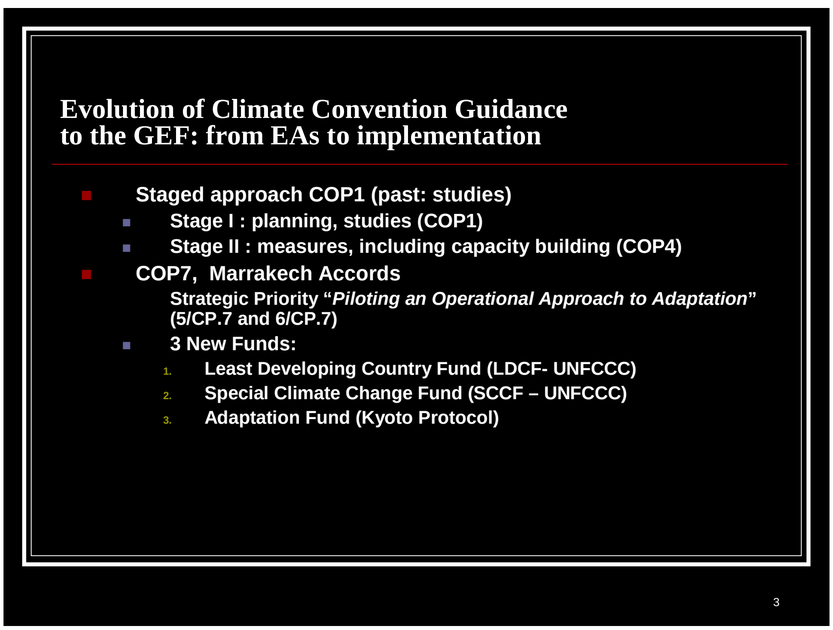
Effectiveness of adaptation. What may show success in the short term may not be the best on a longer time frame. For example, additional use of power to meet space conditioning demands and address the heat waves in the northern hemisphere may end up adding to GHG emissions from thermal-based power grids. The strengthening of sea defenses over a small area in Guyana may have unintended consequences on other less protected stretches. Therefore, effectiveness in adaptation measures needs to be measured over time lines and under criteria that are commensurate with the nature of global and regional impacts from climate changes (Mathur et al. 2004).

Funding for adaptation

The GEF has been supporting work on adaptation to climate change in developing countries through a staged process. Stage I was to support studies and planning, Stage II to support detailed planning and capacity building, and Stage III to support actual adaptation measures. Most developing countries have already carried out the initial assessment (or Stage I) studies on adaptation, many of which are reported in their National Communications to the United Nations Framework Convention on Climate Change (UNFCCC). Several Stage II studies (for example, the Mainstreaming Adapation to Climate Change [MACC] Project in the Caribbean) have also been initiated.

The seventh meeting of the Climate Change Convention in Marrakech in 2001 expanded the scope of activities eligible for funding, in the areas of adaptation and capacity building, and established two new funds under the Convention (plus another, the Adaptation Fund, under the Kyoto Protocol), that were to be managed by the GEF. In addition to its climate change focal area, a Special Climate Change Fund (SCCF) will finance projects relating to capacity building, adaptation, technology transfer, climate change mitigation, and economic diversification for countries highly dependent on income from fossil fuels. The SCCF now has US$60 million in funding. Furthermore, a Least Developed Countries Fund (LDCF) will support a special work program to assist LDC (least developed countries). The GEF is charged with implementing the provisions of the Marrakech Accords in a manner that respects procedural fairness and reflects the priorities of developing countries in seeking to adapt to both climate variability and change. The Delhi Declaration from the Eighth Conference of the Parties in November 2002 reinforced the importance of adaptation.

Figure 8. GEF funding for adaptation



Source: Bonizella Biaggini, personal communication.

In addition, there is a need for the developing countries to prepare more detailed assessments of adaptation to climate change including policies and ensuring their compatibility with action plans under other multilateral environmental agreements (such as biodiversity and desertification) as well as with other national sustainable development plans or strategies. In July 2004, a new window, the Strategic Priority on Adaptation, was made available to fund specific adaptation measures that would result in global benefits while addressing local adaptive capacity. The 2004 GEF plan allocates US$50 million to the window for the period 2004–2007. Most activities under formulation in the regional portfolio (including specific activities in the Caribbean, Colombia, the Central Andes, and others; see section on portfolio) will use these two sources of funding.

However, available funding for adaptation is grossly inadequate. Adaptation on a large scale is now required and the costs, while being borne by all nations, will be particularly onerous for Latin America.

World Bank's current portfolio of adaptation activities in Latin America

This section reviews the experience with the portfolio of adaptation activities in Latin America. The region has a number of activities on adaptation, the first having been approved by the GEF Council in 1997. These activities are being funded primarily through the GEF. However, Population and Human Resources Development Fund (PHRD) resources and even carbon finance are lately being applied to support efforts in adaptation. Table 3 summarizes the activities already under execution and those being planned or under formulation.

Table 1. Activities in adaptation in the Latin America region

Region/ Country	**Project/Activity**	**GEF-TF amount**	**SOF**	**Status**	
Caribbean (CARICOM* nations)	CPACC (Caribbean Planning for Adaptation to Climate Change)	5.8	GEF–Enabling activities	Completed	ICR
Caribbean (CARICOM nations)	MACC (Mainstreaming Adaptation to Climate Change)	5.0	GEF–Enabling activities	Under implementation	PAD
Dominica, St. Lucia, and St. Vincent and The Grenadines	SPACC (Implementation of Adaptation Measures in Coastal Zones)	1.95	GEF–Strategic Priority on Adaptation	In GEF pipeline	PDF-B
Colombia	INAP (Integrated National Adaptation Program)	5.3	GEF–Strategic Priority on Adaptation	In GEF pipeline	Council document
Central Andes	Adaptation to impacts from Tropical Glacier Melt	8.0	GEF–Strategic Priority on Adaptation	Proposal under review	Draft PDF-B
Trinidad and Tobago	Nariva Wetlands restoration and Carbon Offset	3.0	BioCarbon Fund	In the BioCarbon Fund pipeline	CFD
St. Lucia	Reducing uncertainties from projected impacts of climate change	0.3	Climate Change Special Program	Under execution	Grant agreement
Colombia	Measurement of climate trends and impacts in the central range of the Colombian Andes	0.4	Climate Change Special Program	Under execution	Grant agreement

*CARICOM: Caribbean Community

Adaptation in the Caribbean

World Bank involvement in adaptation was initiated in the Latin America region with the formulation of the CPACC (Caribbean Planning for Adaptation to Climate Change) Project in 1997, an enabling activity of regional nature. It focused on the vulnerability of the island nations of the Caribbean to the impacts of climate change. These efforts continue with MACC and the Implementation of Adaptation Measures in Coastal Zones (SPACC) Project, now under formulation. To date, work on adaptation in the Caribbean constitutes the most comprehensive Bank-wide approach, from which valuable lessons can be derived.

The rationale for early involvement was based on a perceived high degree of vulnerability of the ecosystems and economies in the region. An assessment was commissioned (Haites 2002) to understand the ecosystem and economic impact. The results of the assessment are summarized below.

The potential economic impact of climate change on the CARICOM countries is estimated at between US$1.4 and $9.0 billion for the impacts that could be estimated, assuming no adaptation to climate change. The wide range for the estimate of potential economic impacts is due more to the uncertainty relating to the values and assumptions used than to the uncertainty about climate change.[5] In the low scenario the total impact averages about 5.6 percent of the gross domestic product (GDP), ranging from 3.5 percent in Trinidad and Tobago to 16 percent in Guyana. In the high scenario the total impact averages over 34 percent of GDP, ranging from 22 percent in Trinidad and Tobago to 103 percent in Guyana. The relatively low impact in Trinidad and Tobago is due to the country's limited vulnerability to hurricanes and the relatively small size of its tourist industry. The relatively high impact in Guyana appears to be at least partly due to its relatively low per capita GDP and its coastal zone's high vulnerability to flooding caused by sea level rise.

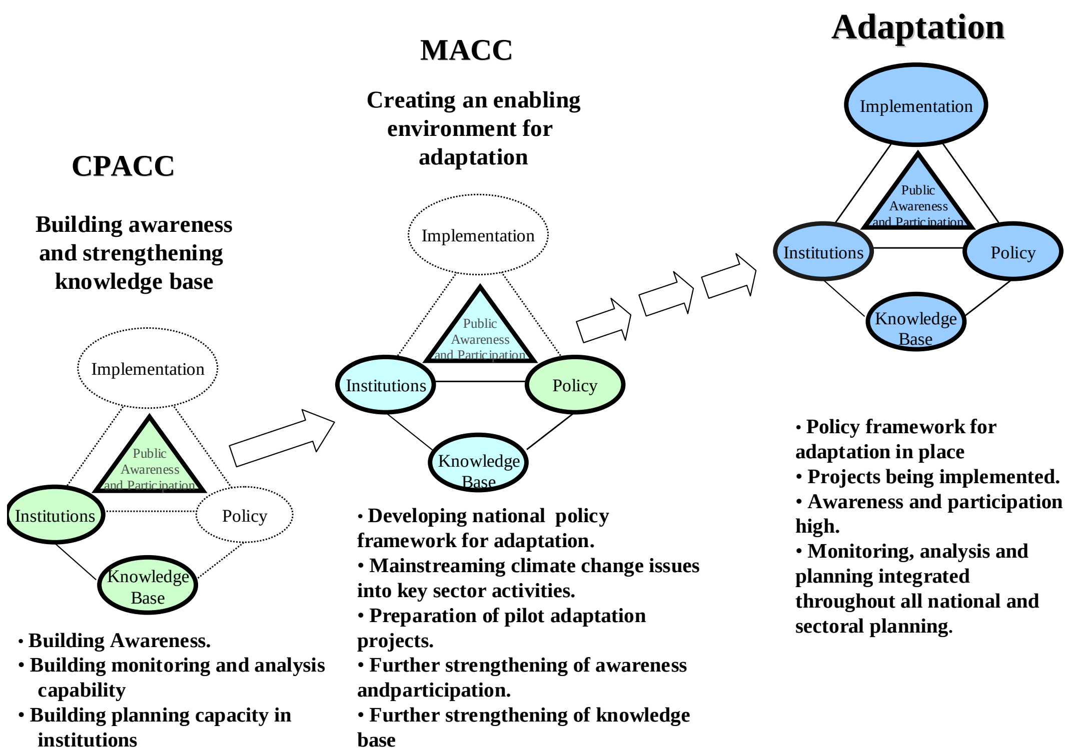
The largest category of impacts is the loss of land, tourism infrastructure, housing, other buildings, and infrastructure due to sea level rise. For example, the recently concluded vulnerability assessment for insular areas in the eastern Caribbean suggests a loss of 17 percent of the land area on the island of San Andrés in the next 80 years.[6] This type of losses represents 65–75 percent of the total economic impacts. Most of the remaining impacts are due to reduced tourism demand, caused by rising temperatures and loss of beaches, coral reefs, and other ecosystems (15–20 percent), and property damage due to the increased intensity of hurricanes and tropical storms (7–11 percent).[7] The increased intensity of hurricanes and tropical storms may also lead to more injuries and deaths. The impacts on agriculture are potentially significant for CARICOM countries. Reduced rainfall, if confirmed, could have serious effects on health and economic activity and could combine with sea level rises to reduce the quality and availability of aquifers.

[5] This estimate is based on limited data and numerous assumptions and hence is only a very rough initial estimate of the potential economic impact due to climate change. This estimate of the potential economic impact of climate change should be used with great care because it does not reflect possible adaptation to climate change and because of the uncertainty in the data and assumptions. These cautions apply with even greater force to the estimates for specific categories of impacts and for individual countries. Estimates are often based on data for a single country, which may not be correct for other countries.

[6] Colombia, Primera comunicación ante UNFCCC. Bogotá. 2002.

[7] The above estimates, with one minor exception, assume no adaptation measures are implemented. The opportunities to adapt to climate change and the potential to reduce climate change damage vary by country. It is clear that adaptation will cost less than the potential damages for at least some of the impacts of climate change in all countries. Thus, the economic cost should be substantially lower than the high estimate of the potential economic impact in the absence of adaptation actions.

Figure 9. Activities on adaptation to climate change in the Caribbean[8]



The process of adaptation in the Caribbean. Figure 9 presents a description of the long-term adaptation process, undertaken through the Bank and emphasizing the relationship between previous work under CPACC, the ongoing MACC Project, and the SPACC Project. It also indicates that this is a long-term and continuous effort to face what constitutes an ever-growing threat to the sustainability of the region. Together, these activities correspond to the stages of adaptation envisioned under the Conference of Parties' (COP's) guidance to the GEF.[1] CPACC (Stage I) focused on building awareness to climate change issues among public officials and the political sector, and initiating the process of strengthening the knowledge base. MACC (Stage II) supports further capacity building and facilitates the formulation of an enabling environment for adaptation and of adaptation measures. SPACC will fund specific adaptation measures and thus corresponds to a pilot Stage III.

[8] Deeb, A. Caribbean Planning for Adaptation to Global Climate Change, in *Adaptation Mosaic*. World Bank 2004.

Caribbean Planning for Adaptation to Climate Change (CPACC–P040739)[9]

Since 1997, the World Bank as an implementing agency of the GEF, in collaboration with the University of the West Indies (UWI), the CARICOM Secretariat, and the cooperation and coordination of the Organization of American States (OAS), was engaged in the implementation of a four-year project entitled "Caribbean Planning for Adaptation to Climate Change" (CPACC). The project was intended to support 12 CARICOM countries[10] in preparing to cope with the adverse effects of global climate change (GCC), particularly sea level rise, in coastal and marine areas. Coordinated through a Regional Project Implementation Unit (RPIU) based in Barbados, the project followed a regional approach through a combination of national demonstration actions and regional training and technology transfer activities to achieve its objectives. CPACC closed in March 2002. An Implementation Completion Report (ICR) was issued in August 2005.[11]

The project was developed in the context of: (i) a region particularly vulnerable to the effects of climate change, especially sea level rise; (ii) weak institutional capacity in environment and very little exposure to climate change issues; (iii) political championing of the climate change agenda at the regional level with limited reach at the national level; (iv) limited environmental data in the region; (v) limited long-term environmental planning and environmental policies; and (vi) the need to respond to the UNFCCC's vision of Stage I adaptation activities.

The project's overall objective was to support Caribbean countries in preparing to cope with the adverse effects of GCC, particularly sea level rise in coastal and marine areas through vulnerability assessment, adaptation planning, and capacity building linked to adaptation planning. More specifically, the project will assist national governments and the University of the West Indies Center for Environment and Development (UWICED) in: (i) strengthening regional capacity for monitoring and analyzing climate and sea level dynamics and trends, seeking to determine the immediate and potential impacts of GCC; (ii) identifying areas particularly vulnerable to the adverse effects of climate change and sea level rise; (iii) developing an integrated management and planning framework for cost-effective response and adaptation to the impacts of GCC on coastal and marine areas; (iv) enhancing regional and national capabilities to prepare for the advent of GCC through institutional strengthening and human resources development; and (v) identifying and assessing policy options and instruments to help initiate the implementation of a long-term program of adaptation to GCC in vulnerable coastal areas.

Some of the project's achievements are presented below.

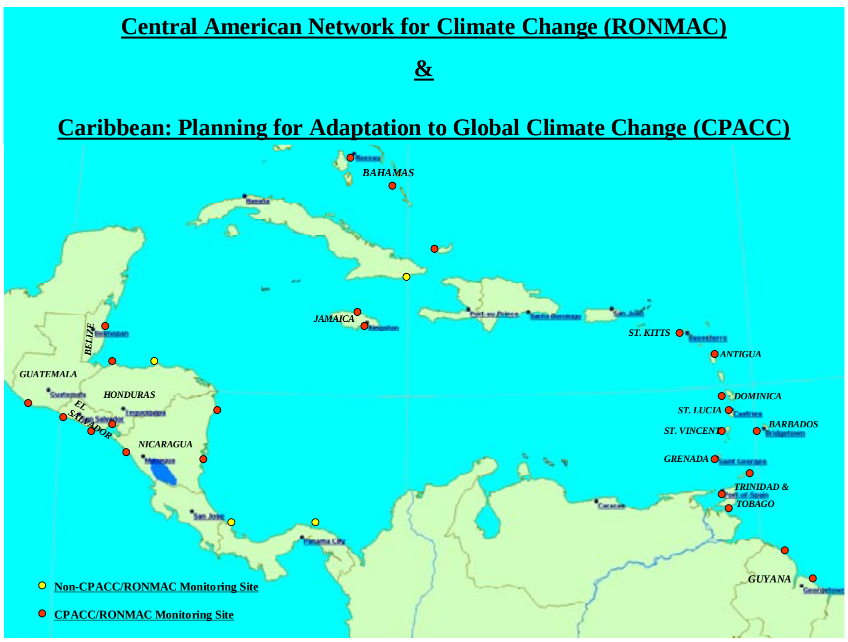
Increased appreciation of climate change issues at national and regional policy making levels. The project needs to be credited with a substantial increase in interest and support from regional policy makers for the specifics of the climate change agenda. This can be best exemplified by the adoption of the Barbados Plan of Action, reached in 1997, which placed climate change at the top of development priorities. The creation of the Caribbean Community Climate Change Centre (CCCCC), a unanimous decision at the meeting of Heads of Government in Canoan in 2001, also reflects the attention paid to the issue. Between these two decisions, the region has seen increased support, understanding, and action taken on the climate agenda, including political

[9] Caribbean Planning for Adaptation to Climate Change (CPACC). Project Appraisal Report. World Bank 1997.
[10] CARICOM. Participating Countries: Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago.
[11] Implementation Completion Report for A Planning for Adaptation of Global Climate Change Project. Report No. 24911. World Bank 2005.

and technical support to better define the regional position at the Convention and Conference of Parties.

Design and implementation of a sea level and climate monitoring system that contributes to regional assessment of the impacts of climate change. A total of 14 stations were set up to document sea level rise, sea surface temperature, and varied meteorological data.[12] The network fills a critical need in collecting and assessing climatic information at a regional scale relevant to the issue of climate change. Data collected by the network are also essential to the success of any downscaling of modeling efforts for projection of climate changes in the region. Most of the stations started operating in 2000. While several have experienced maintenance and operational problems, this network constitutes the largest regional effort to document sea level rise and sea surface temperatures, along with other climatic data.

Figure 10. Network of CPACC stations for measurements of sea level rise and sea surface temperature



A Regional Archiving Centre (RAC) for Regional Climate Change and Sea Level Rise was established at the UWI Engineering Institute in collaboration with the UWI Department of Surveying and Land Information in the Faculty of Engineering at St. Augustine. CPACC has established a Web site as the main source of information on the project. The Web site provides links to other relevant global information sources on climate change. This network continues to operate and is now being updated and refurbished under the MACC Project. Figure 10 shows the location of the stations and their relation to the network of similar facilities in Central America. The stations are being made part of the Global Ocean Observation System (GLOOS). Continuation of this effort is a priority for the region and is being undertaken under the MACC Project.

Development of coral reef monitoring protocols to enhance regional monitoring of coral health and rates of deterioration. Corals are the nursery of the seas, providing the habitat for many sea species. These are very productive ecosystems. However, corals are very sensitive to

[12] Meteorological data included wind speed, direction, humidity, turbidity.

changes in temperature and their upper thermal tolerance is very near the current sea surface temperature. In fact, there is already widespread evidence of a cataclysmic collapse. In a manner akin to the network of sea measurements, CPACC successfully developed a series of regional protocols and actual measurements for documentation of the health of corals in the region. This was required to ascertain the impact of climate changes on the rates of deterioration.

Three monitoring stations (Bahamas, Belize, and Jamaica) were operated for over two years and transect studies were conducted and recorded. The information collected confirmed the deteriorating stage of coral reefs in the region. The results of these measurements[13] also pointed to the need for deep measuring at key sites as well as the urgent need to set up asides (protected reef areas) to improve the odds of surviving ever-warming sea surfaces.

The Caribbean Coastal Data Centre of the UWI Centre for Marine Science has been expanded to a regional center for coral reef monitoring data. Meteorological data of international quality are available through the Caribbean Institute for Meteorology and Hydrology (CIMH). Standards for regional archiving; access, and reporting have been formulated and agreed, but apart from CIMH there are continuing problems with the retrieval and quality of the data from these sources. These problems are being addressed as follow-up activities of MACC.

In addition, under the Mesoamerican Barrier Reef System (MBRS) Project and the Coral Reef Targeted Research and Capacity Building for Management Project (both GEF–funded activities), there are working groups whose activities are directly related to climate change and several others whose research deals with topics that may be influenced by, or help to monitor the effects of, climate change.[14]

Development of vulnerability assessment tools and methods for coastal ecosystems A foundation has been laid in terms of human resource capacity building and heightened awareness of techniques, especially in the Geographic Information System (GIS) and use of satellite imagery to assess and characterize coastal resources. This is a critical task, central to the anticipated impacts of climate change in the region. A Coastal Resources Information System (CRIS) for each participating country has been prepared. Technical capacity and the institutional framework for decision making have been improved through training and arrangements for data gathering and analysis. IKONOS (remote sensing) and CRIS software have been successfully introduced to monitor coastal zones in the region.

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[13] Measurements included: turf algae; encrusting corals; fleshy algae; corals; fish; sponges, as indicators of sewage pollution; chlorophyll obtained by remote sensing; frequency of incidents of coral bleaching, using Hot Spots imagery informing and being supported by ground checks.

[14] Under the MBRS Project, coral cover and coral conditions in participating countries are monitored regularly under a routine protocol that is part of the regional Synoptic Monitoring Program (SMP). Under the coral health monitoring component, coral bleaching and coral disease are routinely monitored in both permanent and random transects that form part of the monitoring SMP. These are then entered into the Regional Environmental Information System database for analysis and reporting back to countries. The Bleaching Working Group is looking into the molecular basis for bleaching (studies include analysis of the metabolic pathway of temperature-related bleaching to understand the mechanism and whether or not it can be controlled by manipulating the symbiotic zooxanthellae within the coral. Evidence indicates that different strains of zooxanthellae show differential sensitivity to thermal stress and it may be possible to innoculate corals with less sensitive strains). In addition to molecular mechanisms, the Working Group is looking at variations in bleaching response at the organism and community levels to predict the long-term implications of recurrent SST increases and bleaching events on community structure, reef function, and ultimately ecosystem goods and services. Another working group is looking at coral disease and its relationship to bleaching (could bleaching trigger disease outbreaks in affected corals by increasing pathogenicity of the disease agent or lowering tolerance in compromised corals?). Moreover, higher temperature may somehow trigger mutations in terrestrial viruses or increase the toxicity of latent vibrio in the water column.

IKONOS satellite imagery was produced and used for updating shoreline and other land features in the region. However, problems prevented its widespread use in the region. The major problems have been in: (i) data collection and retrieval; and (ii) capacity disparities among the participating countries in terms of their abilities to absorb and hence benefit from participation and from receipt of project deliverables. A "virtual critical mass" of GIS practitioners has been created through a regional network. This activity has also provided equipment and software to the UWI Centre for Resource Management and Environmental Studies (CERMES) in support of a one-year academic program leading to the Certificate in Geographic and Land Information Systems. The installed capacity and experience gained will be used as a foundation for the identification of adaptation measures under the SPACC Project.

Creation of a collaborative regional network for the establishment of programmatic linkages between climate change and related activities. Beyond the specific achievements of the project, CPACC must be credited with a significant and early awareness among political decision makers in the region of the gravity and urgency of the climate problem. In fact, CPACC was instrumental in empowering the region to present a coherent and unified vision before international fora on the urgency of adaptation needs. Ultimately, these efforts led to the revisiting of funding issues for adaptation (see INAP section) and contributed to the inclusion of an island climate change agenda at the Conference of Parties.

Mainstreaming Adaptation to Climate Change in the Caribbean (MACC–P073389)[15]

The success of CPACC illustrated both the magnitude of the problem and the need for additional work on adaptation. A key issue early identified in CPACC was the need to mainstream decisions on adaptive capacity and adaptation actions within the economic planning in the region. In addition, while CPACC was very efficiently executed with the assistance of the OAS, the long-term success of adaptation activities in the region made it essential to develop indigenous institutional capacity to lead the adaptation agenda. Further, CPACC work also revealed the need for detailed assessment of vulnerabilities. Within this context and through the involvement of CARICOM, the MACC Project was formulated in 2002, presented to the GEF Council and the Board, and approved in 2003.

The objective is to facilitate the development of an enabling environment for climate change adaptation in CARICOM's small island and low-lying developing states (the participating countries are: Antigua and Barbuda; Bahamas; Barbados; Belize; Dominica; Grenada; Guyana; Jamaica; St. Kitts; St. Lucia; St. Vincent and the Grenadines; Trinidad and Tobago). This will be pursued through support for: (i) further capacity building in adaptation; (ii) mainstreaming adaptation to climate change in sector development planning, policy making, and sector strategies and measures; and (iii) facilitating national policies and formulating a long-term regional strategy for adaptation.

MACC builds on the achievements of CPACC. The linkage between CPACC's activities and achievements and MACC's proposed components is summarized in Figure 11. The project was designed to follow on CPACC's achievements, picking up where the project ended and providing a strong linkage between the stages of adaptation envisioned by the convention. To advance on these achievements, the region considered it essential to incorporate climate change considera-

[15] Mainstreaming Adaptation to Climate Change Project. Project Appraisal Document. Report 25540. World Bank 2003.

tions into sector policies. This is being done, primarily in tourism, water resource planning, fisheries, forestry, and agriculture. The context in which these policies are being developed is summarized below.

Tourism. Among the most important sectors at risk is tourism. Tourism is the single largest contributor to GDP in many Caribbean countries, accounting for up to 83 percent in Antigua and Barbuda, 46 percent in St. Lucia, and about 25 percent both in Belize and Grenada. It is also one of the fastest growing industries in the region. Tourism arrivals in the Caribbean doubled between 1980 and 1996 and the industry has the potential to grow 70 percent and create 2.2 million jobs by 2007. With its economic importance and dependence on sensitive natural resources and coastal property, its vulnerability to climate change is of great concern. Tourism activity has strong linkages to the quality of the area's natural resources including coral reefs and other natural areas, weather, beaches, and coastal property, and access to basic services including water supply. There is a growing consensus within the scientific community that climate change will likely be disruptive to these resources (water supply, coastal resources, and weather) and result in severe economic and social effects on islands where tourism is an important economic sector. Of particular concern is the tourism infrastructure (ports, hotels, water supply) and beaches which are at risk from inundation or erosion due to sea level rise.

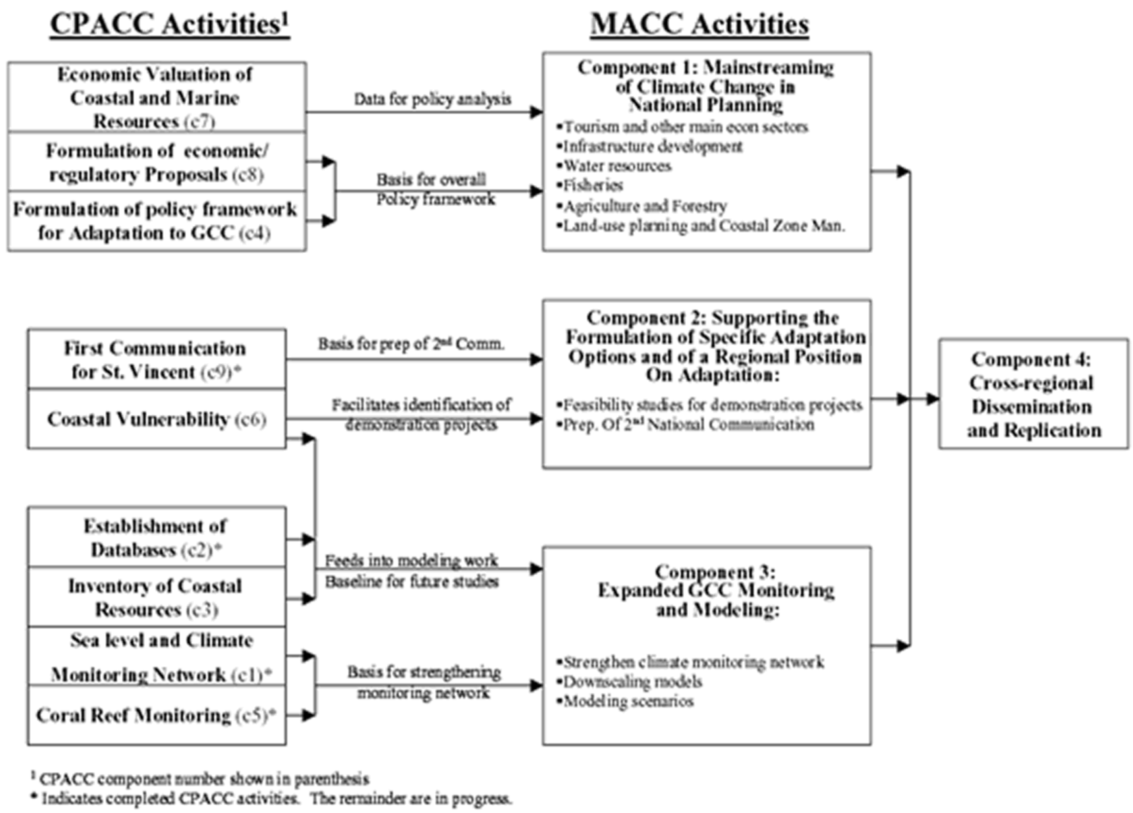
Water Resources. The ability to meet future demand may be affected by climate variability and change since most countries depend significantly on rainfall to replenish aquifers and may also be vulnerable to salt water intrusion as a result of sea level rise. The reductions in rainfall associated with global climate change would have a significant impact on water supplies, agriculture, and forestry. In addition, the infrastructure for water supply may be impacted by the needs for water conservation and vulnerability. Exacerbating this issue is the structure of water tariffs and rates. Generally, water is not being treated in the region as an economic and environmental good. Consequently, water rights, markets, and pricing are not being used to improve its sustainable use. Essentially, governments subsidize water use. Only a few countries (Barbados, Trinidad and Tobago) have national water resource management plans.

Fisheries, Forestry, and Agricultural Sectors. The expected impact of climate change on fisheries in small Caribbean islands is rated as moderate. These ecosystems are not affected by sea level rise per se. But fish banks could suffer if the rate of climate change disrupts the natural succession of coastal ecosystems (e.g., mangroves, sea grasses, corals) on which the species depend. One likely outcome of climate change is the disruption of fishing grounds as a response to possible new sea current patterns with increased upwelling (bringing more nutrients to the surface and providing more food for the fish). Climate change may also result in incidents of coral bleaching and fish kills stemming from algae blooms caused by high nutrient levels in coastal waters, combined with higher temperatures and a reduction in freshwater infusion because of changing ocean currents. The full extents of the impacts on the agricultural and forestry sectors have yet to be assessed and quantified. It is anticipated that climate change will impact food production and yield, food security, and drought relief programs, and will exacerbate other problems associated with the agricultural and forestry sectors, including soil erosion, land degradation, and loss of fertility. Jamaica and Antigua, for example, are experiencing unparalleled droughts affecting their outputs and yields. Infrastructure for water supply in agriculture will be affected by requirements for conservation, storage, and vulnerability.

The project is now being implemented through CARICOM as a transitional arrangement that will lead to implementation through the CCCCC.

Specifically, the project is intended to lead to: improved capacity in the design, implementation and revision of adaptation policies and responses; a more coordinated approach to addressing climate change issues at the subregional and regional levels; improved data sets for utilization in the development of regional climate scenarios; the provision of relevant data/information for informing adaptation policies; and increased involvement of stakeholders through the process of comprehensive public awareness and education programs. The project will also continue supporting the monitoring networks.

Figure 11. Linkage between CPACC and MACC activities



Vulnerability and adaptation assessments.[16] Currently, two general approaches for vulnerability and adaptation assessment in relation to climate change are being applied. The most commonly applied approach uses scenarios of future climate change and socioeconomic conditions as a basis for simulation of impacts and adaptation. Alternatively, use is made of empirical observations, survey instruments, and other methods to investigate vulnerabilities, adaptive capacities, and adaptive responses to climate variability and extremes of the past or present. Given the limited capacity and available data in the region to generate credible site-specific scenarios of future climate and socioeconomic conditions as required under the first approach, MACC has adopted the second approach, involving the use of empirical observations and some expert knowledge, to develop national adaptation policies.

This is premised on the valid assumption that in identifying and taking action to reduce present-day vulnerabilities to situations derived from climate variability, countries would have started a process for adaptation to climate change. As more precise scientific data become available, they

[16] Trotz et al. Climate Change Adaptation Policy: The Caribbean Experience. 2004.

can be fed into the process to better define feasible and cost-effective adaptation options that a country might pursue. This becomes possible as the national policies developed are the beginning of an ever-evolving process, being updated and reviewed as scientific facts become available. This approach also addresses the issue of a need for action now despite the uncertainty associated with climate predictions.

Table 2. Vulnerability of ecosystem services and implications for economic activity

Issue or Resource Vulnerable to Climate Change	Potential Effect of Climate Change	Sectors at Greatest Risk	Economic Relevance
Freshwater availability	Reduced precipitation; increased evaporation and saline intrusion from sea level rise.	Water resources, agriculture and forestry	Water supply is anticipated to be a bottleneck for economic activity and a serious health concern. All water-using sectors would be affected.
Degradation of marine and coastal ecosystems	Sea level rise and changes in sea temperature can affect important ecosystems such as mangroves, fishing grounds, and coral reefs.	Fisheries and tourism	Fisheries account for a sizable share of GDP. Tourism accounts for up to 83% of GDP and is highly dependent on the marine ecosystem.
Land flooding	Sea level rise will result in flooding of coastal areas.	Tourism, agriculture, and forestry	Most tourism activities are located in the coastal zone. Significant capital investment assets and infrastructure could be affected.
Climate	Climate change may increase extreme events such as precipitation intensity, tropical storms, or droughts.	Multisectoral	The cost of hurricanes and other natural disasters in the Caribbean region has been estimated at several hundred million dollars over the past decade. These costs continue to increase.

The support of CIDA (Canadian International Development Agency). The ***Adapting to Climate Change in the Caribbean*** (ACCC) [17] Project was implemented in 12 CARICOM member countries from September 2001 to August 2004. The project was designed to maintain momentum on climate change issues after CPACC which officially concluded in December 2001, and to lead into a later follow-on program being proposed to the Global Environment Facility (GEF). The ACCC Project built on the initial experience gained through the CPACC Project, and addressed key areas that had been identified as priorities by the 12 participating Caribbean countries. This CIDA–funded project served in part as a bridge between CPACC and the MACC Project to which it contributes an integral component.

Like CPACC, several ACCC Project activities built upon the former project's experiences in order to consolidate, extend, and make sustainable climate change responses. A key objective of this project was to create conditions under which the region will be able to sustain climate change activities at the conclusion of the CPACC Project.

[17] The ACCC Project was executed through the Canadian Executing Agency (CEA) which comprised Canadian firms, de Romilly and de Romilly Ltd., and Global Change Strategies International (GCSI). Day-to-day implementation was the responsibility of the Regional Project Implementation Unit, originally established for the CPACC Project.

The project has fostered closer technical collaboration with non-CARICOM countries in the wider Caribbean region and the South Pacific, strengthened regional technical capacity, and established tools for the integration of risk management strategies into national physical planning frameworks. Extensive training has been provided on two comprehensive adaptation risk management tools that have been developed through the project:

- *Caribbean Risk Management Techniques for Climate Change*
- *Guide to the Integration of Climate Change Adaptation in the Environmental Impact Assessment (EIA) Process.*

A postgraduate program in climate change, established under the project at the UWI, will ensure that the region continues to benefit from the skills and expertise of trained technicians.

Building upon the successes of the CPACC and ACCC programs, a need emerged for a permanent mechanism to address climate change issues in the region. The idea to create a Regional Climate Change Center was born. The CCCCC, established in 2003, will serve as a regional mechanism to anchor, support, and sustain the program of action on climate change adaptation for the Caribbean, consistent with the region's position before the COP and the meeting of the Subsidiary Bodies on Science and Technology (STAP) to the UNFCCC. Establishment of a Climate Change Center in the region mirrors similar initiatives for the strengthening of institutional capacity in this field in Latin America and the rest of the world. It is also in direct response to the recommendations contained in the Institutional Development Initiative (IDI) of the UNFCCC, which has called for the establishment of "Regional Centres of Excellence in Climate Change" at the Fifth Conference of Parties.

The Caribbean Community Climate Change Center (CCCCC)

A key achievement of the CPACC–MACC transition was the creation of indigenous institutional capacity. CPACC established a working network of institutions to coordinate and implement regional efforts in climate change adaptation. It also developed a strong technical base capable of providing leadership in the regional effort on climate change, as well as policy advice and momentum. While this institutional arrangement delivered on the objectives of CPACC, it was only intended as a transitional step. An institutional home to anchor the technical capacity of the region, developed over the life of the CPACC Project, was required.

The Caribbean region will likely benefit from global adaptation resources because of the expected permanent impacts from climate change over which it has little control or influence. In this context, the Centre is designed to play several roles. First and foremost, it is expected to become a "regional center of excellence"[18] in capacity building, technical assistance, and coordination, as well as a support mechanism to the CARICOM countries in the areas of climate change adaptation and mitigation. Specifically, the Centre is designed to be:

- An advisory body on climate change policy to the CARICOM Secretariat and its member countries, and a source of scientific and technical information on climate change and its potential impacts on the region.

[18] Capacity Development Initiative (2001), produced by the GEF and UNDP, with technical assistance from the World Bank and UNEP.

- A coordinating body for climate change adaptation and mitigation activities, enhancing institutional effectiveness and maximizing synergies and cross-sectoral linkages among multiple stakeholders, national and regional institutions (public and private).
- A resource mobilization and devolution institution for regional and national activities in the field of climate change.

The Centre will be serving as an "articulating mechanism" for mainstreaming the climate change agenda. The Centre is expected to build upon existing capacity within national or regional institutions (public and private) that are largely focused on specific sectors or disciplines, and to leverage their resources in addressing and responding to climate change. It addresses the perceived need for a coordinating mechanism to maximize the use of scarce regional expertise, and for mainstreaming climate change adaptation and mitigation into national development policies and strategies as well as private sector activities.

As a regional center to facilitate the development of an agenda on climate change, mostly implemented by existing sector agencies at the national and regional levels, the Centre will rely on a limited number of core staff providing: (a) vision and direction for the climate change program in the region; (b) strong technical expertise with state-of-the-art knowledge on technical issues; (c) financial management; and (d) policy analysis. The Centre's creation was mandated at a meeting of CARICOM's heads of state in early 2001. It was inaugurated on August 2, 2005 in Belize, by that country's prime minister. The first years of operational costs will be funded through a grant from the Italian Government, allowing the Centre to establish its credentials. The Centre is now expected to implement both MACC and SPACC. It is now the logical house for all adaptation efforts in the region.

Implementation of Adaptation Activities in the Coastal Areas of Dominica, St. Lucia, and St. Vincent and the Grenadines (P090731)[19]

Once the GEF allowed funds to be invested in specific adaptation measures, it became evident that the Caribbean would be among the first regions to invest these resources in actual adaptation measures. However, given the limited nature of funding, it was necessary to ensure that several well documented and prepared activities would be selected for financing.

In this context, the project is being designed to support efforts by three island states to formulate and implement adaptation measures that would address the impacts of climate change on biodiversity and land degradation along their coastal areas. This project also seeks to make adaptation to climate change an integral part of a broader agenda that incorporates all of the major environmental agreements within national planning processes.

The project complements MACC's goals by seeking to establish an integrated operational framework to address the impacts of climate change on biodiversity and land degradation, and to support the formulation and implementation of specific adaptation measures. The ultimate goal is to make efficient and integrated use of the limited human and financial resources in small island states, taking practical steps to move forward on the implementation of adaptation measures.

[19] Trust Fund for the preparation of Implementation of Adaptation Activities in the Coastal Areas of Dominica, St. Lucia, and St. Vincent and the Grenadines. World Bank 2005.

The project will support the implementation, on a pilot basis, of such selected adaptation measures as: (i) reduction of vulnerability of water resources through supply and demand measures, and legal and institutional improvements; (ii) integration of land use planning, regulation, and enforcement with the conservation and restoration of native ecosystems impacted by climate change; (iii) reduction of pressures on biodiversity arising from habitat conversion induced by climate change impacts, through the adoption of more effective land and buffer zoning; (iv) countering of habitat fragmentation through the establishment of marine and coastal protection corridors; (v) adoption of modified coastal zoning statutes that reflect climate change concerns and policies as well as management options that promote the implementation of common objectives with regard to biodiversity, land degradation, and climate change; and (vi) specific investment options that would reduce the impacts of climate change on coastal and marine resources, thereby addressing impacts on coastal and fishing communities. While the specific measures that will be implemented are still under discussion, the leading options include:

- **Conservation and supply of fresh water in small islands (St. Vincent and the Grenadines)**. Rainfall has been decreasing and some models predict that further reductions would be caused by changes in precipitation patterns. The project will seek to adapt the island to a scenario of reduced rainfall and increased threat of saline intrusion in local aquifers. The adaptation measure would consist in improving demand-side management in water supply, effective collection of rain water, water desalinization, and protection measures for the existing aquifers to prevent overdrawing and surface pollution.

- **Prevention of land degradation measures and protection of critical coastal watersheds in Dominica.** These measures, which must still be defined in detail, will seek to protect coastal ecosystems and the environmental services they provide through a combination of restoration and conservation actions.

- **Protection of critical infrastructure against hurricane-strength winds (St. Lucia).** These measures would focus on beefing up current critical infrastructure (hospitals, fire department, and police stations) to face the likelihood of more intense hurricanes in the Caribbean Basin.

Trinidad and Tobago: Nariva Wetland Restoration and Carbon Offset Project (P094948)[20]

As part of the portfolio of carbon finance activities in the region (World Bank 2004), the Nariva Project offers a unique example of the potential combination of the mitigation and adaptation agendas. The Nariva Protected Area (7,000 ha) is one of the most important protected areas in Trinidad and Tobago (TT). It has a very rich biodiversity due to the varied mosaic of vegetation communities (tropical rain forest, palm forests, mangroves, and grass savannah/marshes). However, it was subject to hydrologic changes due to the building of a water reservoir upstream and more than ten years (1985–1996) of clearing by illegal rice farmers.

The objective of the proposed project is to cause carbon sequestration through the reforestation and restoration of the Nariva wetlands ecosystem. The restoration of the wetlands will result in other environmental benefits, including protection of endemic species in the area. This will be

[20] Trinidad and Tobago: Nariva Wetland Restoration and Carbon Offset Project. Carbon Finance Document. 2005.

achieved through a restoration of the natural drainage regime and natural and forced recovery of original vegetation cover. As a result of these actions, carbon would be sequestered and emission reductions would be caused. Restoration of the wetlands will strengthen their natural buffer service for inland areas, thus also representing an adaptation measure to anticipated increases in weather variability and weather events at these latitudes. The restoration work would also contribute to preserve the ecosystem's rich biodiversity. The project would include four activities:

- Restoration of natural hydrology. A water management plan would be designed and implemented to: (i) review the water budget of Nariva; (ii) identify the land form composition of the Nariva swamp area (geomorphologic analysis); (iii) develop criteria to select high priority restoration areas; and (iv) design and implement natural and engineered drainage options to accelerate the restoration of Nariva's ecological functions.

- Reforestation program. Between 1,000 and 1,500 hectares would be reforested, including areas to be covered with palm forest. Reforestation activities will emphasize forest areas that were present in the 1969 GIS analysis but were missing in the 1994 or 2003 analysis. These areas include the forest to the west of Sector B which was cut down by illegal rice farmers; the "bowl" to the west of Sector B; areas between the Environmentally Sensitive Area and the southwest corner of Sector A; Sandhill; clear-cut areas to the west of Kernahan; and the royal palm forest.

- Only species native to Nariva would be used. The appropriate use of swamp forest or rainforest species will be determined by the water level and extent of the flooding once the surveys provide soil elevation information and the hydrologic conditions have been rehabilitated. The aquatic vegetation will also be managed. Active management and control must be used and monitoring will be an integral component of this activity. Mechanical and chemical treatment of invasive species may be required to open areas for more natural plant communities.

- Fire Management Program. This will include fire training for local fire responders, site assessment of fire problems, overall fire response planning, and community outreach of fire and environmental education.

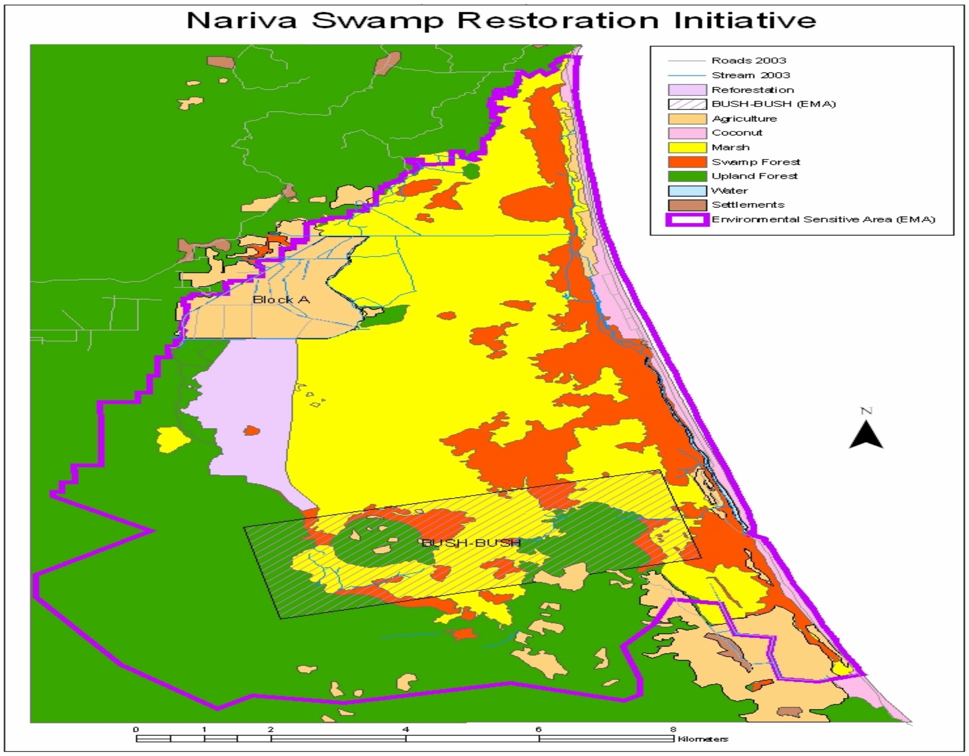
- Monitoring. The monitoring plan includes recording the response of reforestation activities and monitors biodiversity through key species.

Restoration would be achieved through reforestation, rehabilitation, and hydrologic restoration for the entire area. Once the areas to be reforested are defined, an appropriate mix of native species would be selected. Seeds and small trees will be (and already are being) collected from the surrounding forest reserves.

The hydrologic rehabilitation would involve a combination of improvement of existing structures and active management of the landscape to ensure the survival of the existing forest as well as that being replanted. A team of foresters, ecologists, hydrologists, and engineers would guide the work on the ground. In addition, it is expected that the labor force for the completion of the restoration will come mostly from local communities surrounding Nariva.

The project would constitute a unique opportunity to combine the goals of GHG mitigation with adaptation needs. Carbon finance resources, through the BioCarbon Fund, will purchase the reductions, which in turn will make the restoration work viable. A revitalized wetland will constitute a stronger buffer against storms.

Figure 12. Nariva Swamp Restoration Area where a unique combination of mitigation and adaptation measures would be undertaken



Adaptation in Mountain Habitats

Colombia: Integrated National Adaptation Plan (P083075)[21]

This is the first project submitted to the Council under the **Strategic Priority on Adaptation**. The choice of country and climate impacts is most adequate. Colombia has played a pioneering role in the region and indeed in the community of nations in the climate change field through: internalization at its highest decision-making levels of the climate change agenda; the forceful actions taken in terms of institutional strengthening at the Ministry of Environment and in regional and sectoral agencies; the quality of the vulnerability assessment undertaken in the context of the enabling activities under the UNFCCC; and the role the country is playing under the Clean Development Mechanism and the Kyoto Protocol.

Colombia is also a fitting choice, given the well documented vulnerabilities and the potentially large impacts that climate change would impose on the nation's development process. Given the country's natural resource base, climate change impacts are anticipated to have significant and long-term effects on fragile and unique ecosystems, accelerate the pace of land degradation, con-

[21] Colombia. Integrated National Adaptation Plan. Draft Project Appraisal Document. World Bank 2005.

tribute to the impoverishment of biodiversity of species of global importance (such as high altitude flora and fauna and unique corals in the western Caribbean), increase the exposure of its citizens to tropical disease vectors such as malaria and dengue, and generally affect the quality of life and prospects of development of its citizens.

Indeed, the impacts of climate change are already being documented through well designed and pioneering efforts undertaken under the aegis of the National Communications process and other studies. Unprecedented warming of the Caribbean Sea, linked to massive coral bleaching, drying up, warming, and rainfall changes in the mountains and the appearance of tropical disease vectors at 2,000-meter altitudes are part of the emerging picture.

It is in this context that the project has been submitted to the Council to address the top priorities identified in vulnerability assessments and to start what is likely to be a lengthy process of adaptation to climate change. The support from the GEF will make viable the actions proposed under the project. A partnership with agencies from Japan and North America will complement the base of financial and scientific resources that are being committed to ensure that this project is a forceful and influential step on the difficult road to adaptation.

The project will support two main activities:

1. Formulation of adaptation programs. The project will support the formulation of specific programs to address anticipated climate change impacts in high mountain habitats and insular areas of the country as well as in the health sector.

The project will seek to better document GCC impacts by: (i) improving climate monitoring systems, focusing on rainfall, sea level, temperature, and surface temperature measurements and on monitoring key indicators of vulnerable ecosystems; (ii) strengthening the ability to downscale global climate models to design and select climate change scenarios and to interpret results in order to define expected impacts; (iii) gathering baseline data, assessing historical development trends, characterizing key ecosystem cycles, and identifying environmental services; and (iv) completing a detailed epidemiological assessment for malaria and dengue.

2. Implementation of specific adaptation measures. The project will support specific pilot adaptation options to address impacts in high mountain and insular systems. In particular the project will make it possible to: (i) identify alternative options; (ii) prepare cost-benefit analyses of applicable options; (iii) develop an implementation strategy (institutional analysis, legal and regulatory assessments, stakeholder analysis, public awareness dissemination strategy, responsibilities, and implementation time frame); and (iv) support the implementation of key pilot adaptation measures that illustrate how these could be put in place to mitigate impacts and adapt the country to climate change effects. The pilot measures under formulation include:

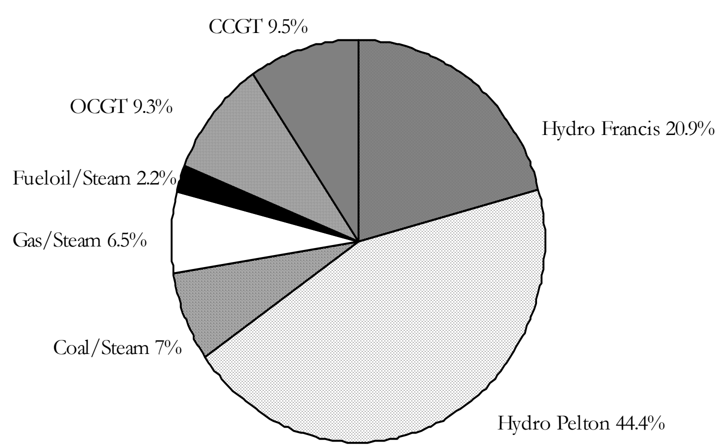
- ***Adaptation measures in the moorlands of the central range of the Andes***. The central range of the Andes in Colombia is host to the largest stretch of moorland habitat on the planet. This region, which covers most of the range's peaks measuring over 3,000 meters above sea level, is also credited with containing the most humid moorland (Páramo Las Hermosas). Altitudinal range and plentiful water have conspired to create a unique, rich biodiversity of unparalleled scenic beauty and valuable environmental services. All of this is being threatened by anticipated warming of the mountains. Local impacts may include extinction of species, reduction of water flows to downstream watersheds, alteration of carbon storage in soil, reduction in ability to provide hydropower, and impacts on agriculture and forestry.

Impact on energy generation. A reduction in the water flows from Las Hermosas Massif will have severe impacts on the ecosystem's ability to generate clean energy. On a wider scale, the impact of changes in the water cycle and the drying of high altitude ecosystems is of strategic importance for Colombia's power sector; which relies to a large extent on hydropower to meet demand (see Figure 13), making the sector a relatively small source of GHG. Two-thirds of capacity and 80 percent of demand are met by hydropower. The ability to continue to generate power using hydrological resources depends on the continuing provision of stable water flows in high mountains and the pattern of precipitation. A reduction in water flows and/or an increase in the uncertainty of supply will force the sector to increase its share of thermal capacity. This already happened during the years 1991 and 1992, when an ENSO reduced precipitation, forcing the country to ration power supply, with substantial costs to the country and impacts on industry, agriculture, and exports.

Thus, adaptation measures to conserve the Massif's ability to regulate water flows will contribute to the mitigation of GHG from the power sector. The project aims at implementing long-lasting measures designed to protect this environmental service. Specific measures being considered include: (i) increasing the buffer zone for Las Hermosas National Park to prevent land use changes as the temperature increases; (ii) strengthening the protection of riparian vegetation in efforts to reduce evaporation; (iii) changing agricultural practices to reduce other stresses into surface waters, caused by fertilizer runoffs; (iv) providing incentives for restoration of natural habitat; and (vi) strengthening protection for megafauna in the area. These measures are being examined and costs assessed. The implementation will begin in 2006.

Figure 13. Current composition of power sector generation capacity

Source: Long-term Planning for the Power Sector, 2004. UPME, Ministry of Mines and Energy, Colombia



- **Linkage to the Amoya Environmental Services Project (a carbon finance–supported activity).** Maintaining the potential to feed hydropower generation in Colombia is important because the country depends on these resources for about two-thirds of power requirements. Permanent disruptions in water supply caused by impacts induced by climate change in high mountain ecosystems would force the sector to diversify resources. This process would very likely lead to a gradual carbonization, as natural gas and other fossil fuels would be used to meet any gaps. In effect, the long-term planning for the sector now includes a scenario of increased thermal capacity to prevent over-reliance on hydropower. Moving to thermal generation will mean higher financial and environmental costs as most of the hydropower capacity already installed has been amortized and the costs of operation are significantly lower than the costs of operating coal or gas generation units. Moreover, increasing the thermal capacity will lead to higher rates of exposure to airborne pollutants such as NOx and particulate matter whose negative health impacts have been demonstrated.

Under the Amoya Project, an 80 MW run-of-river hydropower generation unit will be built using the stream of the Amoya River fed by moorlands of Las Hermosas, located in the central range of the Andes, above 3,500 m. The Amoya plant is expected to displace thermal generation in the region and will sell the resulting carbon emission reductions to the World Bank. The project will invest 10 percent of the expected carbon revenues (about E$ 2 million over the next 14 years)[22] in programs designed to ensure sustainable water supply; these programs would be jointly formulated with INAP.

Specifically, the carbon revenues generated by the operation of Amoya will be earmarked for activities that would document changes in the ecosystem and formulate and implement adaptation programs, thus also constituting one pioneering example of combined mitigation-adaptation efforts. The activities supported under Amoya include: (a) characterization, planning, and conservation of the soil cover in the moorlands; (b) water cycle study in the mountains; (c) monitoring and conservation program for endangered megafauna; and (d) support for sustainable agriculture at lower altitudes.

By linking carbon revenues to activities to conserve the ecosystem that regulates and provides the water for power generation, the project has a positive sustainability cycle (see Figure 13). The clean power generation results in the displacement of current and future thermal capacity which can be purchased under the CDM. Some of these revenues are being invested in conserving the moorlands, actions that would contribute to maintain a sustainable water cycle, under threat by climate change and other anthropogenic impacts. Maintaining a sustainable water cycle would ensure secure water supply to Amoya, which in turn can continue to displace thermal generation and gain carbon emission reduction revenues. The INAP and Amoya Projects demonstrate the potential for synergies between carbon finance and GEF–funded activities on adaptation.

[22] Amoya River Environmental Services Project. World Bank Report No. 26364-CO. 2004.

Figure 14. Las Hermosas Moorland is a wet and biodiverse site threatened by climate change impacts. An adaptation program for this area is part of the INAP and Amoya Projects.

- ***Early detection, diagnostic, and treatment of dengue and malaria in the Andes Piedmont.*** Climate change may have profound impacts on the transmission dynamics of dengue and malaria through other mechanisms besides pathogen development. Increases in temperature increase the rate at which mosquitoes digest blood meals, as well as the rate at which larvae develop into adult mosquitoes. Both of these, in turn, may increase the frequency of vector–human contact and the epidemic potential of dengue and malaria. Furthermore, periods of intensive rainfall or drought associated with the processes of climate change have been implicated in increases in the abundance of larval breeding habitats of vectors, which in turn result in a pattern of dengue transmission that is highly associated with seasonal rainfall, especially in Colombia (García et al. 2004).

  Strategies for adaptation to climate change must simultaneously prepare for uncertainty and work to reduce the vulnerability of populations to the potential negative impacts of global warming. With regard to malaria and dengue, this requires: (i) understanding how climate interacts with the other components of transmission in order to evaluate the risk of dengue and malaria transmission in space and time; and (ii) intervening in the appropriate components of the system and thereby reducing the vulnerability of populations to climate-induced epidemics. Accordingly, in order to mitigate the effects of climate change on dengue and malaria, INAP will develop a National Integrated Dengue and Malaria Surveillance and Control System (IDMSCS) in Colombia whose objectives are to:

  - Establish a surveillance system for dengue and malaria managed by the National Institute of Health of Colombia (INS) that integrates the climatic and nonclimatic components of transmission in order to regularly evaluate the spatio-temporal risk of transmission in populations of 51 cities in Colombia and develop effective dengue and malaria prevention and control strategies.

- Develop the operational capacities to systematically collect climatic, entomological, sociodemographic and epidemiological data necessary to evaluate transmission risk and develop a plan for preventive action adapted to the ecosocial circumstances of each participating municipality.

- Implement on a routine basis the surveillance and control activities and evaluate the IDMSCS taking into account sustainability and cost-effectiveness in the reduction of morbidity and mortality by dengue and malaria infection.

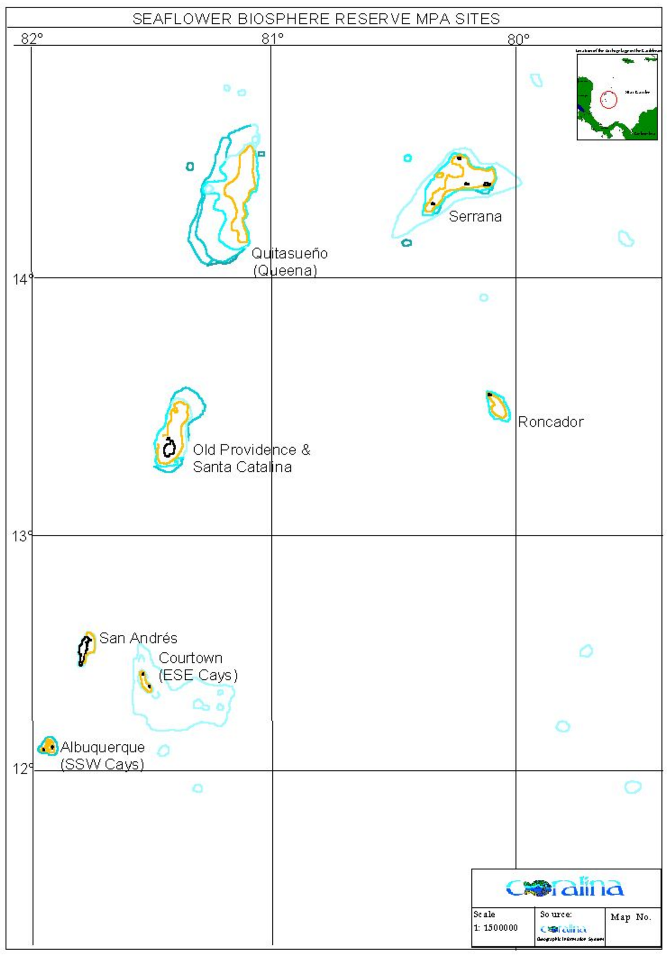
- ***Effective protection and monitoring of a marine protected area in the San Andrés Archipelago*.** Coral reefs in the western Caribbean are among the best conserved in the region. Nevertheless, they show global bleaching effects that can only be attributed to increases in sea surface temperature. The San Andrés Archipelago was recently identified as having one of the highest water temperatures in the region (NOAA 2005). The productive atolls and banks have extensive lagoons and microalgae beds. These ecosystems function as nurseries and feeding sites for a variety of commercially important species and are sites of major marine biodiversity. Fish production and biodiversity obviously would decline if these habitats were endangered or lost from the effects of climate change: specifically, increasing temperatures, salinity, and sea levels. The loss of the cays or their beaches would impact significant regional sea- and shorebird colonies and turtle nesting sites. Sea turtle species are believed to be at high risk from climate change because nesting depends on beaches with a narrow temperature range for successful incubation. Indeed, the very survival of the low-lying cays associated with these atolls and banks is threatened by climate change.

  The entire San Andrés Archipelago makes up the Seaflower Biosphere Reserve, which was declared a member of the UNESCO World Network of Biosphere Reserves in 2000. To implement the Biosphere Reserve in the ocean, the Corporation for the Sustainable Development of the San Andrés Archipelago (CORALINA) set up a marine protected area (MPA) which includes 65,000 km^2 of marine area and was declared by the Ministry of Environment, Housing, and Territorial Development in January 2005 (Resolution 107). It is the first protected area of this type in Colombia, the largest MPA in the Americas, and one of the largest in the world.

  To protect against such threats, there are four adaptation measures in the key area of the MPA: (i) Pilot Project for inter-institutional management of remote cays, atolls, banks, and coral reefs; (ii) Action Plan to develop and implement actions aimed at reducing the effects of increasing water temperatures and sea level rise on the MPA's coastal and marine ecosystems; (iii) Monitoring of coral health; and (iv) Capacity Building to train stakeholders to help with monitoring and adaptation measures. These measures will mitigate the effects of climate change on the MPA's ecosystems by putting in place inter-institutional management that targets climate change effects in remote areas and is sensitive to the potential impacts from increasing water temperatures and sea level rise; carrying out ongoing and events-based monitoring that will focus on biophysical parameters which are indicators of climate change and ecosystem health; and training a wide range of stakeholders and community members to support and play an active role in adaptation and monitoring.

Ongoing monitoring of coral health and ecosystem conditions will provide management with the information necessary to take a precautionary approach to changing conditions. Physical parameters such as water temperature and salinity will be widely monitored. Biological factors such as instances of disease and bleaching are important indicators of ecosystem health. Their relation to changing climate conditions must be assessed. Distribution and abundance of key reef-associated species must also be regularly monitored. This is an effort to completely isolate these areas from anthropogenic impacts so that the corals can have the best possible chance of withstanding the impacts of climate change. The project will support the costs of monitoring and controlling these set-asides.

Figure 15. MPA set-asides for reef protection and monitoring as part of adaptation measures to be funded by INAP



Implementation of Adaptation Measures to Address Glacial Melt in the Central Andes (P098248)[23]

The destruction of glaciers in Latin America is taking place in a geological instant, while their presence in these mountains is estimated at thousands of years. As indicated by Francou (2003), many of these glaciers were here when humans first arrived in the Americas. Quelccaya is at least 1,500 years old, Dasuopo is 9,000 years old, and Huascarán is 19,000 years old. A date for the ultimate destruction of these glaciers is not yet known, but it is likely that many of the smaller glaciers will be completely gone in less than a generation, drastically affecting water cycles and watersheds. These dramatic hydrological and ecological changes will likely result in a loss of global biodiversity, in addition to losses in ecosystem dependent goods and services, especially potable and agricultural water supply and associated hydropower potential.

For example, Peru contains roughly 71 percent of the globe's tropical glaciers. Since the early 1980s Peruvian glaciers have lost about 22 percent of their surface (500 km^2), equivalent to 7,000 million cubic meters of water (about ten years of water supply for Lima). In 1970, an earthquake fractured a glacier mass, causing Llanganuco Lake to overflow and killing 20,000 people in the small cities of Yungay and Ranrahirca. Peru also has over 12,000 lakes and ponds that could be destabilized from glacier melt. Similar reductions have been documented in Ecuador and Bolivia. The glacier on Pico Bolivar in Venezuela may completely disappear in less than a decade.

Furthermore, the combined impacts of global warming, ENSO, and extreme weather events on mountain hydrology are very disconcerting (IRD 2004). The combined impacts of more intense ENSO signals and ENSO's continuing impact on mountainous regions are likely to devastate highland and coastal agriculture and fishery ecosystems.[24]

Potential impact on water supply. Changes are expected in regional water supplies, including areas impacted by accelerated glacier melting, placing millions of already economically and environmentally stressed ecosystems and inhabitants at further risk of inadequate potable water. Furthermore, climate-induced glacial melt will likely precipitate the migration of human populations and megafaunal animals affected by extreme events. Thus, an average change in the distribution of water and agricultural resources will precipitate hydrologic stressors that will likely cause a sharp rise in intraregional and country-scale inequities, and a possible risk of political instability and conflicts.

[23] Regional Adaptation Project in the Central Andes. Project Concept Note. World Bank 2005.

[24] ENSO already exerts a dominating influence on the climate in many parts of the Andean countries and observations suggest El Nino events have become more frequent in recent decades. Identifying measures that strengthen the adaptive capacity of rural communities in Ecuador and Peru to climatic changes associated with El Niño events is the concern of a TFESSD project currently being carried out by the Climate Change Team. Addressing the interlinkages between addressing vulnerabilities to present climate risks and adaptation efforts to climate change will help to strengthen the sustainability of development processes aimed at alleviating poverty in climate sensitive sectors.

Figure 16. Many semiarid inter-Andean valleys depend on glaciers and snowcaps for water regulation and supply.

Potential impact on agriculture. Semiarid mountainous ecosystems in the region are highly vulnerable to disruption of local hydrologic patterns, placing subsistence agriculture and consequently rural livelihoods at risk. Anticipated dramatic fluctuations in the hydrologic cycle will exacerbate already stressed ecosystems and reduce the biodiversity and productivity of highland agricultural lands because of unreliable water supply. Furthermore, poor land use practices exacerbate already compromised and destabilized watersheds, root retention structures, and ecosystems. Much of the current research suggests yield decreases in the Andean highlands, tropics, and subtropics as a consequence of impacts on the water cycle and higher soil surface temperatures. The adaptive limitations of less developed subregions will likely increase the disparity in food production and food security in rural highlands.

Potential impact on energy generation. The region relies on hydropower to cover a majority of its power requirements, and many rivers that are used to generate hydroelectricity are glacier- or mountain lake-fed. Reduction in water flows will impact the potential for power generation and directly induce a carbonization of the power sector (countries going back to thermal power plants to make up for reduced hydropower potential), thereby increasing these systems' GHG emissions. Recent studies in Ecuador suggest that during the low-water period, the Paute Project (Paute River Basin) would only be providing between 43 and 45 percent of average power capacity, representing a reduction of about 27 percent compared to energy production under normal conditions. At least 75 percent of Peru's energy is hydroelectrically generated.

The project objective is to support regional efforts to define and implement pilot adaptation measures in order to meet the anticipated impacts from climate change in the Andean highlands.

Identification, selection, and formulation of adaptive measures. The project will support: (i) development of potential future regional climate scenarios; (ii) assessment of future climate scenario impacts on runoff through major regional watersheds as driven by the melting of glaciers and snow and the warming of moorlands; (iii) assessment of future climate scenario impacts on the incidence of extreme precipitation events (both floods and droughts); (iv) assessment of the impact of a potential runoff scenario on downstream potable water supplies, irrigation water for agriculture, and power generation; (v) identification and selection of highly vulnerable economic activities and ecosystems and identification and preliminary assessment of possible adaptation options (management, policy, infrastructure); and (vi) formulation of a regional adaptation strategy. The project will build analytical capacity for policy and project evaluation that can subsequently be expanded to include other sectors. Likely areas for immediate intervention include watersheds, and consequent impacts on hazards to life and property, watershed ecology and desertification, water availability, agricultural productivity/fisheries, and food security.

Implementation of pilot adaptation measures. The project will support: (i) institutional analysis, legal and regulatory assessments, a stakeholder analysis and consultation process, and public awareness for the implementation of adaptation measures; and (ii) design and implementation of pilot adaptation projects in selected communities, and key economic sectors where vulnerability is greatest and the region's interest is the highest.

Other Priorities

While the work done so far on adaptation focuses on the Caribbean and on Andean mountain habitats, there are other areas that require attention and where impacts are already being felt. For example, analytical work done in Mexico points out the following priorities for adaptation:

a) increased vulnerability of coastal zones to hurricanes, on both coasts, induced by higher sea surface temperatures;

b) changes in the water cycle, with emphasis on Northern Mexico and Chiapas, caused by modifications in precipitation patterns and totals;

c) acceleration in the process of desertification in mountain ranges, caused by higher temperatures, and induced increases in forest fires.

Likewise, other large ecosystems have been identified as vulnerable. These include inland and watershed areas, savannahs, and other inland ecosystems. Relatively little work has been undertaken in these other areas of the region. Nevertheless, these may also have substantial and long-term implications for many people and for large tracts of land.

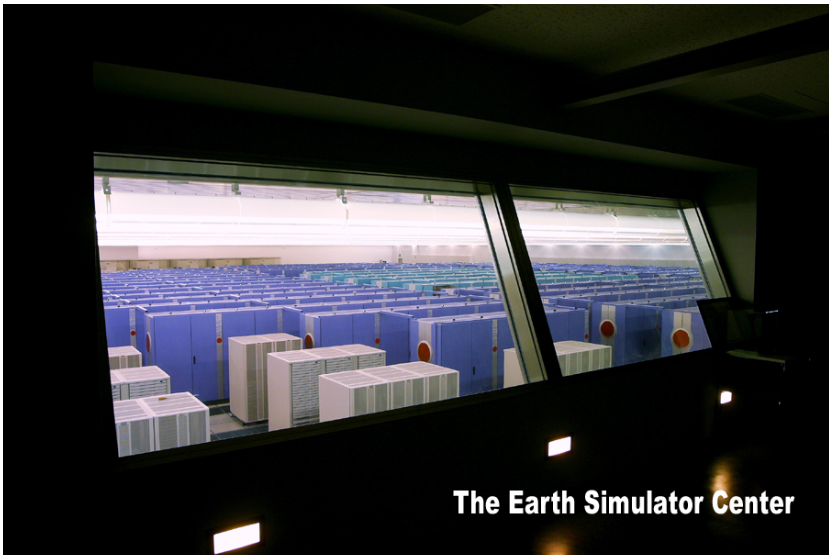
Simulation of climate change impacts at regional scales (Cooperation with the Earth Simulator)

There is a need to work on modeling to better understand the specifics of impacts. Nevertheless, very little is known about local and regional impacts. Most modeling work has been done on a global scale and regional simulations have focused on impacts in northern regions of the planet.

In early March 2002, a massively-parallel-vector supercomputer, the Earth Simulator (ES), came into operation, enabling simulations of the general circulation of the global atmosphere with horizontal resolution of about 10 km. The overall principles of the Earth Simulator Program were established by the Meteorological Research Institute of Japan (MRI) and included: (a) quantitative prediction and assessment of variations of the atmosphere, ocean, and solid earth; (b) production of reliable data to protect human lives and properties from natural disasters and environmental destruction; (c) contribution to the symbiotic relationship of human activities with nature; and (d) promotion of innovative and epoch-making simulation in any fields such as industry, bioscience, and energy.

The MRI employs a general circulation model called AFES[25] which has been fully optimized to the unique architecture of the Earth Simulator, to attain extremely high computational efficiency. The ultra-high resolution global simulations with AFES are able to explicitly represent interaction among planetary, synoptic, and meso-scale phenomena and the topographic modulation of meso-scale precipitation. The Earth Simulator is the fastest civilian-use computer available today (40 Teraflops) and uses SRES scenarios to simulate regional climate changes.

Figure 17. View of the Earth Simulator. The regional results of simulations by the Earth Simulator are being applied in two GEF–funded projects in the region (INAP and SPACC).



As part of the preparatory work for INAP and for the SPACC Project in the Caribbean, an agreement was reached with the MRI to provide technical assistance for interpretation of regional results from the Earth Simulator in Japan.

The agreement covers the following:

Colombia: The Earth Simulator Results (20 km x 20 km grid) would be made available for specific regions in Colombia (i.e., central range of the Andes, covering snow peaks and moorlands as well as downstream watersheds).

Caribbean: Earth Simulator Results (20 km x 20 km grid) would be made available for specific coastal areas in the three countries, covering marshlands, inland wetlands, coral reefs, and areas of tourist and fishery activities.

Scope of the Cooperation. Under the agreement, the following activities would be provided for by the ES team:

[25] The original code of AFES was adopted from version 5.4.02 of an AGCM developed jointly by the Center for Climate System Research (CCSR) of the University of Tokyo and the Japanese National Institute for Environmental Sciences (NIES). The particular version of the CCSR/NIES AGCM has been used for several international modeling efforts, including future projections for the Intergovernmental Panel for Climate Change (IPCC, SRES) and the Atmospheric Model Intercomparison Project (AMIP).

- training in Japan to enable efficient use of ES data
- technical assistance to interpret results
- scientific exchange
- cooperation for dissemination of results in scientific literature
- participation in meetings of the Subsidiary Body for Scientific and Technical Advice (SBSTA) and IPCC.

The agreement responds to the operational principles of the Earth Simulator and constitutes the first cooperation effort to provide the results of simulations on a grid commensurate with local and regional needs in Latin America.

Beyond the specifics of the cooperation and the eventual results, the agreement will help fill a void in information that could seriously delay adaptation work in the region. This partnership is a pioneering effort that should be widely replicated. Together with the expansion of monitoring networks, the simulation of regional impacts will be essential to formulate adequate adaptation measures.

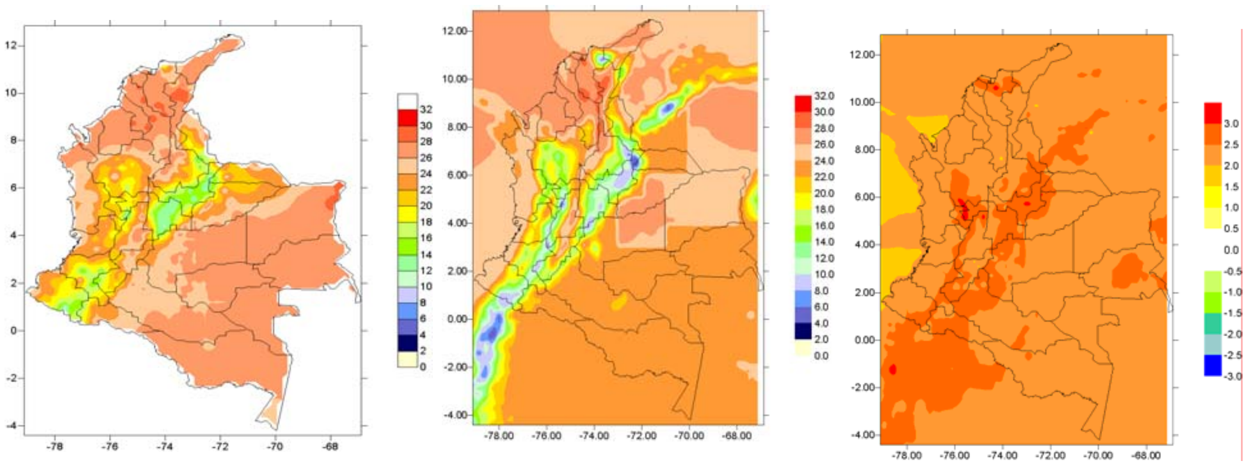
Example of cooperation with Kyo Sei. Early results for INAP. Under the Agreement with the MRI, a team of Colombian scientists visited Japan in August 2005 to begin the process of application of results to areas of work under INAP. The visit and scientific discussions resulted in a wealth of data that will be of use in the formulation of adaptation measures under the INAP Project. Although it is still too early to report on early results and much programmed work must still take place, some of the data collected (IDEAM 2005) is shown below. Figure 18 shows a comparison of surface temperature, between information collected using the network of 685 weather stations of the Colombian IDEAM network and the modeled information from the Earth Simulator for various runs. The runs considered for the cooperation work are shown in Table 3.

The preliminary results show the significant potential that exists for use of Earth Simulator data to assist in adaptation work. The correlation between actual and simulated data is significant. The work already begun on interpretation of results for the pilot areas under INAP (e.g., Las Hermosas Massif) will further facilitate projections on which adaptation measures can be based.

Table 3. Runs through the Earth Simulator, on surface temperatures

Runs	SST	Annual Variation	Integration period
AJ	Observed	No	10 years
AK	Observed + anomalies	No	10 years
AM	CGM SST 1979 to 1998	Yes	1979 to 1998 20 years
AN	CGM SST for scenario A1B, 2080 to 2099	Yes	2080 to 2099 20 years

Figure 18. Comparison of actual (average 1961–1990 data from 685 weather stations) versus modeled isothermals (run AM from the Earth Simulator) and future temperatures (2080–2099) for the month of January[26]



The analysis of the resulting projections for the 2080–2099 period also illustrates some key points:

a) temperature will increase between 1.5 and 2.5 degrees Celsius throughout most of the nation;
b) higher temperature increases are projected for the mountain ranges and the central area of the country, where most of the installed hydropower capacity is located;
c) the same area will experience a net decrease of rainfall;
d) increased variability, with more intense periods of rainfall;
e) an increase in net rainfall over the Amazon and Orinoco regions.

[26] IDEAM, 2005**.** Informe Preliminar de Actividades. MRI.

Recommendations for further work

In the context of the institution (as well as other multilateral agencies and development agencies), the region holds a strong lead in the implementation and formulation of adaptation activities. Given the characteristics of natural resources in the region and the dependence of regional economic activities on environmental services, adaptation work should be central to environmental issues and significantly expanded.

An expanded work program could ideally include at least the following elements:

1. Strengthening and expansion of work on institutional development and technical assistance in climate change is a basis for progress on climate change issues in the region.

Enabling activities (activities in support of institutional strengthening, inventories of emissions, and vulnerability assessments) have been supported by the GEF with assistance from United Nations (UN) agencies and the World Bank since the inception of the GEF Trust Fund. Although there have been significant achievements, including support to the preparation of National Communications, further work is required. The scope and reach of funds for enabling activity funds should be expanded to include major work on vulnerability assessment and scientific and technical assistance required to understand impacts on ecosystem services and the sectors they support.

2. Better understanding of climate trends and projected impacts is essential for the work on adaptation.

Despite some significant progress, very little is documented on local and regional trends and projected impacts. The Bank can play an important role in supporting the application of downscaling tools and models as part of project preparation and in the development of monitoring networks. The partnership between a leading projections group (the Meteorological Research Institute of Japan to use the Earth Simulator results in the INAP and SPACC Projects) and local agencies in Colombia and the Caribbean should be replicated elsewhere.

However, downscaling by itself may not suffice. To ground test model results, local data needs to be available, not only for temperature increases but also for parameters that would illustrate the impacts of climate change at a local level. Without local and regional information, the adaptation work will suffer delays and uncertainties. Useful examples of what can be done consist of the monitoring of environmental parameters in Las Hermosas Moorlands (as part of the INAP Project) and the sea monitoring networks in the Caribbean.

3. Mainstreaming of climate concerns into national and regional policies is required to ensure sustainability of climate initiatives.

Successful adaptation requires a supportive set of policies, regulations, incentives, and their enforcement. While progress has been made in the adoption of sustainable resource management policies, much remains to be done. For example, many policies for the use of natural resources do not take into account relative scarcity or sustainability of use in the long term. Furthermore, climate change impacts are seen by some policy makers and other key stakeholders as issues of little current or local relevance, for which low priority is required. Consequently, some climate change activities have not benefited from long-term sustainable commitment. All of these point to the need to develop an enabling environment for climate change adaptation. Successful integration of local agendas with the long-term concerns about climate change impacts is required to ensure sustainable actions on both fronts. Examples of integration include:

- Coastal zoning in the Caribbean islands to address issues of disaster prevention, adaptation to strengthening of intensity of hurricanes today and sea level increase in the future.
- Land use management in Trinidad and Tobago to prevent wetland degradation and promote restoration work, protecting critical habitat today and providing a buffer zone for increased weather variability in the future.
- Protection of moorlands in the northern Andes to maintain local environmental services (water, energy) today and ensure the ecosystem's survival in the future.
- Disaster prevention measures taken today and future climate change adaptation measures naturally form a continuum and should be integrated.

Incorporating climate change concerns into policy tools will also require a change of attitude. Climate concerns need to be made a central part of policy dialogue and structural adjustment work. Sector policies should incorporate climate concerns to ensure sustainability. This proactive approach of mainstreaming must be integrated as part of sustainable development strategies such as Country Assistance Strategies (CAS), Country Environmental Assessments (CEA), and Development Program Loans (DPL). The recent involvement of the institution in the G-8 agenda on climate change should emphasize adaptation in the dialogue with developing countries.

4. Work on ecosystem restoration and climate change adaptation needs to be made more complementary and mutually supportive.

As illustrated in the MEAR (2005), ecosystems on a global scale have suffered major deterioration, raising doubts about the sustainability of current patterns of use. In many instances the deterioration has also rendered the same ecosystems highly vulnerable to climate impacts. The Strategic Priority on Adaptation incorporates biodiversity and land degradation concerns into climate change. The GEF operational programs on biodiversity and land degradation are incorporating the impacts from climate change.

5. In the same vein, synergies should also be sought between the mitigation and adaptation opportunities and challenges in the region.

Carbon finance resources offer singular opportunities to combine the need to sequester carbon through restoration of ecosystems and the adaptation agenda. The combination of agendas under the Trinidad and Tobago Nariva Wetlands Restoration Project and in the case of Las Hermosas Massif in Colombia, under the INAP and Amoya Projects, provides useful examples for replication. In particular, the BioCarbon Fund represents a unique opportunity to integrate these two agendas around the need to conserve and restore key ecosystems. The region already has a large pool of initiatives under the BioCarbon Fund and provided additional funding is secured, it could contribute to efforts to restore ecosystems that are important in terms of adaptation.

6. While work on coastal zones and high mountain habitats has been undertaken or is under preparation, other priority ecosystems have yet to be covered.

These include inland and watershed areas, savannahs, and other inland ecosystems. Relatively little work has been undertaken in these other areas of the region. Nevertheless, these may also have substantial and long-term implications for many people and for large tracts of land.

7. Sector work.

Climate change will have repercussions on sectors such as coastal development, water supply, energy, agriculture, and health. A major effort, already initiated to some extent in the region, needs to be launched to better understand the anticipated impacts, help strengthen adaptive capacity, and promote adaptation measures. This can be better done once the climate issue is internalized in sector agendas.

- **Disaster prevention and response**. The impacts of climate change on the intensity of hurricanes imply an increase in risks for coastal nations in the Caribbean Basin, both Central American coasts, and possibly the South Atlantic. Increased chances of flooding and sudden glacial outflows also represent higher levels of risk for coastal and mountain populations and infrastructure. Strong coordination between the disaster prevention and response agendas and the climate change adaptation work is required. The impact of climate change on catastrophic weather events has been documented in the cases of hurricanes that lead to consequent quick onset situations of floods and landslides. At the same time, climate change is expected to result in slow onset events such as drought which is not only considered a natural disaster in itself, but also leads to increased erosion, landslides, and forest fires. Adaptation to climate changes leading to catastrophic weather events will require:

    – Strengthening of weather forecasting and monitoring systems;
    – Vulnerability analysis, risk identification and risk mapping;
    – Development of land use plans for risk reduction;
    – Development of emergency plans;
    – Identification, construction and/or reinforcement of disaster mitigation works and measures;
    – Identification and reinforcement of lifeline infrastructure at risk;
    – Planning for financial risks.

- **Coastal zone development**. The potential impacts of climate change pose serious concerns for populations, infrastructure, and economic activities in the coastal zones of the region. This concern is exemplified by the vulnerability of island nations in the Caribbean but extends to all coasts in the hemisphere. Major work is required on reducing vulnerabilities of existing infrastructure and on incorporating the climate issue in future development.
- **Impact of climate change on the endowment base for power generation capacity.** Variations in the hydrologic system and rainfall patterns raise concerns about the sustainability of hydropower generation along the Andes and the mountain areas of Central and North America. In particular, there is a likelihood of an increase in the rate of desertification in high mountain ecosystems (the source of many of the headwaters of the region's largest rivers). The impact on the overall hydropower generation capacity has yet to be ascertained but is likely to induce a diversification away from hydropower and probably an increase in thermal-based capacity. This would lead to higher GHG emissions from the power sector.
- **The promotion and development of renewable energy** is being actively pursued by some countries in the region and must be supported as an alternative to meet the power sector's adaptation needs. Wind, geothermal, and other sources have strong potential in the region and are already being supported through GEF and Carbon Finance resources. More resources are

required. There is also a need to protect the hydropower potential through more aggressive conservation of basins.

- **Agriculture.** Impacts on agriculture are expected to be local and subject to climate variability patterns. The IPCC has warned of decreases in yields in the tropical areas. However, it is very difficult to generalize the impacts and draw conclusions based on available regional data. Sensible courses of action call for work on drought-tolerant varieties and diversification away from monocultures. In any event, as in all other sectors, climate change concerns need to be integrated into agriculture.
- **Health.** INAP's pioneering work in health and climate change has just started, yet it already offers some useful insights. Increases in exposure to tropical disease vectors are anticipated in the region. Temperate areas of the Andes and other mountain ranges are of primary concern. Additional work is required to gauge the magnitude of the issue, which can easily overwhelm already stressed services. Other health work in tropical diseases needs to incorporate climate concerns in its planning.
- **Water management.** Climate will affect water regulation and supply in Andean mountain areas, the availability of fresh water aquifers in islands and coastal zones, and the overall precipitation patterns near the equator. All of these will impact water supply for agriculture, power generation, and ecosystem integrity. Water management measures need to be closely coordinated with the climate agenda.

8. Harmonization of a long-term vision of climate change with short-term priorities for vulnerability to current climate variability.

Most of the countries in the region place more attention on responsive actions to natural disasters than on preventive actions by reducing risk, a responsibility that environmental authorities must integrate within planning mechanisms such as zoning plans. Adaptation is likely to be more successful to the extent that it is incorporated into the sustainable development process and it is recognized that response to current climate variability and extremes is a necessary, if not sufficient, part of an effective adaptation strategy. Moreover, adaptation is not only a matter of projects and measures but also involves the evaluation and development of policies. Accordingly, work on disaster management should be linked to climate change concerns and vice versa.

Vulnerability reduction is a cross-cutting issue that must be addressed in a comprehensive manner together with other aspects of sustainable development, preferably at the level of country dialogue instruments in the long term, the medium term (Poverty Reduction Strategy Paper–PRSP), and the short term (CAS-CEA). Although there is no consensus regarding the impact of climate change on the frequency and intensity of hurricanes and weather variability, it is prudent to link work on adaptation with disaster management and prevention. A linkage with ENSO events is also being debated in the literature and its implications should also be considered for adaptation work along the Pacific coast.

9. A major infusion of resources is required for adaptation.

Adaptation, even if carried out through the adoption of "no regret" actions, will be expensive. The region, while contributing little to the global issue, is at the receiving end of anticipated impacts. Adaptation will require considerable funding, well beyond what is available today through GEF funds and other sources. These resources will need to be complemented with additional funding. In the meantime, several regional priorities must be carefully selected to cover a range of affected situations, ecosystems, and economic activities.

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