Background paper

Impacts, vulnerability and adaptation to climate change in Latin America

Lima, Peru

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Executive Summary

- Observational records show that Latin America, with a few variations, has been warming throughout the 20th century
- Future climate change scenarios for Central and South America derived from global climate models for a range of greenhouse gases emissions scenarios (SRES scenarios) indicate considerable increases of temperatures and drier conditions for central and tropical South America
- The North Atlantic Ocean shows an increasing trend in frequency and duration of hurricanes that is significantly at the 99% confidence level. There is a large increase in the number of hurricanes reaching categories four and five
- Impacts of natural climate variability, including extremes, and climate change affect all sectors:
    - Droughts reduce agricultural production in many countries of the region
    - Torrential rains and resulting floods, including those associated with tropical cyclones, account for considerable human and economic losses
    - Receding glaciers in many Andean areas present a threat to water availability for hydro-energy, agriculture and settlements as well as to tourism
    - Sea-level rise is expected to affect most coastal zones in Latin America through salt water intrusion and increases in the frequency and intensities of storm surges
    - Vector-borne diseases such as malaria and dengue fever could spread
- Availability of climate data is limited in Latin America and there is a need to improve Latin American countries' capabilities and knowledge to undertake and maintain systematic long-term climate observational programs, along with the capacity to undertake analyses and modelling of climatic information
- Water resources, terrestrial ecosystems, agriculture and sea-level rise are the most common sectors reported to be vulnerable to climate change in the national communications
- Several Millennium Development Goals (MDGs) will directly be impacted by climate change. The MDGs are of vital importance in the context of sustainable development and constitutes a framework for international cooperation
- Adaptation options and strategies are reported unevenly in the national communications. Few of them report explicitly adaptive capacity determinants
- In Latin America, funding for adaptation studies and projects comes predominantly from international sources, in particular the Global Environmental Facility (GEF), the World Bank, and the International Development Bank.

I. Introduction

1.   The Intergovernmental Panel on Climate Change (IPCC), in its Third Assessment Report (TAR) reports a possible warming of about 0.7°C over most of the Latin America and the Caribbean during the 20th century. The exact nature of the changes in temperature, precipitation, and extreme events are not known, but there is a general agreement that extreme events may happen more frequently. By the end of this century, global mean surface temperature could increase by up to 6ºC. Sea levels could rise between 9 and 88 cm in the next 100 years. These are significant increases, and it is likely that the temperature increases are due to emissions of greenhouse gases mainly caused by human activities (IPCC 2001).

2.   During the past 400,000 years the concentration of atmospheric carbon dioxide has varied between about 180 and 280 parts per million by volume (ppmv) (IPCC 2001). However, in 2003 the level was 375 ppmv and there is a risk of an accelerating increase due to the rise in atmospheric concentrations of carbon dioxide, methane, nitrous oxide, tropospheric ozone and water vapour. Due to the amplification of the natural greenhouse effect, risks to human societies and ecosystems grow considerably. Many coral reefs and even the Amazon rainforest could suffer irreversible damage. In addition there is the risk of sea-level rise due to rapid melting of the world's glaciers and thermal expansion of the oceans.

3.   The impact of global warming on human life, livelihoods and economies will be wide-ranging. Reliable and easily understandable information is needed to establish the right level of awareness that is required to mitigate the worst consequences.

4.   Latin America and the Caribbean cover an area of about 19.9 million km^2. This region includes countries with the planet's greatest fresh-water reserves and is among the most biologically diverse. However, several countries in the region are vulnerable to extreme weather and climate and other climate change phenomena that may endanger biodiversity and the general basis for development.

5.   In 2000, Latin America and the Caribbean contributed 5.5 per cent of the world's total CO_2 emissions (excluding land-use change). The total global CO_2 emissions were estimated at 24,000 million tonnes. The CO_2 emissions from land-use change and forestry from the region make up 30 per cent of the world's total. This was attributed mostly to the destruction of the rainforest (figure 1).

Figure 1. Carbon dioxide emissions in the world and in Latin America and Caribbean

Source: UNEP

6.   Although the region contributes a relatively small fraction of the global emissions of greenhouse gases, it will be affected by climate change impacts as much as anywhere else in the world. In fact, considering that most Latin American countries are developing nations, the population, natural ecosystems, coastal zones, water resources, agriculture, forestry and human health are particularly vulnerable to climate change.

7.   The aim of this paper is to provide an overview on climate change impacts and adaptation in Latin America focusing on Central and South America. Impacts of current climate variability and projected change are reviewed, the vulnerability of a number of sectors and regions is analysed and adaptation strategies are elaborated. Finally, the constraints, needs and concerns of Latin American countries are evaluated and conclusions and recommendations are developed.

II. Data and information

8.   The study of climate change impacts over Latin America requires good quality information. Reaching conclusions on how a given region is being affected by climate changes requires access to data sources and knowing how to use them. This section provides a summary of available data and information for Latin America.

A. Status of availability of climate observations and analytical tools

9.   The Global Climate Observing System (GCOS) Climate Monitoring Principles (GCMPs) provide basic guidance for planning, operation and management of observing networks and systems, including satellites, to ensure that high-quality climate data are available and contribute to effective climate information. The GCMPs address such issues as the effective incorporation of new systems and networks; the importance of calibration, validation and data homogeneity; the uninterrupted operation of individual stations and systems; the importance of additional observations in data-poor regions and regions sensitive to change; and the crucial importance of data management systems that facilitate access, use and interpretation of the data. These principles have been adopted or endorsed by the UNFCCC process, World Meteorological Organisation (WMO), the Committee on Earth Observation Satellites (CEOS) and other bodies.

10.   The GCOS Surface Network (GSN), together with the other surface atmospheric networks, provides the basic observations of the surface climate. The GCOS Upper-Air Network (GUAN), together with related satellite observations, provides a baseline for the upper atmosphere. In the upper atmosphere, water vapour plays a critical role in climate feedback, and information supplementary to the current baseline observations is needed from reference networks and Global Positioning System (GPS) based techniques. Annex V presents a list of GSN and GUAN stations for Latin America. There are 119 GSN and 23 GUAN stations located in Latin America.

11.   The United States National Climatic Data Center (NCDC) is the archive centre for the GSN and GUAN, as well as being a WMO Commission for Basic Systems (CBS) lead centre for GSN and GUAN data. Its responsibilities include contacting countries to obtain historical data sets, digitize paper records, reformat received data, oversee GSN/GUAN monitoring activities, and make all received data available.

12.   However, the existence of a large gap in observational coverage in Latin America is a major problem, mainly at higher elevations along the Andes Range. High-elevation data are very important for the detection and assessment of climate change and its impacts on glaciers, snow cover, and run-off. There is now ample evidence to show a major retreat of most mountain glaciers during the past 100 years in response to widespread increases in temperature. In recent decades, the rate of glacial recession has increased tremendously (Houghton et al. 2001).

13.   The improved coordination of existing networks could yield benefits in efficiency and effectiveness, and collaboration between the nations of Latin America, such as in the area of instrument calibration, could and should be enhanced. Institutions in Latin America could solve some of the challenges being faced. For instance, in the La Plata Basin Project sponsored by the Global Environment Facility (GEF), it was suggested that cooperation and project proposals should focus on a regional to subregional scale, as continental-scale initiatives have proven difficult to carry out successfully.

14.   Locally, in some countries of Latin America, selected information is available on the Internet. In Annex II to this document, a list of online climate information from Latin American countries is presented. Most of the information was obtained from official WMO-accredited institutions (national meteorological services) in each country. All of them offer weather forecasts and satellite images, but just a few have climate information and/or analytical tools to study or improve information on climate and/or climate change.

15.   In general, Latin American countries do not have enough analytical tools for climate and climate change analyses. According to the GCOS February 2005 report, another reason for large gaps in observational coverage lies in the fact that the network of national correspondents works only on a voluntary basis. Retirements, political instability, economic problems and over-tasking of staff are only a few of the things that endanger the continuity of climate data series.

B. Training and capacity-building activities

16.   The UNFCCC Marrakesh Accords of November 2001, agreed upon at the seventh session of the Conference of the Parties (COP 7), include a decision and a framework outlining the initial scope of needs and areas for capacity-building in developing countries (decision 2/CP.7). The framework identifies the specific scope for capacity-building which seeks, among other objectives, to strengthen effective participation by Parties not included in Annex I to the Convention (non-Annex I Parties) in the Kyoto Protocol process and to strengthen existing and, where needed, establish new training and research institutions to ensure the sustainability of capacity-building programmes. According to the framework, these capacity-building initiatives should be country-driven and involve stakeholder participation. The main objective of this training is to increase the capacity of developing country officials to effectively integrate intergovernmental climate policy debate and climate change policies into sustainable development.

17.   Few countries in Latin America have the expertise needed for the study of climate, climate variability and climate change, as is apparent from the relatively short bibliography of research by local authors. But this expertise is important because recent observations have shown that the southern hemisphere, where the largest portion of the region lies, is warming more than the northern hemisphere (adapted from IPCC 2001).

18.   The situation in Latin America calls for specific research initiatives, comprehensive meteorological and ecological databases, appropriate data validation techniques, proxy data capture, and appropriate training of personnel, particularly on integrated assessments and development of appropriate adaptation option methodologies. More fundamental research on potential impacts of climate change is needed to develop appropriate adaptation and mitigation alternatives (IPCC 2001).

19.   One such initiative is the START project (SysTem for Analysis, Research and Training). It provides an international framework for capacity-building to conduct necessary regional and local-scale research into environmental changes and to inform decision makers. Some assessments of impacts of, and adaptation to, climate change in multiple regions and sectors (regional studies in Latin America) have been made.

20.   Given that more assessments of vulnerability and adaptation are required to develop adaptation strategies, a number of training activities have been developed to help users to analyse current climate

variability and to model projected changes and how these could impact each country (see Annex IV). Training programmes could be held at research centres across Latin America, such as the Brazilian Centro de Previsao de Tempo e Estudos Climaticos (CPTEC), the Argentinean Centro de Investigaciones del Clima y de la Atmósfera (CIMA), the Permanent Commission for the South Pacific (CPPS), the Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI), the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) and Universities in the region.

III. Assessment of the use and availability of general circulation models and downscaling tools

21.   The development of climate modelling capability for studies on impacts and vulnerability to climate change confronts a knowledge gap in Latin America. In Latin America, few countries are concentrating their resources on the development of detailed regional climate scenarios based on input from general circulation models (GCMs) designed in developed countries, i.e. downscaling. These scenarios provide crucial information for the definition of policies for adaptation to climate change. The provision of these scenarios has been the subject of training programmes such as the regional climate change workshop efforts by the United Kingdom Hadley Centre for Research and Climate Prediction and the British Department for Environment, Food and Rural Affairs (DEFRA) through the "Providing REgional Climates for Impacts Studies" (PRECIS) workshops.

22.   The climate change impacts community has long been dissatisfied with the inadequate spatial scale of climate scenarios produced from the output of coarse-resolution global atmospheric or coupled atmosphere-ocean general circulation models (AOGCM) (Mearns et al. 2001, 2003). This concern emanates from the perceived mismatch of scale between coarse resolution GCMs and AOGCMs (100s of km) and the scale of interest for regional impacts (an order or two orders of magnitude finer scale). For example, mechanistic models used to simulate the ecological, health or hydrological effects of climate change usually operate at spatial resolutions varying from a single plant to few hectares. Their results may be highly sensitive to fine-scale climate variations that may be embedded in coarse-scale climate variations, especially in regions of complex topography, along coastlines, and in regions with highly heterogeneous land surface covers. There are now techniques available for generating high resolution climate information, but some tend to be complex and/or computationally expensive. It is also not always straightforward to choose which techniques one should use, or to decide whether high resolution information is even necessary for approaching certain types of impacts problems.

23.   The horizontal atmospheric resolution of present global AOGCMs is still relatively coarse, of the order of 300 km, and regional climate is often affected by forcings and circulations that occur at smaller scales (Giorgi and Mearns 1991). As a result, AOGCMs cannot explicitly capture the fine-scale structure that characterizes climatic variables in many regions of the world and that is needed for many impact assessment studies. Therefore, different "regionalization" techniques have been developed to enhance the regional information provided by GCMs and AOGCMs and to provide fine-scale climate information. To date, most impact studies have used climate change information provided by equilibrium GCMs or coupled AOGCM simulations without any further regionalization processing. This is primarily because of the ready availability of this information and the relatively recent development of regionalization techniques (Annex VI).

24.   However, for some applications, the regional information provided by AOGCMs may be sufficient, for example when sub-grid scale variations are weak or when assessments are global in scale. In fact, from the theoretical view point, the main advantage of obtaining regional climate information directly from AOGCMs is the knowledge that internal physical consistency is maintained. AOGCMs cannot provide direct information about climate at scales smaller than their resolution; neither can they capture the detailed effects of forcings acting at sub-grid scales (unless parameterized).

25.   Therefore, in cases where fine-scale processes and forcings are important drivers of climate change the use of regionalization techniques is essential and recommended to the extent that it enhances the information of AOGCMs at the regional and local scale. The "added value" provided by the regionalization techniques depends on the spatial and temporal scales of interest, as well as on the variables concerned and on the climate statistics required.

26.   This chapter contains an assessment of the use and availability of GCM future climate change projections and downscaling tools in the Latin-American region. A review is made on the potential use of global climate change scenarios by Latin American countries as reflected in the national communications submitted to the UNFCCC secretariat, reports of the Inter-American Institute for Global Change (IAI), the Assessments of Impacts and Adaptations to Climate Change (AIACC) projects in Latin America, and national internal reports. This review is directed towards the identification of gaps in the technical capacity of each Latin American country regarding the development of, or access to, model climate change projections at global and regional scales using global or regional models.

A. The use of regional climate models as downscaling tools for climate projections

27.   Adaptation planning would benefit from knowledge of how the climate will change at spatial resolutions that are much finer than the relatively coarse resolutions of AOGCMs. Various methods are possible for downscaling the projections of GCMs to finer spatial scales, including regional climate modelling, statistical downscaling, and simple scaling procedures. Each has advantages and disadvantages; all are subject to uncertainties imparted by the AOGCM projections that are used as a starting point, all introduce their own uncertainties, and none is demonstrably better than the others for all users and all possible uses. Research is needed to evaluate the importance of spatial scale as a source of uncertainty relative to other sources in terms of impacts and implications for adaptation decisions.

28.   In climate change studies, RCMs/statistical downscaling is used to produce scenarios of future climate at high resolution. The main objective of downscaling is to take coarse resolution climate change results and produce climate change information at a higher spatial scale closer to that required for the impact application. Obtaining such high resolution results introduces its own uncertainty, as different regional models (or statistical downscaling methods) can yield different results, even when conditioned by the same AOGCM. The downscaling of climate change scenarios follows the methodology developed by the Hadley Centre (Jones et al. 2004). Previous experiments have suggested that regional climate model domains that are too large may allow the climate simulated by the regional model to decouple unrealistically from that of the driving boundary conditions. In contrast, if the domain is too small, the regional model may not have sufficient physical space to fully develop the dominant meso-scale flow features indigenous to the region.

29.   The importance of high resolution climate scenarios for impacts and adaptation studies has still not been thoroughly explored in Latin America. High resolution scenarios developed from regional climate model results have been applied to impacts assessments only in the past five years in various parts of the world, (North America and Europe, for example, as part of international projects). Initial national communications to the UNFCCC of Latin American countries, which were produced between 1997 and 2001, have shown some progress on the analyses of future climate change projections using global models. Most of these documents use the "older" IPCC IS92 model output used for the IPCC Second Assessment Report (SAR) (IPCC 1996), whereas the communications published after 2001 started to use the IPCC TAR Special Report on Emission Scenarios (SRES) scenarios. All these documents do not report the use of regional climate models for deriving future climate change scenarios.

30.   A recent assessment of climate change projections for the 21st century in South America (Marengo 2006) describes scenarios for various time slices of the 21st century in that region, derived from five IPCC TAR global coupled models. The analyses are focused on various regions of Brazil for mean

and extreme temperature and precipitation for the SRES A2 (pessimistic) and B2 (optimistic) emission scenarios. This publication acknowledges that the necessary adaptation measures vary with the spatial resolution, and that Latin American countries need to develop or have access to regional climate change projections. Climate projections for various emission scenarios and global models used for the IPCC SAR and TAR are freely available from the IPCC-Data Distribution Centre (DDC).[1] New climate change model projections from the generation of global coupled models used for IPCC AR4, for both mean climate and extremes up to 2100, are expected to be available during the second half of 2006.[2]

31.   In Latin America, the development of regional modelling for climate prediction and climate change projections is restricted to some countries or centres that are able to run regional models; these include the Center for Weather Forecasts and Climate Studies of the National Institute for Space Research (CPTEC/INPE), Brazil, the Centre for Investigation of the Sea and Atmosphere (CIMA), Argentina, the University of Chile (UChile), Chile, the National University of Mexico (UNAM), Mexico, the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC), Panama, and the International Center for Research and Study of the El Nino Phenomenon (CIIFEN), Ecuador. These centres of excellence could expand their roles in building and extending capacity to others.

32.   In the past, CPTEC/INPE and CIMA have fostered training activities on the enhancement of capacity to generate and to process future climate change scenarios using regional models, by means of the PRECIS initiative. These centres, together with UNAM, CIIFEN and CATHALAC, may play a future role in providing knowledge and application tools in a more concerted matter for activities on climate change modelling and data processing, and in hosting training activities at various levels. These capacity-building activities can also include the provision of some minimum computer equipment needed for climate runs, and especially data storage for archiving the climate change scenarios.

B.   Experience in the use of general circulation models and downscaling for regional climate projections

33.   This section gives an overview of projects that include future climate change projections from global models or from downscaling activities at the regional level in various countries and regions in their analysis. Besides some individual country efforts funded by local governments and funding agencies, such as the Inter-American Institute for Global Research (IAI), two major efforts have used climate change projections and downscaling: AIACC projects, and national communications to the UNFCCC.

1.   AIACC projects in Latin America

34.   Capacity-building programmes, including those under START, AIACC, IAI, PRECIS and the Third World Academy of Sciences, which were based on a "learning-by-doing" approach and engagement with stakeholders, have demonstrated real benefits. For example, some AIACC projects focused on climate change impacts and vulnerability assessments in Central America (Mexico, Nicaragua, Honduras, Costa Rica and El Salvador), and South America (Brazil, Argentina, and Uruguay) (see Table 1)[3].

Table 1. GEF-funded AIACC projects in Latin America

Project title and code	Countries involved
Assessment of impacts and adaptation measures for the	Central America (Costa Rica,

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[1] The DDC is jointly managed by the Climatic Research Unit (CRU) in the United Kingdom, the Deutsches Klimarechenzentrum (DKRZ/MPI) in Germany, and the Center for International Earth Science Information Network (CIESIN) at Columbia University, New York, USA. The main IPCC DDC web site is located at the Climate Research Unit in the UK (<www.ipcc-ddc.cru.uea.ac.uk>).

[2] Access to IPCC's AR4 is so far password protected and available at the Program for Climate Model Diagnosis and Intercomparison PCDMI web site in the US (<http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php>).

[3] Reports from those projects are available from the AIACC web site (<http://sedac.ciesin.columbia.edu/aiacc>).

water resources sector due to extreme events under climate change conditions in Central America (LA06)	El Salvador, Nicaragua)
Impact of global change on the coastal areas of the Rio de La Plata - sea level rise and meteorological effects (LA26)	Southeastern South America (Argentina, Uruguay)
Building capacity to assess the impact of climate change/variability and develop adaptive responses for the mixed crop/livestock production systems in the Argentinean and Uruguayan Pampas (LA27)	South America (Brazil, Argentina, Uruguay)
Integrated assessment of social vulnerability and adaptation to climate variability and change among farmers in Mexico and Argentina (LA29)	North and South America (Mexico and Argentina)
Assessing global change impacts, vulnerability, and adaptation strategies for estuarine waters of the Rio de la Plata (LA32)	South America (Argentina, Uruguay)

35.   All these projects have applied various scenarios from the IPCC TAR global climate models, currently available from the IPCC DDC web-site. Downscaling has been performed using stochastic weather generators, the Statistical Downscaling System Model (SDSM) and the MAGIC-SCENGEN for all three time slices 2010–2040, 2041–2070 and 2071–2100 projections for the SRES A2 and B2 scenarios. These projects have not used regional climate change scenarios.

2. National communications to the UNFCCC

36.   The initial national communications from Latin American countries are available from the respective national meteorological services web-site and from the UNFCCC web-site[4]. Two countries, Mexico and Uruguay, have already submitted their second national communications. Most of the countries have included in their analysis of global climate change the simulations from the IS92 scenarios and $2CO_2$ projections for 2010, 2030 and 2100 from the IPCC SAR (Bolivia, Chile, Colombia, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Mexico, Uruguay and Venezuela), while some other countries do not include assessments of global climate models (Brazil, Colombia, Peru). The most used global models are the GISS, HadCM2, UKTR ($1CO_2$ and $2CO_2$), GFDL, CCCM, ECHAM3. The global models used for each country have been chosen depending on their ability to simulate realistically the present climates of the countries. Venezuela used the A2, B2, A1 and B1 from IPCC SRES together with the IS92 scenarios. Downscaling was done using MAGIC-SCENGEN (Bolivia, Cuba, Dominican Republic, El Salvador, Guyana, Haiti, Honduras and Venezuela) as well as LARS-WG and SDMD. Other models used are the Holdridge Life Zone methods for ecological purposes (Bolivia, Cuba, Colombia, Ecuador, Guatemala and Guyana), and agricultural models such as DSSAT, CERES and others (Cuba, Guatemala, Guyana, Haiti, Uruguay and Venezuela).

37.   The second national communication of Uruguay was published in 2004, and it used results from the IPCC TAR models, including HadCM3, ECHAM4, CSIRO, and GFDL, as well as regional climate models, including HadRM3, for future climate scenarios and assessments of vulnerability (Unidad de Cambio Climatico 2005). So far, Uruguay is the only country in Latin America that used dynamic downscaling in its national communication.

C. Availability of future climate change projections

38.   Global model projections of climate change used for the IPCC TAR have provided a variety of information on climate scenarios at regional and global scale for the 21st century. Some of the analyses

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[4] <http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php>.

have produced documents and scientific papers or national reports such as the national communications. In Latin America various working papers derived from the AIACC funded projects have used the IPCC TAR AOGCMs for all available SRES emission scenarios. Currently, the IPCC DDC web-site holds the IPCC TAR AOGMCs, together with the baseline climate data from models and observations for the 1961–90 period, and the older IS92 and SRES scenarios used in the TAR. The DDC also holds a data visualization tool that allows for graphic options, guidance material for downscaling, and other material including monthly and annual data, for mean climate and basics variables (mean, maximum and minimum air temperature, SLP, wind, precipitation, mean sea level, solar radiation and humidity) up to 2100. No data for indices on extremes are available from TAR models.

39.   Daily data from TAR models are available directly from the numerical centres that run and produce the models (CSIRO, Hadley Centre, NCAR, NIES, GFDL, Max Planck Institute for Meteorology and Canadian Climate Centre). Seven models are available: HadCM3, CCCMa, CSIRO, CCSR/NIES, NCAR PSM, ECHAM4.5 and GFDL. For the TAR, climate scenarios from the seven AOGCM are available in the form of monthly means of selected variables from the IPCC-DDC web site in the United Kingdom, and this poses a notable limitation on the many aspects of analysis of extremes for impacts studies. Some progress has been made with the PCMDI for the IPCC AR4 data archive of AOGCM simulation output, where daily mean values for time slices of the future and the 20th century simulations are available, together with some derivatives indices for extremes as represented by the AOGCMs. Unfortunately, access to large data archives by climate change scientists in developing countries is limited by infrastructural problems of downloading processes or data storage.

40.   Currently, the IPCC TGICA (Task Group on Data and Scenario Support for Impact and Climate Analysis) that oversees the IPCC DDC is discussing the transfer of the AR4 model data to the DDC model site run at the Max Planck Institute's Word data Climate Centre WDCC, where the data will be freely available to the science community in the second half of 2006. Once the WDCC is operational, data from the AR4 models can be downloaded either for selected regions (South America among them), or for selected band providing latitude and longitude.

41.   Daily data from the IPCC AR4, needed either for calculation of other indices of extremes or to run regional models (each six hours), will be available upon request from the meteorological centres that produced the data. For instance, daily data are available from the ECHAM5 from the Max Planck Institute. In relation to IPCC TAR daily data, the Hadley Centre has undertaken this effort in South America by providing a sub-set of the HadAM3P model for South America, and sending it to Brazil, Argentina and other South American countries on a portable hard disk, so downscaling activities in such countries can be implemented. This has been part of the PRECIS training activities.

D. Availability of model projections

42.   Various international projects across the world are currently working with regional climate scenarios on studies of detection and assessments of impacts and vulnerability. In Europe, there is the Prediction of Regional Scenarios and Uncertainties for Defining European Climate change Risks and Effects (PRUDENCE) project, and in North America, the North American Regional Climate Change Assessment Program (NARCCAP) (Mearns 2004). Both PRUDENCE and NARCCAP use the HAdAM3P as a global model that generates various regional models from meteorological services and research institutions. Typically, present climate (e.g. 1961–1990) and future climate (2070–2100) time slices are simulated to calculate future changes in relevant climatic variables. Another regional effort, a Canadian research consortium on regional climatology and adaptation to climate change (OURANOS), aims to promote the acquisition of expertise that will advance the understanding of regional climate change and its environmental, social, and economic impacts. To this end, it develops and adapts the tools necessary for providing decision makers with detailed climate change scenarios on a regional scale. It also performs evaluations of expected sector impacts in order to optimize adaptation strategies. To fulfil

its mission, OURANOS participates in the construction of historical climate databases. It also supports the development of the Canadian Regional Climate Model (CRCM) and runs climate simulations on geographic scales required for various impact and adaptation studies. OURANOS is also responsible for developing detailed medium- and long-term scenarios of the evolution of the climate of Québec. OURANOS has strong links with NAARCAP.

43.   In South America, some groups have developed the capacity to use dynamic and statistical downscaling techniques using GCM-generated climate scenarios over a region. Examples of dynamic downscaling efforts are those of the Brazilian Center of Weather Forecasting and Climate Studies (CPTEC) and of the Center for Sea-Atmosphere Research (CIMA) from the Argentinean National Research Council CONICET. Both groups have developed or are developing scenarios for regional climate change for extreme emissions scenarios A2 and B2 using the global scenarios from the Hadley Centre Global Coupled Model HadAM3P. In Brazil, an initiative has been the implementation of Regional Climate Change Scenarios for South America (CREAS) (Marengo 2004). CREAS was established by CPTEC for studies on impacts of climate change in natural ecosystems in Brazil (PROBIO). Funding for CREAS comes from GEF and the United Kingdom Global Opportunity Fund project "Using Regional Climate Change Scenarios for Studies on Vulnerability and Adaptation in Brazil and South America", aimed at providing high resolution climate change scenarios in the three most populated basins in South America for raising awareness among government and policy-makers in assessing climate change impact and vulnerability and in designing adaptation measures. CREAS is using the HadAM3P that was made available to CPTEC by the Hadley Centre, and three regional models with resolutions varying from 40 to 50 km that are being run at CPTEC for the whole of South America. The regional models are the RegCM3, Eta/CPTEC and HadARM3 (this is from PRECIS). The regional future climate change projections from CREAS will be made available to all South American countries upon request. Furthermore, the Brazilian Ministry of Science and Technology made these data available to all South American countries.

44.   It is clear that some countries are making their own efforts on downscaling and regionalization of future climate change scenarios, and the CREAS-generated data will help them in comparing projections. The Argentinean efforts are concentrated on the region south of 20 S using the MM5 model (50 km) and will use the HadRM3 model also as part of PRECIS. From these initiatives, data will be available for the 2071–2100 time slice and the A2 and B2 scenarios. Upscaling techniques will be used to generate projections for the 2010–2049 and 2041–2070 time slices. These CREAS activities include for now the use of the HadAM3P model from the IPCC TAR. As part of CREAS future activities, improved versions of the Eta/CPTEC will be run using the new HadGEM1 model from the Hadley Centre and the ECHAM5 for the A1B, A2 and B2 scenarios used for the AR4. The ECHAM4.5 global model is also being run using the REMO regional model of the Max Planck Institute for the A1B and B2 as part of the CLARIS project for South America (A Europe-South America Network for Climate Change Assessment and Impact Studies). The domain of NAARCAP reaches up to 20°N covering most of Mexico. Mexico has been constructing future climate change scenarios for a region between the southern United States and northern South America using the HadRM3 from PRECIS, together with the statistical downscaling using the Statistical Downscaling System Model (SDSM) model.

45.   So far, in Central American, in the context of the Regional Visualization and Monitoring System (SERVIR, in Spanish) the output of the CAM3 global model has been downscaled for the Mesoamerican region for the 2025 time horizon. Also, the Instituto Nacional Meteorologia de Cuba has utilized the PRECIS model in the context of the UNDP-GEF-CATHALAC project Capacity building for Stage II Adaptation to Climate Change in Central America, Mexico and Cuba. Regional training activities have been conducted under these two initiatives.

E. Training activities

46.   Among the training and capacity-building activities that took place in Latin America since 2004 is the PRECIS program. PRECIS involves the regional climate modelling infrastructure developed by the Hadley Centre, and has been implemented and is in use in various countries in Latin America. Training courses have been developed in Argentina, Brazil and Cuba during the past three years and almost all Latin American countries are running or starting to run the PRECIS system, with the global model HadAM3P serving as boundary conditions for the regional United Kingdom Met Office HadRM3 model with a 50 km resolution. Most of these countries are running it for vulnerability and impact studies, including for their national communications. Funding for PRECIS activities comes from DEFRA and some additional funding for the implementation of the training courses in the region has come from national sources, as well as from IAI and AIACC. The PRECIS modelling system is freely available to groups of developing countries so that they can develop climate change scenarios at national centres of expertise (Jones et al. 2004). PRECIS workshops organized by the Hadley Centre and funded by DEFRA have taken place since 2004 in Havana, Cuba, Sao Paulo, Brazil and Buenos Aires, Argentina.

IV. Impacts of climate variability, extremes and projected change

47.   Impacts of natural climate variability, including extremes affect all sectors and systems throughout Latin America. In this chapter, commonly occurring impacts are summarized by sector and by hazard. A discussion of impacts due to projected climate change is also included. Non-climate pressures such as population growth, changes in land-use patterns and the exploitation of natural resources may add to Latin America's overall vulnerability.

48.   To give an indication of expected changes, table 2 shows a range of temperature and precipitation changes for sub-regions of Latin America for several time-slices (2020, 2050, 2080), based on seven GCMs and the four main emissions scenarios (SRES). Highest values of warming are projected to occur over tropical South America (Amazon Basin). The case for precipitation changes is more complex because regional climate projections show a much higher degree of uncertainty. Uncertainty is greatest for southern South America both for winter and summer seasons.

Table 2. Projected changes in temperature and precipitation for broad sub-regions of Central and South America[a]

Region	Season	Changes in temperature (°C)		
		2020	**2050**	**2080**
Central America	Dry	+0.4 to +1.1	+1.0 to +3.0	+1.0 to +5.0
	Wet	+0.5 to +1.7	+1.0 to +4.0	+1.3 to +6.6
Amazon Basin	Dry	+0.7 to +1.8	+1.0 to +4.0	+1.8 to +7.5
	Wet	+0.5 to +1.5	+1.0 to +4.0	+1.6 to +6.0
Southern South America	Winter (JJA)	+0.6 to +1.1	+1.0 to +2.9	+1.8 to +4.5
	Summer (DJF)	+0.8 to +1.2	+1.0 to +3.0	+1.8 to +4.5

Region	Season	Changes in precipitation (%)		
		2020	**2050**	**2080**
Central America	Dry	-7 to +7	-12 to +5	-20 to +8
	Wet	-10 to +4	-15 to +3	-30 to +5
Amazon Basin	Dry	-10 to +4	-20 to +10	-40 to +10
	Wet	-3 to +6	-5 to +10	-10 to +10

[a] Ranges of values encompass estimates from seven GCMs and the four main SRES scenarios.

| Southern South America | Winter (JJA) | -5 to +3 | -12 to +10 | -12 to +12 |
| | Summer (DJF) | -3 to +5 | -5 to +10 | -10 to +10 |

Source: Based on Ruosteenoja et al. (2003)

A. Extreme events

49.   This section describes the impacts of extreme weather and climate events: tropical cyclones, heat waves and cold fronts, torrential rains and flooding, droughts and forests and wildfires

1. Tropical cyclones

50.   During the 2004 cyclone season an exceptional number of tropical storms (14) occurred in the North Atlantic and the Caribbean. Nine achieved hurricane intensity and, perhaps for the first time in records, a hurricane called Catarina developed in the South Atlantic, offshore southern Brazil. Yet, in the 2005 season, 27 tropical storms developed. For the first time since systematic record began 150 years ago, 14 hurricanes, 7 of them major hurricanes (Dennis, Emily, Katrina, Maria, Rita, Wilma and Beta) formed. All of these hurricanes reached wind speeds above 70 mph (110 km/h) (with Katrina, Rita and Wilma reaching wind speeds greater than 97 mph (155 km/h)).

51.   There is a large increase in the number of hurricanes reaching categories 4 and 5 (e.g. Dennis, Katrina, Rita and Wilma). These increases have taken place while the number of cyclones and cyclone days has decreased in all basins (e.g. south-west Pacific Ocean) except the North Atlantic during the past decade. The North Atlantic Ocean experiences an increasing trend in frequency and duration that is significant at the 99 per cent confidence level. The observation that increases in North Atlantic hurricanes characteristics have occurred simultaneously with statistically significant trend in sea surface temperature (SST) has led to the speculation that the changes in both fields are a result of climate change.

52. According to the IPCC TAR, tropical cyclone peak wind intensities are expected to increase during the 21st century. Also, mean and peak precipitation intensities from tropical cyclones are likely to increase considerably. Some important examples of projected impacts due to increase in tropical hurricanes are the increased risk of infectious diseases, increased coastal erosion and damage to coastal buildings and infrastructure, and increased damage to coastal ecosystems such as coral reefs and mangroves.

2. Torrential rains and floods

53.   Torrential rains and resulting floods, including those associated with tropical cyclones, are among the main natural hazards in Latin America, resulting in injuries and deaths (CRED 2004; Schultz et al. 2005). In particular, the floods and landslides in Venezuela in 1999 killed 45,000 (CEPAL-PNUD 2000) and 10,000 people died after hurricane Mitch in 1998 in Central America (ECLAC, América Latina y El Caribe: El Impacto de los Desastres Naturales en el Desarrollo, 1972-1999, LC/MEX/L.402).

54.   A recent study (Wang and Chameides 2005) summarizes the impacts of the Venezuelan floods of 1999: "One of many extreme flooding events that may have been exacerbated by global warming occurred in December 1999, when Venezuela experienced its highest monthly rainfall in 100 years, with massive landslides and flooding that killed approximately 30,000 people. Total December rainfall in the coastal city of Maiquetia, near Caracas, was almost 4 feet (1.2 m), more than 5 times the previous December record. Rainfall on two of those December days were "1,000-year events"—in other words, that daily amount of rainfall is expected to occur in that location on average only once in 1,000 years. Rainfall amounts in the neighbouring mountains are estimated to have been twice as high, or around 8 feet over the month."

55.   The rainfall was unusual not only for its intensity, but also because it occurred outside the normal rainy season (May to October) and was not produced by a hurricane or other tropical cyclone. The ensuing flows of mud and boulders are thought to have been among the largest anywhere in the world in at

least a century. It is worth noting that the high death toll was partly due to large numbers of people living in homes built on steep slopes prone to landslides and low-lying areas susceptible to floods.

56. Floods make land unsuitable for agricultural production until waters recede, whereas hurricanes might wash out arable land or permanently increase its salinity through storm surges and flash floods. Loss of perennial crops such as forests or banana trees also has long-term consequences for the ability to generate income. In the case of Hurricane Mitch, banana production is expected to return to its historical level in 2002, i.e. four years after the disaster (Charvériat 2000).

57. El Niño and La Niña have been associated with floods in many parts of Latin America, and many impacts were recorded during the 1997–98 strong El Niño episode. In Peru, high rainfall, floods and landslides produced important damage to agriculture, fisheries, transport, housing and health in the northern, central and southern coastal areas, as well as in the country's inland areas. The total damage amounted to USD 3.5 billion, which represented 5 per cent of the GDP that year (CAF 2000). In Colombia, the abnormal September–November 2005 rainy season resulted in 70 deaths, 86 people injured, and 140,000 flood victims. In Ecuador there were losses in excess of USD 3 billion due to heavy precipitation and hundreds of human lives lost (CAF 2000).

58. As for projected changes, IPCC TAR predicts, at a high level of confidence (67–97 per cent), that floods will become more frequent with increased sediment loads and degraded water quality.

3. Droughts

59. El Niño and La Niña are the main climate phenomena associated with droughts in many parts of Latin America. For example, the recurrent droughts in northeast Brazil are associated with particular patterns of sea surface temperature in the tropical Atlantic Ocean, in addition to the tropical Pacific Ocean. The socio-economic impacts of droughts on northeast Brazil were recently summarized (Charvériat 2000) (see box below).

Box 1. Impacts of drought on Northeast Brazil

A study of several droughts in Sub-Saharan economies, as well as India and Australia, found that the aggregate impact of droughts could be quite significant in terms of growth. A 50% fall in agricultural GDP would translate into a 10% decrease in GDP for an economy in which agriculture accounted for 20% of total activity in the pre-drought year.[28]

A study of the supply-side shock (and associated demand effects) triggered by 10 drought episodes in Northeast Brazil between 1970 to 1993 produced similar results (see Table 1.6).[29]

Table 1.6 Estimates of Drought Impact on the GDP of North-East Brazil

Drought years (Y)	Growth of regional agricultural GDP, year Y (%)	Growth of regional GDP, year Y (%)	Estimated supply and demand effect of drought on regional GDP (%) (D)	Difference between actual growth of regional GDP and growth trend of GDP (G) (% points)	Difference between drought effect and deviation from growth pattern (D-G) (% points)
1970	-17.5	-4.2	-9.2	-9.2	0
1976	-8.3	7.0	-4.8	2.0	6.8
1979	-0.5	7.2	-1.0	2.2	3.2
1980	-6.5	2.9	-3.4	-2.1	1.3
1981	0.8	-0.7	-0.4	-5.7	-5.3
1983	-29.7	-3.8	-9.0	-8.8	0.2
1987	-1.7	-1.0	-5.0	-5.1	-0.1
1990	-10.5	-5.9	-3.6	-10.9	-7.3
1992	-10.5	-2.3	-4.0	-7.3	-3.3
1993	-24.4	-1.7	-6.0	-6.7	-0.7

Source: Gomes and Vergolino (1995).

Despite the decrease of the weight of agriculture in the regional GDP (from 23.5% in 1970 to 11.3% in 1993), droughts resulted in the decrease of the region's GDP by 4 to 9 percentage points. Over the whole period, the main determinant of the fluctuations of GDP of the Northeast region was still the national GDP. For instance, in years of rapid growth in Brazil, such as 1976, the region's GDP grew even if there was a drought because of a growth rate of fixed capital of almost 30%. Nevertheless, it appears that, during years of severe drought (such as 1970, 1983 and 1993), when the agricultural GDP decreased between 17.5 and 29.7%, the behavior of the region's GDP can be almost entirely explained by the occurrence of drought (as shown by column D-G).

The aggregate impact of droughts on Brazil's GDP is limited, as the GDP of the Northeast only represents 14.4% of the country's GDP. Nevertheless, the repeated occurrence of droughts, with their recessionary effects, might contribute to worsened, regional inequalities. In fact, the estimated GDP per capita in the Northeast was $1,494 in 1993, compared with $3,010 in the rest of the country.

Source: Charvériat 2000: 26

60. Droughts associated with La Niña increase the vulnerability of water supplies and irrigation systems in central western Argentina (Meza et al. 2002), central Chile (CONAMA 2001), and the soybean agriculture in the Pampas region of South-eastern South America. Droughts related to El Niño decrease river flows of the Colombia Andean region basins (Carvajal et al. 1999) and the Magdalena river basin (IDEAM 2004). During the 1997–98 El Niño as much as 10 per cent of Colombia's coffee production was lost due to the drought. Other crops, such as potatoes, corn, beans, soybean, sugar cane, banana, and tobacco, suffered severe impacts during the warm event; for example, Colombia had to import more than 3.5 million tonnes of grains and other food supplies.

4. Heat waves and cold fronts

61. There is recent evidence that heat waves can greatly affect agricultural production. For instance, Valtorta et al. (2004) report that heat waves have affected dairy productivity of dairy cattle and that post hot spell productivity did not return to former levels. In desert areas of northern Mexico heat waves increase mortality, especially for the elderly and people with poor health conditions, who are further affected by the lack of air conditioning and adequate housing (Meléndez 2004).

62.   There is plenty of evidence of impacts of cold fronts and snow storms. For instance, in Peru, in 2004, recurrent freezing fronts with hail and low temperatures affected more than 300,000 families, in the poorest areas of the southern Peruvian highlands, and these fronts were associated with the death of over 250,000 head of cattle and the loss of over 1,000,000 ha of pastures and crops (National Institute on Civil Defence INDECI, 2004; Gonzales 2005). The extensive snow storm of July 2002 affected large areas in Argentina, Bolivia, Chile and Peru, dumping record levels of snow and killing tens of thousands of camelid livestock.

5. Forest and wildfires

63.   Forest ecosystems throughout Latin America are vulnerable to fires. In particular, the tropical forests of Amazon Basin have been increasingly susceptible to fire due to increased occurrence of droughts (El Niño and non-El Niño related) and land-use change (clear-cut deforestation, forest fragmentation, selective logging) (Nepstad et al. 1999; Barbosa and Fearnside 1999; Fearnside 2001; Cochrane 2003). During the severe drought related to the 1997–98 El Niño, an estimated area of 40,000 km^2 of tropical forest was burned in the Brazilian Amazon alone (Nepstad et al. 2004), more than 25,000 km^2 of forests were affected in Central America (Cochrane 2006) and close to 15,000 fires were recorded in Mexico (FAO 2001).

B. Agriculture and forestry

64.   The impact of climate variability and extreme events is most noticeably seen on Latin America's subsistence agriculture. For example, northeast Brazil has seen reductions of agricultural GDP of up to 25 per cent for years of severe drought, which resulted in displacements of up to a few million low income, rural people.

65.   There is a wealth of studies on the impact of ENSO-related climate anomalies on crop yield variability in Latin American countries. By and large, those impacts bear strong relation to increased crop yields for increased precipitation and decreased crop yield for decreased precipitation, as documented in IPCC (2001). Climate anomalies associated with El Niño, such as increased rainfall and air humidity, have been found to be linked to increase outbreak of plant diseases in south-eastern South America, such as "Cancrosis" in citrus (Canteros et al. 2004).

66.   On the other hand, there are important non-ENSO related climate anomalies which affect agriculture (Baethgen and Magrin 2000; Podesta et al. 2002). For instance, patterns of sea surface temperature over the subtropical South Atlantic affect agriculture over southeastern South America (Doyle and Barros 2002; Berri and Bertossa, 2004; Travasso et al. 2003a,b).

67.   As for future impacts, a recent meta study (Smith and Lazo 2001) drew the following conclusions:

> Results from Latin America are limited to only three countries and have both increased and decreased yields. Because results are limited and scattered, these conclusions should be treated as preliminary. Overall, the results suggest that while agricultural impacts may not be catastrophic, especially when potential adaptation measures are considered, individual countries and regions within countries could experience significant negative impacts. Thus, some countries could be harmed while others could benefit. Many countries included CO_2 fertilization effects on crop yields in their analysis. In some cases, CO_2 fertilization was found to have a larger impact on crop yields than temperature or precipitation changes, although drier conditions could offset the positive effects of CO_2 fertilization. Although countries found no significant overall change in grasslands and livestock, several did note that changes in inter-annual climate variability would have important impacts. For instance, Uruguay found that because seasonal variability is already a major concern for farmers, increased variability would be detrimental to the production of livestock.

C. Water resources

68.   Water resources for agricultural, domestic and industrial use, averaged per capita among Latin American countries, vary substantially. These averages hide the huge disproportion in many areas, such as poor rural areas where there is a lack of water resources. Natural hazards have affected the region in the past few years: those due to heavy precipitation caused floods in many countries, for example Argentina, Bolivia, Brazil, Costa Rica, Mexico and Venezuela, and those due to low precipitation caused droughts in some other regions or countries, for example, in Brazil, Central America and Mexico.

69.   Some studies (e.g. Mendoza 1997; Planos and Barros 1999; Garcia Vargas 2003) indicate that climate change would impact the water resources of the region. Watersheds in arid and semi-arid areas are especially vulnerable. The impact of climate change on water resources depends not only on changes in the volume, timing, and quality of stream-flow and recharge, but also on the characteristics and in other stresses exerting pressure on the system. Non-climatic factors may have a greater impact on water resources than climate change (Arnell et al. 2001).

70.   The projected number of people living in Mesoamerica and South America in water-stressed areas is shown in Table 3. Climate change will exacerbate the number of people affected.

**Table 3. Projected number of people living in Mesoamerica and South America
in water-stressed areas**

SRES scenarios	Number of people living in water-stressed areas (millions)	
	2025	**2050**
A1/B1	35.7	54.0
A2	55.9	149.7
B2	47.8	59.3

Source: Arnell, 2004

D. Snow and land ice

71.   It is well documented that the glaciers of the tropical portions of the Andes have been receding at increasing rates since the 1980s. The glaciers on the Cotopaxi volcano, Ecuador, lost more than 30 percent of their area between 1976 and 1997 (Jordan et al. 2005). In Cusco, Peru, the freezing altitude has risen 100 m. The analyses of climate data do not reveal major changes in climate parameters such as precipitation and cloud cover that could explain the observed trends in glacier retreat in the tropical Andes (Francou et al. 2003). The best explanation continues to be global warming, recognized in the study of Delgado et al. (2005) for the Ayoloco glacier at the Iztaccíhualt volcano, in Mexico. The accelerating rate of glacier retreat is larger for small glaciers (Francou and Coudrain 2005). Impacts of glacier retreat on economic activities have been felt already and include total or partial loss of tourism and snow sports, such as for Chacaltaya glacier in Bolivia, and shortage of water supply for urban populations and agriculture.

E. Sea-level rise and coastal zones

72.   Sea-level rise is a direct consequence of global warming. Global average sea-level rise increased at an average rate of about 0.5 mm/yr over the past 6,000 years and at an average rate of 0.1 to 0.2 mm/yr over the past 3,000 years. Based on tide gauge, global average sea level rise during the 20th century is in the range of 1.0 to 2.0 mm/yr. According to the IPCC TAR global average sea level is expected to rise by 0.09 to 0.88 m over 1990 to 2100, with a central value of 0.48 m (IPCC 2001)

73.   Sea-level rise is expected to affect natural resources, wildlife and populations due to a series of physical, chemical and ecological changes in the coastal areas, for example, increased shoreline erosion

around coastal lagoons and a decrease in the rate of land formation in deltas, such as the Parana delta (figure 2).

Figure 2. Land formation in the Parana delta, Argentina (1750–2002)
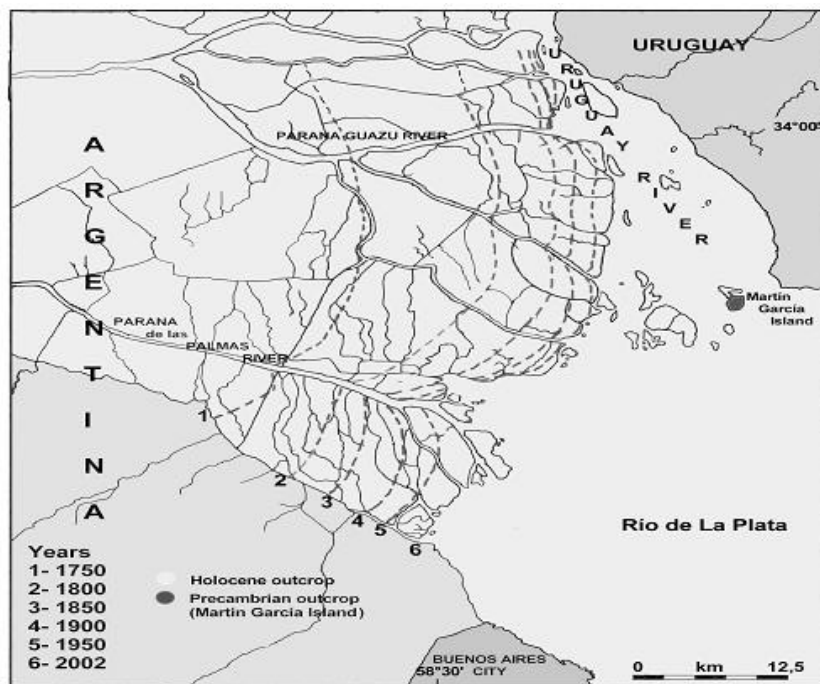
Source: Codignotto 2004, Dragani and Romero, 2004

74.   On the other hand, sea-level rise may lead to a decrease in the salinity of hypersaline lagoons, such as the Laguna Madre of Mexico, as less saline sea water intrudes into the lagoon systems. That trend in lowering salinity has been observed since at least 1949 due to the dredging of a waterway and drainage from agricultural land. This led to a change in grass species diversity to less saline-tolerant grasses (Quammen and Onuf 1993).

75.   Exposed mangroves in many low-lying coastal areas of Latin American countries (Brazil, Colombia, Ecuador, El Salvador, Guyana and Venezuela) could disappear (Medina et al. 2001; Hensel and Proffit 2002). Salinization of drinking water can become an increasingly serious problem (Ubitaran Moreira et al. 1999).

F. Natural ecosystems

76.   A recent study (Scholze et al. 2005) quantified the impacts of several scenarios of climate change on global ecosystems. The study concludes that "the reduction of tropical forests area, especially in the tropical rainforests, will probably imply the loss of many species".

77.   Based on the Hadley Centre GCM projections for A2 and B2 emissions scenarios, there is a potential that 24 per cent of the 138 tree species of the central Brazil savannas might become extinct by 2050 for a projected increase of 2° C in surface temperature (Thomas et al. 2004; Siqueira and Peterson 2003; Miles et al. 2004). The effect would be larger over the eastern Amazon than over the western Amazon, a conclusion supported by a projection of 'savannization' of the central-eastern Amazon (Nobre et al. 2004). This study also indicated that for most climate change projections, the semi-arid region of Northeast Brazil could become even drier. Thomas et al. (2004) calculated that global warming projected for the year 2050 could sharply increase species extinction in Mexico. World Wildlife Fund (WWF) (2001) also projected the possibility of species extinctions in dry areas of Argentina, Bolivia and Chile.

78.   The continued warming can be expected to result in the shifting of species range and yearly cycles of species. That is particularly important for those animal and plant species associated with disease-causing agents.

79.   On the projected impacts of climate change on wetlands, Spalding et al. (2000) summarizes the most likely impacts as follows: "Wetland areas are likely to be impacted by higher temperatures and changes in precipitation. There is concern that two extremely important wetland regions in Brazil, the flooded forest of Várzea in the Amazon and the Pantanal in Southern Brazil, may well become highly reduced in area, with subsequent losses of biodiversity."

80.   It appears that major events of coral reef bleaching are associated with the occurrence of warm sea surface temperatures across the equatorial Pacific (Hoegh-Guldberg 1999) and other ocean warming events such as the Indian ocean dipole (Webster et al. 1999; Wilkinson 2002). Caribbean coral reefs have been affected by an array of environmental factors which explains changes of dominant species and reductions in area. Aeolian transports of dust from the Sahara and Sahel in Africa and land derived flood-plumes from Central American basins, white band disease and direct human interference through shipping lines are also involved (Gardner et al. 2003; Buddemeier et al. 2004; Aronson and Precht 2002; Shinn et al. 2000; Andréfouët et al. 2002).

81.   There has been a precipitous decline of mountain amphibians of Central and South America, including the golden toad and most of the species of harlequin frogs. Most of those species have died off since 1970. The reasons for such decline are complex and apparently linked to subtle changes in mountain climate, likely associated to global and regional warming. Typically amphibians need to bask temporarily in sunny, warm microclimates to escape a fatal fungal parasite of the skin (Chytrid fungi). Global and regional warming has been associated to increase of cloud cover in Central American mountains reducing the occurrence of sunny microclimates. An additional factor is the observation of a decrease in the amount of mist due to the warming, along with an increase in the occurrence of higher clouds since the early 1970s in Costa Rica mostly during the dry season. That would make the frogs look for moister environments during the dry season to avoid losing body water, increasing the effectiveness of the fungi, which thrives in cool, moist conditions (Ron and Merino 2000; Pounds 2001; Díaz-Páez and Ortiz 2003; DeVries et al 2005; Burrowes et al. 2004).

G. Human health

82.   A recent study (Githeko and Woodward, 2003) concluded that heat stress, malaria, dengue, cholera and other water-borne diseases are reasons of concern of potential impacts of climate change on human health in Latin America. To date, very few countries have taken into account scenarios of climate change in their public health policies or long term planning.

1. Outbreaks of vector-borne diseases

83.   The effect of El Niño on the risk of malaria epidemics has been relatively well established for parts of South America (Poveda el al. 2001) and inter-decadal reductions in rainfall are apparently linked to reductions in transmission rates. In Venezuela, reductions in malaria vector distribution were observed under periodic droughts (Kovats et al. 2003). In principle, malaria epidemics could be predicted from climate predictions if other causative factors of epidemics can be removed. For the Amazon Basin, proximity of deforestation fronts is the most important non-climate related influence on the risk of malaria epidemics, being 10 to 100 times more important in explaining epidemics along the deforestation fronts in comparison to other factors.

84.   Malaria has been a major focus of attention because climate change is likely to increase the geographical distribution of vectors. Increases and decreases of transmission of malaria are projected. Declines in transmission rates are projected for those areas where GCM projections indicate dryer

conditions, such as parts of the Amazon and Central America (for Hadley Centre climate change scenarios). Increased risks of malaria are expected southward of the current southernmost distribution in South America (Lieshout et al. 2004) and in Bolivia a large increase of malaria is projected. Increases area also expected in Central American countries (Marena 2001). On the other hand, a number of studies concluded that dengue transmission will increase in many regions in Latin America (Gagnon et al. 2001; Hoop and Foley 2001; Hales et al. 2002).

85.   There was a trend of emergence or reemergence of infectious diseases such as the visceral leishmaniasis in urban areas of northeast Brazil in the 1980s and 1990s due to rural-urban migration of drought displaced subsistence farmers (Franke et al. 2002; Confalonieri 2003). Rodent-borne infections, such as Weil's diseases, apparently increase after floods due to complex human–pathogen–rodent interactions, and those outbreaks are well documented for many Central and South American countries (Ko et al. 1999; Kuper et al. 2000; Vanasco et al. 2002; Ahern et al. 2005). Rodents are also associated with the emergence of cases of Hantavirus Pulmonary Syndrome (HPS) in Central America (Bayard et al., 2000). On the other hand, outbreaks of HPS were reported for Argentina, Bolivia, Brazil, Chile and Paraguay under prolonged droughts (Pini et al. 1998; Espinoza et al. 1998; Williams et al. 1997; Hacon, 2004).

2. Other climate-related impacts on human health

86.   There are studies (Checkley et al. 2000; Speelman et al. 2000, Lama et al. 2004) establishing that hot spells are associated with increased frequency of the occurrence of diarrhoea in low and middle income adults and children in Peru, and increases in mortality of elderly people in Northern Mexico (Meléndez 2004).

87.   In Buenos Aires roughly 10 per cent of summer deaths may be associated with thermal strain because of the urban heat island effect (de Garín and Bejarán 2003). Large high pressure systems often create a temperature inversion, trapping pollutants in the boundary layer at the Earth's surface, as is the case of Mexico City and Santiago de Chile. In Mexico City, ozone has been linked to increased hospital admissions for lower respiratory infections and asthma in children (Romieu et al. 1996). Concurrent hot weather and particulate air pollution can have interactive impacts on health.

88.   The expected increase of forest fires due to warmer, drier climate and increased deforestation and forest fragmentation will increase the vulnerability of the population to health effects of biomass burning smoke. This has already been observed in Brazil for respiratory diseases and other smoke and fire related problems (Haines and Patz 2004; Haines et al. 2000; Patz 2004).

V. Case studies of regional vulnerabilities

A. Deforestation in the Amazon Basin

89.   The dynamics of terrestrial ecosystems depend on interactions between biochemical cycles, in particular the carbon cycle, which may be modified by human actions. Terrestrial ecological systems, in which carbon is retained in live biomass, decomposing organic matter, and soil, play an important role in the global carbon cycle. Carbon is exchanged naturally between these systems and the atmosphere through diverse mechanisms such as photosynthesis and combustion. Human activities, such as land-use change, alter carbon stocks in these pools. Substantial amounts of carbon have been released from forest cut in the tropics during the latter part of the 20th century.

90.   The Amazon Basin is home to some 40 per cent of the world's remaining tropical forest. Much of this area is reserved for the indigenous peoples living within the basin. They have their numerous cultures and economic aspirations that affect land uses. There is a constant demand for pasture land. The most

deforested areas of the Brazilian part of the Amazon Basin are in the south-east fringe along the roads and the Amazon River. Today, deforestation in the Amazon Basin is the result of several activities:

      (a)   Clearing for cattle pasture

      (b)   Colonization and subsequent subsistence agriculture

      (c)   Infrastructure improvements

      (d)   Commercial agriculture

      (e)   Logging.

91.   Deforestation in Brazil for the period 2000-2004 is presented in table 4.

Table 4. Deforestation in Brazil (2000–2004)

Year	Deforestation (km^2)
2000	7,658
2001	7,025
2002	9,845
2003	9,500
2004	10,088

Source: National Institute of Space Research

92.   Deforestation in the Amazon Basin might influences rainfall from Mexico to the southern United States. Some research has suggested that extreme drought in the basin are linked to deforestation. If the Amazon Basin loses more than 40 per cent of its forest cover a turning point could be reached and then a savannization process could become irreversible.

93.   Deforestation and climate change could convert large portions of Amazonian tropical forest into savanna, with tremendous effects on biodiversity and climate itself. Projections of climate change indicate a warmer and dryer environment for the basin. This may lead to a decrease in precipitation over portions of the Amazon Basin.[5] These changes could result in substantial shifts in ecosystem types, from tropical to savanna, and a significant loss of species in many parts of the Amazon Basin. The combined effects of climate changes and deforestation could convert 30 to 60 per cent of the Amazon rain-forest into a form of dry savanna.

94.   The current policies in the Amazon Basin to protect tropical ecosystems and biodiversity are centred around the establishment of so-called ecological corridors, a series of protected areas connecting areas of high biodiversity and endemism through the South American tropics. However, it is important to point out that this is an adaptation measure mostly in response to current patterns of deforestation. Current policy measures do not take into account projections of climate change, which might make some of the topology of ecological corridors quite ineffective. In essence, potential climate change presents an important threat to Amazonian biodiversity.

B. Glaciers in the Andean region

95.   The state of mountain glaciers is an excellent indicator of climate change. Several studies show a well documented retreat of glaciers in non-polar regions of the world during the 20th century. On a global scale, air temperature is considered to be the most important factor controlling glacier retreat. For a characteristic mid-latitude glacier, a one degree temperature rise would have the same effect as a 25 per cent decrease in snow precipitation. The warm (El Niño) phase of ENSO, influencing the phase of

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[5] However recent satellite research by NASA suggests contradictory results.

precipitation at the altitudes of the glaciers' "accumulation zones" has become more intense, more frequent, and more long-lasting in recent decades (IPCC 2001).

96.   Tropical and subtropical areas are of particular concern. Unparalleled retreat of old glaciers has been observed and projections are made of complete disappearance of small glaciers. There is growing evidence that the observed glacier retreat in the warming tropical Andes has accelerated significantly in the past decades. The mass reduction includes even large glaciers, but it is particularly striking for the small glaciers, such as the Chacaltaya glacier in Bolivia. Glaciers have been retreating in the Andes of Central Chile during the past hundred years, probably due to changes in both temperature and snow precipitation (Carrasco et al. 2005). Also, ice-capped volcanoes (e.g. Mocho-Choshuenco) of the Chilean Lake District have undergone significant glacier retreat during recent decades. Many glaciers in the Andes of Ecuador (e.g. Cotopaxi) have lost surface area during the past years. The Cordillera Blanca (Peru), the Nevado of Santa Isabel (Colombia) and the Sierra Nevada in Venezuela have experienced a significant retreat during the past century.

97.   Figure 3 shows the shrinkage of the Chacaltaya glacier in Bolivia. In 1940 the surface area of the glacier was 0.223 km^2, whereas in 2001 it was only 0.048 km^2. As of 2005, the glacier exists only in three parts and the whole glacier may disappear before 2010 (Coudrain et al. 2005).

Figure 3. Chacaltaya Glacier in Bolivia
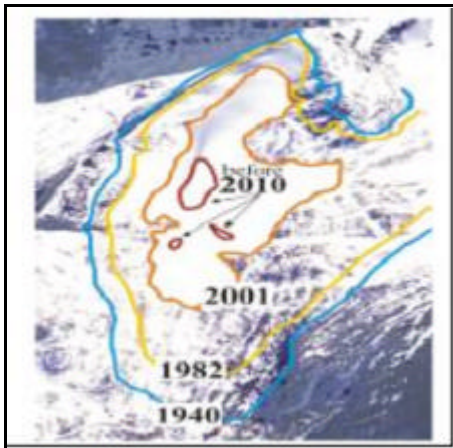
Photo, dated 2001; estimates of glacier extent: Bernard Francau

98.   Mountain glaciers allow the storage of large amounts of precipitation, which is subsequently released to river networks during warm and dry seasons. The population along the Andean Cordillera depends on this seasonal discharge for their water supply as well as for hydro-energy. Very likely, the reduction of glaciers, as is happening and is projected to continue, will have adverse consequences on the water availability of the region. Rapid shrinkage of glaciers in the Andean countries, for example in Bolivia, Chile, Ecuador and Peru, could lead to droughts which would affect people and the biodiversity of the region. An observed increase in run-off has only been temporary. It cannot last very long without increasing precipitation. The melting of glaciers will cause water shortage for millions of people in the region. This is the main vulnerability in the Andean region.

C. Food security in Mexico

99.   Mexico has a long and diverse experience with droughts. More than 85 per cent of its territory is covered by arid or semi-arid areas. The climate spans from the hot and dry conditions of the north-western Sonora desert, with annual rainfall less than 100 mm, to the wet tropical climate that characterizes southern Mexico, for example Chiapas and the Gulf Coast. However, the annual cycle of precipitation over the southern part of Mexico (and also Central America) exhibits a bimodal distribution, i.e. a maxima

during some months and a relative minimum during July and August. This is known as the midsummer drought.

100.   During past decades the region had several droughts episodes (for example, in 1942, the 1950s and 1987–1988). Droughts exist when precipitation has been significantly below normal record levels, causing serious hydrological imbalances that adversely affect land resource production systems. It is important to note that the midsummer droughts do not correspond to a definite drought period but rather to a decrease in the amount of precipitation. Climate change is expected to increase the frequency of droughts. The impact of droughts on crop yield in the region would adversely affect food production. Model simulations indicate that under different climate scenarios, Mexico would suffer a substantial reduction in food crop production, for example, in maize (Liverman and O'Brien 1991; Liverman et al. 1994).

101.   Vulnerability to droughts is determined by both biophysical and social conditions. In Mexico some adaptation measures to alleviate the negative impacts of climate change on some yields have been proposed; for example, nitrogen fertilization, could be the best option to increase maize yields, although it might not be economically feasible to implement (Conde et al. 1997).

102.   Local communities have developed many traditional options for coping with droughts. In many semi-arid areas refined irrigation systems (e.g. Chinapas and Galerias) have been developed over the centuries to store and transport water to settlements and for agriculture. Indigenous social institutions and traditions also served as drought adaptation and risk management strategies. Urban areas have responded to droughts and increased demand by constructing storage and by rationing water.

D. Sea level rise in La Plata River Basin

103.   Coastlines, particularly in areas that are already under stress from human activities, are substantially at risk from sea-level rise. Particularly at risk are the large deltas or estuarine regions, such as the coastline of the La Plata River where 14 million people live, most of them in the metropolitan region that includes the city of Buenos Aires. The La Plata River is a freshwater estuary which at its source has a width of 50 km and is broader, up to 90 km, in the Montevideo section. At the outer limit of the La Plata River, the width of the estuary reaches about 200 km (see figure 4 below).

Figure 4. La Plata estuary
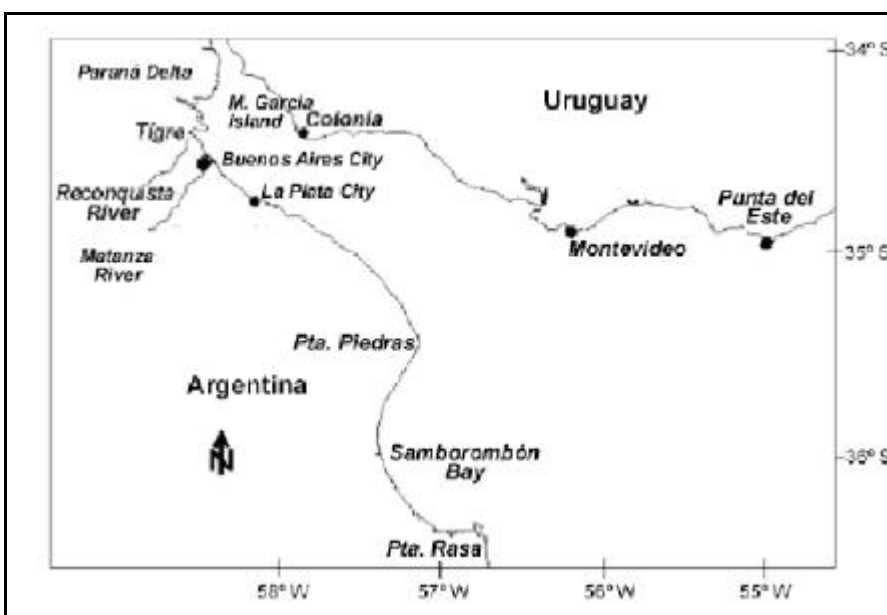
Source: AIACC, 2006

104.　　Strong winds from the south-east and high tides cause floods all along the coastline and with potential increase in sea level, storm surge floods will become more frequent. Under one climate change scenario (SRES-A2), the social vulnerability to floods will become worst in the 21st century along the Reconquista and Matanzas-Riachuelo rivers and south of greater Buenos Aires, in zones relatively far from the coast. In a scenario of 0.4 m sea-level rise by 2070 (the IPCC central value is 0.48 m) the population at risk of some floods would reach about 1.7 million, which is more than three times the current population exposure to floods (AIACC 2006).

105.　　If adaptation options are not implemented, losses, in for example real estate and operational cost of coastal facilities, for the period 2050-2100 are estimated at USD 5 to 15 billion (AIACC 2006). This estimation is extremely scenario dependent. On the other hand, for some areas which experience frequent floods, there are informal alert networks among neighbours, which may help to decrease the vulnerability to floods. Population dynamics (newcomers) in some of these neighbourhoods are altering this conventional adaptation option. The current defences (barriers) against floods were designed without considering the impact of global warming (sea-level rise).

VI. Interaction of climate change impacts and sustainable development

106.　　The economic, social and environmental links between climate change and sustainable development have relevance for Latin America. Climate change poses a serious challenge to the sustainable development of the region and the achievement of the Millennium Development Goals (MDGs).

107.　　The MDGs are important aims for the region; achieving the MDGs by 2015 will imply that 118 million people will be getting out of poverty (53 million will be getting out of extreme property). Some 50 million more people would have access to safe drinking water and 87 million additional people would enjoy the benefits of basic sanitation.[6] Climate change could jeopardize three MDGs, namely, goal one - the eradication of poverty, goal seven - achieving environmental sustainability and goal eight - the creation of a global partnership for development.[7]

108.　　In 2002, the Latin America and Caribbean Initiative for Sustainable Development was launched. This initiative promotes the implementation of solid actions through cooperation with developed countries and multilateral and regional organizations, including financing institutions, and through intensifying South–South cooperation.

109.　　The objectives of the initiative can be summarized as follows:

(a)　　To consolidate and continue efforts, in projects and programmes at different levels of government and civil society

(b)　　To develop, in selected areas, actions by the private sector and civil society to promote investment that may generate sustainable activities and maintain sustainable livelihoods while allowing for the conservation and sustainable use of essential environmental goods and services

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[6] The Millennium Development Goals in Latin America and the Caribbean: Progress, Priorities and IDB Support for their Implementation, Inter-American Development Bank Report, 2005.

[7] For a complete discussion see Sperling, F. (ed.), 2003. Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation. Inter-agency report by the African Development Bank (AfDB), Asian Development Bank (ADB), Department for International Development (DFID, UK), Federal Ministry for Economic Cooperation and Development (BMZ, Germany), Ministry of Foreign Affairs - Development Cooperation (DGIS, The Netherlands), Organisation for Economic Co-operation and Development (OECD), United Nations Development Programme (UNDP), United Nations Environment Program (UNEP), and the World Bank.

(c)   To contribute effectively to implement Agenda 21 and the Barbados Programme of Action

(d)   To promote the implementation of competitive sustainable development models (e.g. policies designed to develop science and technologies)

(e)   To identify appropriate topics and proposals for coordination and cooperation with other regions (e.g. New Partnership for Africa Development and the Asia Pacific Initiative).

Many priority areas for urgent action are suggested; among others, eradicating poverty and social inequalities, promoting regional cooperation and collaboration that increase the region's capacity to access international markets, promoting sustainable management of water resources and adapting to impacts caused by climate change.

110.   As impacts of climate change threaten to undo decades of development efforts, the best way to address these impacts is by integrating adaptation measures into sustainable development strategies, because the most desirable adaptive responses are those that augment actions which would be taken even in the absence of climate change, due to their contributions to sustainable development.

111.   Consequently, in April 2006 the Development and Environment Ministers of OECD Member Countries adopted the Declaration on Integrating Climate Change Adaptation into Development Co-operation.[8] They declare that they will work to better integrate climate change adaptation in development planning and assistance, both within their own governments and in activities undertaken with partner countries. In addition they encourage regional initiatives that include common actions on impacts and vulnerability assessment and adaptation options, in order to promote transboundary initiatives, encourage South-South co-operation and avoid duplicated efforts.

112.   Adaptation measures and sustainable development can reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor. Climate change solutions will need to identify and exploit synergy, as well as seek to balance possible trade-offs, among the multiple objectives of development, mitigation and adaptation policies.

VII. Adaptation

113.   Adaptation will be carried out by people and communities, who will be supported by governments. Government interventions are necessary in many Latin American countries as many communities and sectors of the economy do not have the necessary financial and technical resources to carry out activities that would facilitate adequate adaptation. The type of interventions will depend on national circumstances, but would necessarily include: integration of appropriate risk-reduction strategies with other sectoral policy initiatives, sustainable development planning, disaster prevention and management, integrated coastal zone management, health care planning, land-use planning, zoning, building codes, regulations, legislations, health education programmes, health monitoring and surveillance, solid and liquid waste management, use of traditional knowledge and coping mechanisms. Support from external sources, in the form of funding, technology, cooperation and pooling of resources, either through existing bilateral and multilateral mechanisms or new areas will become important.

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[8] <www.oecd.org/dataoecd/44/29/36426943.pdf>

A. Vulnerability and adaptation frameworks

114.   Vulnerability has been defined in many different ways in the past decade. With regard to disaster risk reduction, vulnerability is defined as the conditions determined by physical, social, economic and environmental factors or processes that increase the susceptibility of a community to the impact of hazards (UNISDR). The IPCC has defined vulnerability to climate change as follows: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC 2001).

115.   In order to reduce vulnerability, the adaptive capacity, which is the vector of resources and advantages that characterize the asset base from which adaptation actions and investments can be made (Adger 2005), needs to be enhanced.[9]

116.   In order to analyse a given vulnerability for a region, to evaluate adaptive capacity and to design concrete adaptation measures, a number of vulnerability and adaptation frameworks and tools have been produced in recent years, including:

(a)   The IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptation (1994) <www.ipcc.ch>

(b)   The National Adaptation Programmes of Action (NAPA) guidelines developed through the UNFCCC process <http://unfccc.int/files/cooperation_and_support/ldc/application/pdf/annguide.pdf>

(c)   The UNDP Adaptation Policy Framework <www.undp.org/cc/apf.htm>.

B. Initiatives and institutions

117.   Besides the general frameworks, there are a number of initiatives that support Latin American countries in their adaptation endeavours. For example, the Latin American and Caribbean Forum of Ministers of the Environment is a political forum to provide environmental authorities of the region with a space for agreement and reflection on the main challenges on the regional agenda in the context of sustainable development. At their fifteenth meeting in Caracas, Venezuela from 31 October to 4 November 2005, ministers established a working group on climate change (UNEP/LAC-IG.XV/7), which should initiate a dialogue, including on adaptation, in the region. In addition, the Inter-Agency Technical Committee (ITC) was asked to increase its contributions to the countries of the region in activities relating to climate change and to support the work on the development of the systematic climate observation network, early warning systems, education, research and capacity-building activities as well as the strengthening of existing regional centres that work on climate change and to promote when necessary the establishment of new centres.

118.   The "Red Iberoamericana de Oficinas de Cambio Climático" (RIOCC), or Ibero-American Network for Climate Change Offices, was proposed by the government of Spain in a meeting in Colombia in 2004. This initiative aims to generate links and exchange of information among the countries of Iberoamerica in order to identify priorities and problems in relation to climate change and facilitate consensus on responses.

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[9] Uncertainty in Adaptive Capacity in IPCC Workshop on describing scientific uncertainties in climate change to support analysis of risk and of options: 2004, Maynooth, Ireland.

C. Disaster risk reduction and adaptation

119.   In terms of integrating risk management and adaptation, a number of areas exist where such integration could occur in Latin America, including: land-use planning; development and field testing of climate change adaptation planning frameworks; sharing of best practices and guidelines; consideration of climate change concerns/risks at the planning phase of investment and development projects; and implementation of adaptation demonstration projects.

120.   The United Nations International Strategy for Disaster Reduction (ISDR) has highlighted that it is vital to integrate disaster reduction management into development and adaptation strategies. Examples in the Hyogo framework, which was adopted at the World Conference on Disaster Reduction in Kobe, Japan, in January 2005, where adaptation is given prominence include:

(a)   Promoting the integration of risk reduction associated with existing climate variability and future climate change into strategies for the reduction of disaster risk and adaptation to climate change

(b)   Mainstreaming disaster risk reduction measures appropriately into development assistance programmes, including those relating to, inter alia, adaptation to climate change.

121.   The Inter-American Development Bank[10] has a disaster risk management policy which was developed in the context of an increase in the number and gravity of natural hazards resulting in disasters in Latin America. The policy, which emphasizes risk reduction, is intended to improve the institutional and policy framework of the bank's support to disaster risk management in order to help protect the socio-economic development of member countries and improve the effectiveness of the bank's assistance.

122.   The International Red Cross/Red Crescent Centre on Climate Change and Disaster Preparedness in the Netherlands is providing support to National Red Cross and Red Crescent Societies to eventually reduce the loss of life and the damage done to the livelihoods of people affected by the impacts of climate change and extreme weather events. For example, in Nicaragua the climate change and disaster preparedness project was set up to improve the capacities of vulnerable communities to cope with disasters caused by climate change and extreme weather events along the Atlantic coast, specifically in the Municipalities of Bluefields (El Bluff) and Puerto Cabezas (Betania and Wawabom).

D. Traditional knowledge and coping strategies

123.   One of the key parameters of adaptive capacity has been the use of traditional knowledge. Much of the adaptation action undertaken at the community level provides efficient, appropriate and time-tested means for coping with climate change. Local and indigenous communities in Latin America have developed a number of strategies to cope with droughts, floods and tropical cyclones, including rainwater harvesting, soil conservation and specific housing design.

124.   For example, farmers in Peru have been using an ancient irrigation and drainage system "waru waru", or raised field agriculture, which makes it possible to bring into production the low-lying, flood-prone, poorly drained lands found all over the Altiplano. The shallow canals provide moisture during droughts and drainage during the rainy season. When filled with water they also create a microclimate that acts as a buffer against night time frosts. The waru waru system provides farmers with greater harvest security and reduces the risks associated with frosts and drought.

125.   In Mexico, the Cajete Terrace agroecosystems have been in place for three thousand years in hillside regions in Tlaxcala. In these rainfed Corn–Bean–Squash agroecosystems, food is grown on steep erosion-prone slopes. Rainfall is concentrated between May and September and often occurs in sudden

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[10] <www.iadb.org>.

downpours. Sloping terraces feed excess water into tanks (cajetes). The water, which would otherwise not be absorbed into the soil, is collected inside the cajetes and slowly percolates into the surrounding soils after the rain has ended. Eroded soils are also trapped inside of the cajetes, preventing soil loss down the slope. Nutrient rich soils inside of the cajetes are later gathered and distributed into the fields.

126.   Likewise, the Aymaran indigenous people of Bolivia have been coping with droughts through the construction of small dams "qhuthañas". These dams collect and store rain water from 50 to 10,000 cubic meters. In El Salvador communities employ a number of soil conservation measures to cope with recurrent droughts, for example, they build barriers consisting of stone and pine suckers, which serve two purposes: within a year their fruits can be eaten, thus improving the diet, and they provide additional income.

127.   In Costa Rica and Ecuador local communities have improved their housing design to better cope with floods and droughts. Houses are either elevated or have a reinforced concrete strip as a foundation on top of which concrete blocks form the bottom layer of the wall. Like that, the bamboo walls are not touching the ground and are protected from deteriorating due to fungi. These houses are cost-efficient and last longer than regular houses.

128.   The UNFCCC secretariat has developed an online database of local coping strategies (<http://maindb.unfccc.int/public/adaptation>), promoting a South-South transfer of knowledge and sharing of experience on adaptation action directly undertaken by those who are vulnerable, without reliance on external intervention.

E. Funding sources

129.   There are a number of funding resources that are available through the financial mechanism of the Convention and the Kyoto Protocol and from bilateral partners to implement activities that would enable countries in Latin America to enhance their adaptive capacity and to strengthen adaptation to climate change in the long run. The funding opportunities available include:

> (a)   The Global Environment Facility (GEF) Trust Fund
>
> (b)   The Special Climate Change Fund (SCCF)
>
> (c)   The Adaptation Fund under the Kyoto Protocol
>
> (d)   Funds under other Multilateral Environmental Agreements (MEAs)
>
> (e)   Bilateral funding.

130.   The GEF, as an entity entrusted to operate the financial mechanism of the UNFCCC, established the Strategic Priority on Adaptation (SPA) under its Trust Fund. The objective of the SPA is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in the focal areas in which the GEF works. The SPA supports pilot and demonstration projects that address local adaptation and generate global environmental benefits.

131.   The SCCF was originally aimed at supporting activities in the following areas: (i) adaptation, (ii) technology transfer, (iii) energy, transport, industry, agriculture, forestry and waste management, and (iv) economic diversification. Adaptation activities to address the adverse effects of climate change have top priority for funding under the SCCF.

132.   The Kyoto Protocol Adaptation Fund will be financed from the share of proceeds of the clean development mechanism (CDM) and other sources.

133.   As for the three GEF implementing agencies, UNDP–GEF is currently supporting a portfolio of adaptation projects that focus on different sectors, such as water resources, management of climate related risk, health, environment and agriculture. The amount of money allocated to adaptation projects in Latin America has amounted to USD 106.4 million out of a total of USD 556.2 million[11] (Meeting the Climate Change Challenge Sustainable Livelihoods 2004). The World Bank has been supporting adaptation projects in Latin America and the Caribbean with USD 18.7 million out of a total of USD 288.4 million.[12] UNEP's support to adaptation in the region amounts to USD 0.5 million out of a total of USD 14.5 million.

134.   Funding is also available under other MEAs whose areas of work could be synergetic with adaptation, including the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD) and the Ramsar convention on the conservation of wetland resources.

F. Planned and ongoing adaptation projects

135.   Most of the ongoing adaptation projects in Latin America are related to capacity-building and vulnerability assessment (c.f. chapter III). Aside from autonomous adaptation of natural systems, concrete adaptation measures are scarce, though countries have highlighted a number of potential adaptation options and strategies in their national communications (see Table 5 and Annex VII).

Table 5. General adaptation options and determinants of adaptive capacity for sectors and systems in some Latin American countries

Region and country	Adaptation options or strategies	Some determinants of adaptive capacity
Central America and Mexico		
Costa Rica	Public awareness and adaptation policy measures	Environmental laws
Honduras	National Adaptation Plan and Water Resources Management	Legal framework
Nicaragua	Implementation of a plan to control the quality of water Reforestation on the floodplains of rivers	Raise awareness about climate change and its link to disaster
Mexico	Several projects relating to agriculture National programme of forest health: control of plague Mangrove restoration and conservation	
South America		
Argentina	Several adaptation policy measures	Environmental laws
Bolivia	Implementation of a programme on food security that includes human health, education and public outreach on climate change	Legal framework Regional services on technology transfer
Brazil	Integration of climate change issues in medium and long-term planning: Brazilian Agenda 21. Creation of national and regional capacity: CPTEC/INPE Monitoring of land cover: the project for gross deforestation assessment in the Brazilian legal Amazon (PRODES)	
Colombia	Proposal to attack the negative impact of sea-level rise: change in land use, relocation of settlements, increasing protected areas	
Ecuador	Water resources: water irrigation system in the Guayas river basin, integral rural development in some small basins Agriculture: establishment of community agricultural system and of a project on agroforestry	

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[11] Figures are historical and cumulative from July 1991 through June 2004.
[12] World Bank GEF database <www-esd.worldbank.org/gef> (accessed 11 April 2006).

	Forest: production activities at community level to use residue material from dry forest, sustainable development of forest plantation	
Peru	Control of water resources from glaciers	Environmental laws

Uruguay	Water resources: incorporate climate change variables in hydraulic works, formulate and propose approval of effective national water policy enabling integration of climate change variables Agriculture: promote sustainable soil management, including no-tillage techniques and other measures directed at soil conservation and improved practices Coastal resources: promote management of coastal area in an integrated manner and establishment of a systematic monitoring system for surge and beach profiles	
Venezuela	General: soil and water preservation programme Water technical roundtable discussions National action programme to combat droughts Agriculture: development and distribution of hybrids and varieties of crops resistant to adverse climate conditions, evaluation of social-economic conditions of farmers Water resources: uncertainties in the impact of climate change on water at the basin level require improving observation networks for precipitation and run-off	Institutional and social reinforcement Lack of specialized human resources Weakness in the inter-institutional relations to confront problems that may require multifactorial solution Limited capacity of technological development
Caribbean Islands		
Cuba	A general adaptation strategy in Cuba would guarantee: (1) rational use and protection of water resources (2) conservation and protection of beaches and mangrove swamp areas (3) improvement of Cuban agriculture and the conservation and protection of forest resources Creation of national capacity: Institute of Meteorology and National Civil Defense System	Institutional level of preparedness to reduce the impact of extreme events Monitoring and warning systems need to be improved
Dominican Republic	A framework for adaptation policy addressing the issue of droughts Implementation of a drought early warning system	

Source: National communications, and Program of General Measures for Mitigation and Adaptation to Climate Change in Uruguay

136. Aside from the national communications, concrete planned or ongoing adaptation projects funded under the GEF include:

    (a)   **Community-based Adaptation (CBA) Programme, Bolivia**
        This project is aimed at: (i) developing a framework, including new knowledge and capacity, that spans the local to the intergovernmental le vels to respond to unique community-based adaptation needs; (ii) identifying and financing diverse community-based adaptation projects in a number of selected countries, including Bangladesh, Bolivia, Niger, Samoa; and (iii) capturing and disseminating lessons learned at the community level to all stakeholders, including governments. This project is to be funded through GEF's SPA and to be implemented by UNDP.

    (b)   **Integrated National Adaptation Plan: High Mountain Ecosystems, Colombia's Caribbean Insular Areas and Human Health (INAP), Colombia**
        The project will support two main activities. First, the formulation of adaptation programs to address anticipated climate change impacts in high mountain habitats and insular areas of the country as well as in the health sector. Second, 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. This project is funded through GEF's SPA and implemented by the World Bank.

(c)   **Adaptation to climate change through effective water governance, Ecuador**
The project's objective is to reduce Ecuador's vulnerability to climate change through effective water resource management. Three major project outcomes are envisioned: (i) strengthened policy environment and governance structure for effective water management through the mainstreaming adaptation to climate change in water governance structures; (ii) improved information and knowledge management on climate risk in Ecuador and (iii) application of sustainable water management and water related risk management practices to withstand the effects of climate change. This project is to be funded through the SCCF and to be implemented by UNDP.

(d)   **Implementing pilot climate change adaptation measures in coastal areas, Uruguay**
The main objective of this project is to promote adaptation measures necessary to protect coastal wetlands and international waters of the Rio de La Plata Estuary from the impact of climate change, through the sustainable use of coastal resources. The proposed adaptation measures will aim to increase the resilience of the coastal resources to climate change, by building upon climate change vulnerability and adaptation assessments already carried out as part of Uruguay's national communications. The project will develop a three level approach to adaptation in Uruguay's coastal areas: (i) information gathering, identification and monitoring of critical exposed elements of coastal ecosystems and human settlements; (ii) identification of barriers (limits) to adaptation in coastal areas of Uruguay, design of policy interventions for their effective removal and (iii) incorporation of an adaptation policy into existing national sustainable development policies, through targeted approaches at key sectors, such as tourism. This project is to be funded through GEF's SPA and to be implemented by UNDP.

(e)   **Capacity building for Stage II adaptation to climate change, Costa Rica, Cuba, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama**
Central America, Mexico and Cuba serve as the pilot region for elaborating and applying an Adaptation Policy Framework for preparing adaptation strategies, policies and measures. The application of this framework will demonstrate how policy for adaptation can be integrated into national sustainable development for at least three human systems: water resources, agriculture and human health. This demonstration project builds upon the Stage I vulnerability and adaptation assessments of the Initial National Communications of the eight participating countries of the region and will prepare them to move onto Stage III Adaptation. The outputs of the project, Stage II adaptation strategies may be used for preparing second National Communications. This project is funded through the GEF Trust Fund and is implemented by UNDP.

(f)   **Design and implementation of adaptation measures to address glacial melt in the central Andes, Bolivia, Ecuador and Peru**
The project is planned to 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. This project is to be funded through the SCCF and to be implemented by the World Bank.

VIII. Lessons learned: needs and concerns

137.   The Office of the Prime Minister of the United Kingdom recently made a global call for project proposals on the topic of adaptation. The office received 195 contributions in response. Not a single one was related to Latin America. The reason is simple: few studies and success stories about adaptation exist for Latin America. Countries have, as a whole, dedicated "the overwhelming part" of available time and funds towards their national communications and country studies, in particular to the selection and application of climate scenarios and, to a lesser extent, to "gross impact studies" (Burton et al. 2002). Latin American countries have not yet fully considered the merits of adaptation as an element of overall policy responses, and to actively pursue adaptation research and policies (Burton et al. 2002), despite their leadership (in particular in the case of Brazil) in international climate politics and despite projections of significant, deleterious impacts of human-induced climate change in the region (IPCC 2001). Realizing the lack of response in the adaptation area on the part of Latin American countries, the Prime Minister's office now has a tender out, offering GBP 50,000 for adaptation studies and analyses relating to adaptation in Latin America.

138.   Why has Latin America produced so little in this area of research and action. This section attempts to call greater attention to socio-cultural, political, economic, environmental, technological and institutional constraints to adaptation, in particular often overlooked constraints reflecting the weight of resource inequities, globalization and long-standing approaches to decision-making in Latin America.

139.   While the threat of climate change can be analysed using a scenario, "top-down" approach, the question as to how to adapt requires "bottom-up" analysis of vulnerabilities to climate change at local levels and how decision-making at that level affects vulnerabilities (Barry Smit, Canada, in Reid et al. 2004). The latter type of research thus, especially, depends on national governments to fund, authorize and otherwise enable the production of studies. According to analysts, developing countries have a special interest in adaptation knowledge because this can help them reduce their vulnerability to climate change and form a foundation for requests for external assistance to bear the costs of adaptation (Burton et al. 2002). The lack of adaptation studies and policies in the developing countries of Latin America is thus especially puzzling.

140.   Being in a relatively less developed region, Latin American countries have to balance concerns about climate change and adaptation against competing social and environmental priorities. For instance, as a whole, Latin American countries consider poverty the basic social issue, and to many populations in the region the most important environmental problem is the lack of basic sanitation in urban areas (Tesh and Paes-Machado 2004).

141.   The research gap in the area of adaptation reflects the above need to make trade-offs between competing priorities. It also reflects the emphasis given to mitigation over adaptation during the initial negotiation processes: only recently did adaptation become a prominent issue in the negotiations and only relatively recently did the UNFCCC begin to encourage developing countries to undertake adaptation needs assessments and to outline possible vulnerability reduction strategies (Eakin and Lemos 2006). Insufficient time and capacity also partly explain the lack of attention to adaptation, as does the existence of uncertainties relating to adaptive capacity and the nature of climate impacts, and, hence, how to design adaptive responses (Reid et al. 2004).

142.   All of the above factors are likely to have limited Latin American countries' submissions of requests for funding for adaptation related research and action to funding organs such as the GEF and the World Bank, among others.

143.   Brazilian choices of climate research and action could serve to illustrate how national research and action projects relating to climate change may have consistently given priority to mitigation measures, in line with the government's emphasis in international negotiations. Some 80 percent of all GEF-funded studies and projects in Brazil have been in the area of mitigation, with the large majority of them focused on emission reductions through energy technology improvements. Yet, mitigation potential through emission reductions in energy production and energy consumption in Brazil would at most reduce emissions by 15–20 million tonnes of carbon. Putting that in perspective, Brazil's overall carbon emissions are 400 million tonnes, of which 75 per cent are due to land use. Energy accounts for only five per cent.

IX. Conclusions and recommendations

144.   Though scientific, technical and socio-economic aspects of vulnerability and adaptation have progressed considerably over the past decades, the majority of comprehensive and consistent analyses of projected climate change impacts at the regional scale is still based on information taken more or less directly from the coarse resolution of the AOGCMs. Therefore, it is recommended that very high dynamic or statistical downscaling is required to simulate the local climatic variations that are present in the Latin American region.

145.   There is a need to focus on the continued improvement of both technical studies and policy development as science-based understanding increases, and their inter-relationships and complexities become clearer. Efforts should not focus solely on studies, but rather the implementation of the developed policies and plans, and on identifying the ways and means to ensure that these efforts are harmonized and mainstreamed with national and sectoral Latin American development plans.

146.   Understanding climate change, climate variability and extreme events at the local and national levels will be critical, as will the development of appropriate methods and technology, the use and integration of traditional knowledge and the communication of science in ways that can be understood and used by Latin American policymakers and their constituencies.

147.   Many concerns and gaps have been identified, which relate to capacity-building, institutional strengthening, scientific understanding, monitoring, evaluation and project implementation that are relevant for enhancing the adaptive capacity of Latin American countries. There is a need to:

  (a)   Strengthen and enhance the capacity of Latin American countries and their respective national institutions and regional organisations to undertake the assessments of impacts relating to climate change. In addition, collaboration between the national governments and regional organisations with regard to climate change, climate variability and extreme events needs to be further strengthened and maintained

  (b)   Provide appropriate training of national experts in methods and tools for integrated assessment. The training needs to be strengthened by the provision of an appropriate level of resources at the country level and in-country training

  (c)   Enhance coordination among all regional and international agencies to disseminate information on impacts of climate change, climate variability and extreme events;

  (d)   Integrate risk management into sustainable development planning and in development strategies of key sectors, including agriculture, forestry, water resources and coastal zones

(e)   Strengthen local, national and regional networks, including sharing data, best practice examples, early warning, co-coordinated emergency response systems and other cooperation mechanisms.

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<u>Annex I</u>

List of organizations working on vulnerability and adaptation with known projects, links or programmes in the region

A. Regional organizations and initiatives

Name and location	Website
Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC), Panama	www.cathalac.org
Caribbean Community Climate Change Centre (CCCCC), Belize	www.caribbeanclimate.org
Caribbean Community and Common Market (CARICOM), Guyana	www.caricom.org
Consejo Nacional del Ambiente (CONAM), Perú	www.conam.gob.pe
Centro de Ciencias Ambientales (EULA), Chile	www.eula.cl
Centro de Previsao de Tempo e Estudos Climaticos (CPTEC), Brasil	www.cptecinpe.br
Centro de Estudios Sociales y Ambientales, Argentina	www.cesam.org.ar
Centro de Investigaciones del Clima y de la Atmosfera (CIMA), Argentina	www.cima.at.fcen.uba.ar
Comité Regional de los Recurso Hídricos (CRRH), Costa Rica	www.aguayclima.com
Forum of Minister of the Environment of Latin America and the Caribbean	www.pnumw.org
Instituto Geofísico del Perú (IGP), Peru	www.igp.gov.pe
Instituto de Clima y Agua (INTA), Argentina	www.intacya.org
Instituto Nacional de Ecología (INE), México	www.ine.gov.mx
Instituto de Meteorología (INSMET), Cuba	www.insmet.cu
Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM), Colombia	www.ideam.gov.co
Instituto de Pesquisa e Prevencao um desastres Naturais (IPEDEN), Brazil	www.ipeden.org
Fundacion Bariloche, Argentina	www.fundacionbariloche.org.ar
Ministerio del Ambiente, Ecuador	www.ambiente.gov.ec
Ministerio del Ambiente y Recursos Naturales (MARENA), Nicaragua	www.marena.gov.ni
Recursos e Investigaciara el Desarrollo Sustentable (RIDES), Chile	www.rides.cl
Red Iberoamericana de Oficinas de Cambio Climático (RIOCC)	www.mma.es
Universidad Nacional de La Asunción, Paraguay	www.una.py
Universidad de la Republica de Uruguay, Uruguay	www.rau.edu.uy/universidad
Universidad de Los Andes, Venezuela	www.ula.ve
Universidad Nacional de México (UNAM), México	www.unam.mx
Universidad Nacional de Rió Cuarto, Argentina	www.unrc.edu.ar
University of Nur, Bolivia	www.nur.edu
Universidad Federal do Para,Brasil	www.ufpa.br
Universidad del Valle, Colombia	www.univalle.edu
Vitae Civiles, Brazil	www.vitaecivilis.org.br

B. Donor and implementing agencies

Name	Website
Canadian International Development Agency (CIDA)	www.acdi-cida.gc.ca
German Technical Development Agency (GTZ)	www.gtz.de
Global Environment Facility (GEF)	www.gefweb.org
InterAmerican Development Bank (IADB)	www.iadb.org
Japan International Cooperation Agency (JICA)	www.jica.go.jp
Norwegian Development Agency (NORAD)	www.norad.no
Swedish International Development Cooperation Agency (SIDA)	www.sida.se

UN Environment Programme (UNEP)	www.pnuma.org
UN Development Programme (UNDP)	www.undp.org/regions/latinamerica
UN International Strategy for Disaster Reduction (UNISDR)	www.unisdr.org
UK Department for International Development (DFID)	www.dfid.gov.uk
US Agency for International Development (USAID)	www.usaid.gov
World Bank	www.worldbank.org

C. Research organisations and NGOs

Name	Website
Assessments of Impacts and Adaptations to Climate Change (AIACC) Project	www.aiaccproject.org
Center for Development Research (ZEF), Germany	www.zef.de
Center for International Climate and Environmental Research (CICERO), Norway	www.cicero.uio.no
Centre for International Cooperation (CIS), Free University of Amsterdam	www.cis.vu.nl
Climate Action Network (CAN)	www.climatenetwork.org
Institute of Development Studies (IDS), United Kingdom	www.ids.ac.uk
Inter American Institute for Global Research (IAI)	www.iai.int
Intergovernmental Panel on Climate Change (IPCC)	www.ipcc.ch
International Development Research Centre (IDRC)	www.idrc.ca
International Institute for Environment and Development (IIED), United Kingdom	www.iied.org
International Institute for Sustainable Development (IISD), Canada	www.iisd.org
International Research Institute for Climate and Society (IRI), USA	http://iri.columbia.edu
International Water Management Institute (IWMI), Sri Lanka	www.iwmi.cgiar.org
IUCN - the World Conservation Union	www.iucn.org
Mountain Research Initiative (MRI)	www.mri.scnatweb.ch
Potsdam Institute for Climate Impact Research (PIK), Germany	www.pik-potsdam.de
START - the global change SysTem for Analysis, Research and Training	www.start.org
Stockholm Environment Institute (SEI), Sweden	www.sei.se
The International Human Dimension Programme on Global Environmental Change (IHDP), Germany	www.ihdp.uni-bonn.de
Tyndall Centre for Climate Change Research, United Kingdom	www.tyndall.ac.uk
World Wildlife Fund for Nature (WWF)	www.panda.org

<div align="center">Annex II</div>

X. Climate products of Latin American countries

Argentina (<http://www.meteofa.mil.ar>)
Precipitation and Temperature
- Precipitation and temperature extremes (records) maps

Climatology information
- Diagnostic bulletin
- Seasonal forecast bulletin
- WMO South America seasonal forecast forums
- General information on information on climate change
- Statistical information (tourism)
- Mean values of precipitation and temperature (line graphs)
- 1961–1990 base-period climatology maps
- Antarctic climatology (description and line graphs of some stations)

Hydrometeorology information
- hydro-meteorological information
- La Plata rivers discharge
- non-rainy days
- accumulated precipitation

Barbados (<www.agriculture.gov.bb/default.asp?V_DOC_ID=1150>)
Climate and data information
- Daily minimum and maximum temperature
- Monthly precipitation outlook

Belize (<www.hydromet.gov.bz>)
Climate and data information
- Daily minimum and maximum temperature
- Monthly precipitation outlook
- Agrometeorology
- Flood and drought alerts
- Climatology of some cities

Bolivia (<www.senamhi.gov.bo>)
Data and Climatological information
- ASCII daily data (precipitation and temperature) from 2004 up to 2006
- ASCII climatological data (precipitation and temperature)
- Monthly climate diagnostics bulletin (September 2003 – August 2004)

Brazil (<www.inmet.gov.br>, <www.cptec.inpe.br>)
Dynamic forecast
- CPTEC GCM, AGCM, CGCM, stochastic models

Climate and data information
- Agroclimatological description
- Climatic classification

- Accumulated hydrological year and river discharges data
- Climatology of some cities in Brazil
- Climate in homogeneous regions
- Diagnostic bulletin
- Seasonal forecast bulletin
- WMO South America seasonal forecast forums
- General information on information on climate change
- Statistical information
- Mean values of precipitation and temperature (line graphs)
- 1961-1990 base-period climatology maps

Studies
- Amazon Climatology
- ENSO
- Natural disaster warning
- Climate change – regional and global
- Brazilian climate change forum
- Regional and national precipitation
- Droughts and their impacts
- Environmental impacts
- Bioclimatology
- Climatic evaluation

Hydrometeorology information
- Hydrometeorological information
- La Plata river's discharge
- Non-rainy days
- Accumulated precipitation

ENSO information
- Monthly bulletins
- Seasonal forecast bulletins

Chile (<www.meteochile.cl>)
Precipitation information
- ASCII precipitation data in 22 stations
- ASCII climatological information
- ASCII previous year information
- ASCII anomaly
- ASCII annual climatology

Temperature information
- ASCII maximum temperature in the previous day
- ASCII daily minimum temperature
- Daily maximum and minimum temperature maps (updated daily)

ENSO information
- Monthly bulletins
- Seasonal forecast bulletins

Climatology information
- Climatology of some cities in Chile
- Climatic classification
- Climate in homogeneous regions

Colombia (<www.ideam.gov.co/pronos/tiempo/index4.asp>)
Seasonal forecast
- Available in txt and pdf formats

Hydrology and data information
- Basins' characteristics and information on main rivers
- Climate, water and ecosystems atlas
- Data series and maps (metadata) of some stations/regions

Costa Rica (<www.imn.ac.cr>)
Climate and data information
- Daily minimum and maximum temperature
- Monthly climate bulletin

ENSO information
- Monthly bulletins
- Seasonal forecast bulletins

Studies
- Climate change

Cuba (<www.met.inf.cu/asp/genesis.asp?TB0=PLANTILLAS&TB1=INICIAL>)
Seasonal Forecast
- Seasonal forecasts (3 months lead time)

Data information
- Last 24-hour observations (maximum temperature, minimum temperature, relative humidity, wind speed and rainfall

Climatological and data information
- Last 24-hour observations (maximum temperature, minimum temperature, relative Humidity, wind speed and rainfall
- Diagnostics bulletin
- 1-month lead forecast
- ENSO information
- Drought monitoring
- Cuba climate information
- Tropospheric ozone information

Ecuador (<www.inamhi.gov.ec>)
Climate and data information
- Daily minimum and maximum temperature
- Monthly climate bulletin
- Agrometeorology

ENSO information
- Monthly bulletins
- Seasonal forecast bulletins

El Salvador (<www.snet.gob.sv>)
Climate information
- Climatological description (line graphs and maps)
- Climate classification

French Guyana (<www.meteo.fr/temps/domtom/antilles/pack-public/princ.htm>)
Climate and data information
- Daily minimum and maximum temperature
- Monthly precipitation outlook
- Seasonal forecast bulletin
- Climatological description (line graphs and maps)

Guatemala (<www.insivumeh.gob.gt>)
Climate information
- Climatic zones (text)

Climatological information
- Climatological atlas

Guyana (<www.guyanaclimate.org>)
ENSO information
- Abstract research papers on ENSO and its effects over irrigation water supply
- Impacts mitigation and information dissemination
- Hydrology

Honduras (<http://tco.fmi.fi/honduras.html>)
Institutional information only

México (<http://smn.cna.gob.mx>)
Climate and data information
- Daily minimum and maximum temperature
- Daily precipitation map
- Weekly precipitation map
- Monthly accumulated precipitation
- Climatology
- Seasonal forecast
- Monthly accumulated precipitation in Mexico (ASCII) from 1941 to 2005

Nicaragua (<http://tco.fmi.fi/nica_achievements.html>)
Institutional information only

Panama (<www.hidromet.com.pa>)
Climate and data information
- Pacific and Atlantic climatological description
- Precipitation and temperature daily values
- Hurricane description and climatology

Paraguay (www.meteorologia.gov.py/db1.html)
Climate and data information
- Daily minimum and maximum temperature

Peru (<www.senamhi.gob.pe>, <www.corpac.gob.pe>)
Dynamical forecast
- CCM3 model (restricted access)

Climate and data information
- Agroclimatological description
- Climatic classification
- Accumulated hydrological year and river discharges data

Studies
- Amazon climatology
- ENSO
- Natural disaster warning
- Climate change
- Regional and national precipitation
- Droughts and their impacts
- Environmental impacts
- Bioclimatology
- Climatic evaluation

Suriname (<www.meteosur.sr>)
Weather forecast information

Uruguay (<www.meteorologia.com.uy>)
Data information
- Monthly statistics for 12 stations (1961-1990 base period) for mean temperature, maximum absolute temperature, minimum absolute temperature, maximum mean temperature, minimum mean temperature, relative humidity, pressure, wind speed, monthly accumulated precipitation and rainy days
- Previous month maps (precipitation and temperature)
- Uruguay climatological characteristics

Venezuela (<www.marnr.gov.ve>)
- Seasonal forecast
- Climatological and agrometeorogical bulletins

Proposals for training and capacity-building activities on data, information and climate modelling

A. Training for installation and operation of meteorological networks

1.   Maintenance of long-term climate observation networks is of very high priority for the assessment of climate change, according to GCOS (2003a) and IPCC (2001). Use of observations for policy and planning purposes depends on access to information beyond the basic observations. To meet the needs of all nations for climate information, the global observing system for climate must generate useful climate products. The preparation of climate products almost invariably involves the integration of data in time and space, as well as the blending of data from different sources.

2.   Participants of a training activity could discuss the following issues:

      (a)   Status of the historical daily dataset available for the Latin America GSN and GUAN stations

      (a)   Needs of data recovery and digitization to complete the GSN and GUAN daily database

      (b)   Training and development of network exchange protocols

      (c)   Archiving of data in accessible formats and networks

      (d)   Data networking, accessibility and sharing

      (e)   Potential need for the establishment of a regional information coordinating center

      (f)   Digitization and archiving of historical data in the Latin America GSN and GUAN stations in the different countries.

3.   Resources needed include conventional and automatic stations, technicians, electronic engineer, structured auditorium (space, good internet connection, data show), PCs.

4.   Possible site: Centro de Previsao de Tempo e Estudos Climaticos (CPTEC). CPTEC have has been training Brazilian Regional Meteorological Centres on installation and operation of meteorological networks.

B. Training on freeware visualization packages, statistical analyses of climate change scenarios and developing analytical and useful products

5.   Climate data is fundamental to model how a given climate and/or climate change affects users' regions. Developing region specific products according to the needs of Latin American users, i.e. essential climate variables (ECVs) is very important. However, it is important to recognize that some alternative analysis approaches are required to verify the accuracy of the various outputs for specific variables. There are few analysis centres that are integrating observations of a given variable using data from different networks, but it is very important to make some analysis to identify, for example, specific climate change impact in each Latin America country.

6.   Resources: large structured (space, good internet connection, data show) auditoriums to host the participants, instructors and PCs.

7.   Possible sites: institutions that can provide the resources above, such as CPTEC, CIMA, CPPS/ERFEN, SENAMHI – PERU, CATHALAC and universities.

C. Training workshops

8.   The proposed workshops are intended to improve the capabilities of Latin America nations in the following aspects -- to understand the behaviour of the global climate system; to use such understanding to develop or adapt seasonal climate (especially rainfall) prediction schemes for their countries; to understand climate/climate change impact analyses for their countries; and to work with professionals in their nations to apply the climate change impact analyses and the prediction schemes in the management of agricultural production, water resources, energy generation and consumption, public health, and the environment.

9.   The proposal is to establish a workshop series similar to the one conducted by the Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, USA (CIMMS). These workshops use various activities to impart a wide range of material and broaden participants' experience. Many participants come to the workshops with a definite goal of developing a mitigation or prediction tool urgently needed by their nation. There are informal lectures on the maintenance of the general circulation of the atmosphere, the hierarchy of climate models, the development of understanding the El Niño-Southern Oscillation, and climate change impact analysis, including the development and strengthening of in-country modelling tools to assess the adverse effects of climate change and drivers of regional climate trends. At the more practical end, participants undertake small research projects that is often a "first" for them and their country. Seminar-like presentations by invited experts reveal how state-of-the-science understanding of regional climate variability, predictability and climate change has been developed and applied for each country.

10.   These workshops are guided by two beliefs. First, at a general level, it is assumed that a country's capacity is increased by participating in, having access to, and applying cutting-edge scientific research. Second, more specifically, young meteorologist in a developing country, we believe the capability to address a contemporary national or regional climate problem will be a function of his/her appreciation of the wider scientific context of the problem. The workshops would allow:

   (a)   Enhancing the abilities of Latin America countries to meet GCOS, regional, and national requirements for observations and related products to support climate change detection, monitoring of climatic variability, climate modelling and prediction, climate impact assessments, and planning for sustainable development and for adaptation to climate and its extremes

   (b)   Improving domestic coordination among national institutions, agencies and individuals engaged in data collection, data management, data exchange, and production of related products and services and between these entities and the user community

   (c)   Improving coordination across the region and with international programmes to ensure that regional and global needs for climate data are met

   (d)   Surveying the status of historical daily datasets available for the Latin America GSN and GUAN stations in Latin America National Weather Services.

11.   Resources required include large structured (space, good internet connection, data show) auditorium to host the participants, instructors, expert lecturers and laptops.

12.   Potential Sites: institutions that can provide the resources above such as CPTEC, CIMA, CPPS/ERFEN, SENAMHI – PERU and Universities.

D. Developing a multimedia CD ROM with topics about the environment and climate change

13.   A multimedia and interactive product using the internet could help to improve teaching, lecturing and learning quality of issues related to the environment and climate change. The aim is to create a well

explained, interactive and high quality CD-ROM to facilitate studies and understanding on geography and/or general science. This CD ROM will help to involve students and teachers in an awareness campaign on climate change and sensitize them on issues like global warming, sea-level rise, desertification, deforestation, consumerism, industrialization, depletion of energy resources etc. Users should use PCs. Information could be widely disseminated through formal and informal education sectors so that required actions are widely understood. Additionally, environmental education for children and adults must be integrated into education al all levels.

14.   Resources required: latest generation and powerful PC to put up with design software, web designers, programmers, multi-media software, medias (CD/DVD).

15.   Suggested site: CPTEC. MACA project of CPTEC (MACA – Meio Ambiente e Ciências Atmosféricas - Atmospheric Sciences and Environment) developed multimedia CD ROMs with topics about environment for educational purposes, which have been thoroughly tested in Brazil.

E. Internet use for simple and easy results on climate and/or statistical applications

16.   Many people and organizations now run websites where they provide climate data and even software for the analysis of this data. It is now feasible to do extensive climate research with a simple PC and internet connection. NOAA's Climate Diagnostics Center CDC (<www.cdc.noaa.gov>) contributes to maintaining and updating, mainly global data. Diagnostic analysis, bulletins and studies can be easily performed with this data. Other sites, useful for conducting climate research, include:

(a)   KNMI Climate Explorer (<http://climexp.knmi.nl>) - This site allows external users to produce spatial averages of climate variables such as rainfall from global, gridded data sets, and relate these to global data sets such as SSTs and NCEP reanalysis

(b)   Climate Diagnostic Center (<http://www.cdc.noaa.gov/ncep_reanalysis>) - Plots maps, cross-sections and time series based on the NCEP reanalysis dataset. There are options to plot anomalies and compare the data with the GFDL model results dataset and plot the GFDL dataset

(c)   Virtual Centre for Decadal Climate Variability (<http://www.decvar.org>) (Vikram Mehta - Univ. of Maryland). Provides access to long-term data sets integrated with analysis and visualization software, and allows community-wide planning of experiments and analyses

(d)   SERVIR - Regional Visualization and Monitoring System (<http://servir.nasa.cathalac.org>) This site allows users to visualize numerical forecast from Weather, Research, and Forecasting (WRF), and MM5. It also provides a variety of NASA geospatial data and ecological forecasting products.

(e)   Interactive statistics pages (<http://members.aol.com/johnp71/javastat.html>) (StatPages). Lists pages with programs for calculating confidence intervals, Bayesian methods, interactive tutorials etc.

(f)   WebStat (<http://www.stat.sc.edu/webstat>) On-line statistics, including multiple regression

(g)   Hyperstat Online (David Lane) (<http://davidmlane.com/hyperstat>) Statistics "textbook"

(h)   Regression explained (Vijay Gupta) (<http://www.spss.org/wwwroot/TIPS_ADVISE/regression_explained.doc>). MS Word document explaining output of multiple regression

(i)   Wavelets (Torrence & Compo <http://paos.colorado.edu/research/wavelets>) a complete interactive course in introductory statistics from Massey University (Douglas Stirling)Climate Change Outreach to Youth (<http://edugreen.teri.res.in>)Resources required: PCs or laptops with good internet connection.

F. Downscaling of climate change scenarios working package

18.   A key limitation in developing climate change projections from both global and regional models is the availability of trained personnel to produce, disseminate, and support the use of downscaled and tailored data for impacts studies. There is a need of identifying institutions in Latin America to foster capacity-building to develop and apply data and scenarios for impacts research and evaluation of adaptation options by users in the countries in the region. There is always a possibility of implementing mentorship and guidance to provide practical experience in developing and disseminating appropriate data products based on emerging resources.

19.   Institutions in countries such Argentina, Brazil and Mexico could assume that role by providing mentors and fostering training and capacity building activities. Successful realization of these activities will require identification of not only an implementing agency, in the Latin American case, that could be the IAI or START, but also potential experts from the region. While recognizing the infrastructural limitations of countries in Latin America, there is a need for disseminating high quality model data products using low-technology means. Of immediate benefit would be the availability of low cost CDs, DVDs and other simple media forms, of climate projection data products directed to targeted key economical and social sectors and regions. This could include appropriate software tools for data processing and visualization, as well as estimates of skill and uncertainties that could serve as support resources for the regional scientists.

20.   For regional modelling of climate change, a "Downscaling of climate change scenarios working package" is proposed that could include a User's guide, a list of variables that can be generated and used for studies on vulnerability and impacts, a PC with configuration and system that would allow for the runs of regional climate models and hard disks with a capacity of at least 500 GB to guarantee that there is enough space to save model scenarios and products generated by the activity. If computer means are not limited, Latin American countries could use regional models for generating climate change scenarios derived from regional climate models. The exception could be in small countries, where the application of statistical downscaling methods (MAGICC, SDMS) directed at regional climate change scenarios instead of global climate models, i.e. "double downscaling", is proposed.

21.   Such a working package could be made available in Spanish, English, and Portuguese and could consist of a workbook, a set of DVDs with programs and applications for graphic display, and the Eta/CPTEC regional model that can be run on UNIX environment. The global models that are used to run the models are the HadGEM1 and the ECHAM 5 from Germany. Talks are underway with the UK Met Office and the Max Planck Institute to get access and distribute the daily data from the 21st century as part of the working package. Funding is being asked from the GEF.

22.   Given the experience in model development and the generation of regional climate change scenarios, and considering the computing facilities and expertise, the Brazilian CPTEC is proposed to function as the focal point for: running regional climate models to produce climate change scenarios for the future and then make them available to other countries in the region; training and capacity-building in downscaling both statistical (MAGICC, SDSM) and dynamic (regional climate modeling) in South and Central America; and training in the use of visualization tools (GRADs) and statistical analyses of regional climate change scenarios.

23.   CPTEC could act as a centralized facility that builds up human and technical capacity in core activities (advanced computational infrastructure, training, and internships) but could also engage in collaborations with other universities and government agencies on applied regional projects, with outreach

to rural and agricultural communities at the level of individual farmers. CPTEC could build upon its strong climate modelling capability due to its computational equipments (NEC SX-6 supercomputer) in the broad areas of climate modelling, climate system dynamics, climate change, and seasonal forecasting.

24.   While CPTEC could concentrate on model runs and training at the higher level of model development and understanding, data processing and visualization, other training activities for various regions in South America could be the responsibility of other institutions with proven capability in climate change issues such as the CIIFEN in Ecuador, the CIMA in Argentina and UNAM in Mexico that cover various regions of Latin America. Interaction between these institutions could involve the availability of models, tools and visualization techniques. Training activities could take place in Guayaquil (hosted by CIIFEN), Buenos Aires (hosted by CIMA), Mexico City (hosted by UNAM) and in Sao Paulo (hosted by CPTEC).

25.   More specific activities that can involve CPTEC, CIIFEN, CIMA and UNAM, as well as other centres in Latin America could be:

   (a)   A mentor program for climate change modelling, downscaling, and analyses, with the mentors available for three years, with a yearly stipend of USD 3000. Because of the experience in climate change modelling at global and regional scale, it is suggested that two mentors could be from South America (From CPTEC and CIMA), and the other for Central America could be from UNAM. These mentors can work from their offices with no need for continuous travel, and positions can be assessed and reviewed on a yearly basis

   (b)   Programmer and specialist on HTML and visualization, located in Brazil, Argentina, Ecuador and Mexico with possibilities of travelling for training activities, and to provide assistance in programming and computer support for running downscaling experiments, data processing and visualization, with a salary of USD 4000 per year and a budget for travel outside the base country.

26.   CPTEC, CIMA, UNAM and CIIFEN are proposed because these institutions have the computer capability, local expertise, experience on climate studies and applications to society. Some of them work on seasonal climate forecasts and host regional meetings between climatologists and users of various sectors of society. Some of these institutions also host post graduate programs (CPTEC, CIMA, and UNAM) in environmental sciences and training activities and capacity-building that can be very relevant to this project. There is always a possibility that Mexico, Argentina, Brazil and Ecuador could provide some limited funding for regional training activities that would match funding from IAI, START, AIACC, GEF or other funding agencies.

G. Internet resources for access to model climate projections

   (a)   IPCC DDC for TAR models (in the UK, with links to the Max Planck Institute for Meteorology and the Columbia University Socio Economic data) (<http://ipcc-ddc.cru.uea.ac.uk>)

   (b)   PCMDI access to IPCC AR4 data (there is a need for registration and data can be downloaded for free) (<http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php>)

   (c)   PRUDENCE web site (regional projections Europe) (<http://prudence.dmi.dk>)

   (d)   NAARCAP web site (regional projections for North America): (<http://www.narccap.ucar.edu/index.html>)

(e)   CREAS web site (regional projections for South America), available in July 2006: (<www.cptec.inpe.br/mudancadeclima/CREAS>)

(f)   AIACC web site (for projects on climate change in Latin America): (<http://sedac.ciesin.columbia.edu/aiacc>).

Annex IV

Latin America Network Global Climate Observing System

GCOS Latin América Network
Source: GCOS-96 – February 2005

A. GCOS Surface Network (GSN)

Country (Area)   ARGENTINA / ARGENTINE

Index Nbr	Station Name	Latitude	Longitude	Elevation (m)
87007	LA QUIACA OBSERVATORIO	22 04S	55 76W	3,459
87047	SALTA AERO	24 51S	65 29W	1,221
87065	RIVADAVIA	24 10S	62 54W	205
87078	LAS LOMITAS	24 42S	60 33W	130
87129	SANTIAGO DEL ESTERO AERO	27 46S	64 18W	199
87155	RESISTENCIA AERO	27 27S	59 04W	52
87217	LA RIOJA AERO	29 23S	55 49W	423
87227	CERES AERO	29 53S	61 57W	88
87270	RECONQUISTA AERO	29 11S	59 42W	53
87345	JACHAL	30 15S	68 46W	1,176
87344	CORDOBA AERO	31 19S	64 15W	474
87374	PARANA AERO	31 47S	60 29W	78
87418	MENDOZA AERO	32 50S	68 47W	704
87534	LABOULAYE AERO	34 55S	63 22W	137
87544	PEHUAJO AERO	35 52S	61 54W	87
87623	SANTA ROSA AERO	35 34S	64 16W	191
87692	MAR DEL PLATA AERO	37 56S	57 35W	21
87715	NEUQUEN AERO	38 57S	68 08W	271
87750	BAHIA BLANCA AERO	38 44S	62 10W	83
87803	ESQUEL AERO	42 54S	71 09W	797
87828	TRELEW AERO	43 12S	55 16W	43
87860	COMODORO RIVADAVIA AERO	45 47S	67 70W	45
87925	RIO GALLEGOS AERO	51 37S	69 17W	19

Country (Area)   BOLIVIA / BOLIVIE

Index Nbr	Station Name	Latitude	Longitude	Elevation (m)
85041	COBIJA	11 02S	68 47W	
85043	RIBERALTA	11 00S	16 07W	
85112	MAGDALENA	13 20S	64 07W	
85141	RURRENABAQUE	14 25S	67 34W	
85207	SAN IGNACIO DE VELASCO	16 33S	60 56W	
85223	COCHABAMBA	17 25S	66 11W	
85230	CHARANA	17 35S	69 26W	
85289	PUERTO SUAREZ	18 58S	57 49W	
85364	TARIJA	21 32S	64 42W	
85365	YACUIBA	22 07S	63 29W	

Country (Area)   BRAZIL / BRÉSIL

Index Nbr	Station Name	Latitude	Longitude	Elevation (m)
82024	BOA VISTA	02 49N	60 39W	
82106	SAO GABRIEL DA CACHOEIRA	00 06S	67 05W	
82113	BARCELOS	00 55S	62 56W	
82193	BELEM (AEROPORTO)	01 23S	48 29W	
82331	MANAUS	03 05S	60 01W	

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Country (Area)   BRAZIL - BRESIL

Index-Nbr	Station Name	Latitude	Longitude	Elevation (m)
82353	ALTAMIRA			
82400	FERNANDO DE NORONHA			
82410	BENJAMIN CONSTANT			
82425	COARI			
82571	BARRA DO CORDA			
81594				
82704	CRUZEIRO DO SUL			
82825	PORTO VELHO			
82964	PORTO NACIONAL			
83229	SALVADOR			81
83255	BARREIRAS			
83264	BELO HORIZONTE			
83361	CUIABA			
83484	JOAO PINHEIRO			762
83453	ITAMARANDIBA			
83488	CARAVELAS			
57692	BELO HORIZONTE (CONFINS)			
83818	TRES LAGOAS			
83840	TRINIDADE (ILHA)			
83746	GALEAO			
83781	SAO PAULO			
83827	RIO DO JANEIRO (AEROPORTO)			
83842	CURITIBA			
83851				207

Country (Area)   CHILE - CHILI

Index-Nbr	Station Name	Latitude	Longitude	Elevation (m)
85406	ARICA			
85442	ANTOFAGASTA			
85469	ISLA DE PASCUA			
85485	LA SERENA			
85543	QUINTERO			
85543	JUAN FERNANDEZ			50
85629	CURICO			
85743	TEMUCO			
85799	PUERTO MONTT			
85874	BALMACEDA			
85934	PUNTA ARENAS			

Country (Area)   COLOMBIA - COLOMBIE

Index-Nbr	Station Name	Latitude	Longitude	Elevation (m)
80222	BOGOTA/ELDORADO			2,546
80241	LAS GAVIOTAS			167
80259	GABRIEL			267
80342	SAN ANTONIO			

Country (Area)   ECUADOR / ÉQUATEUR

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
84008	SAN CRISTOBAL (GALAPAGOS)	00 54S	89 37W	6
84088	RIOBAMBA	00 21S	78 73W	3,056
84143	PICHILINGUE	01 05S	79 19W	120
84270	LOJALA ARGELIA	04 00S	79 12W	2,150
84073	MACARA AEROPUERTO	84 22S	79 46W	427

Country (Area)   FRENCH GUIANA / GUYANE FRANÇAISE

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
81405	ROCHAMBEAU	04 50N	52 12W	9

Country (Area)   PARAGUAY

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
86065	PUERTO CASADO	22 17S	57 52W	87
86217	ENCARNACION	27 19S	55 50W	91

Country (Area)   PERU / PÉROU

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
84377	IQUITOS	03 45S	73 15W	126
84444	CHACHAPOYAS	06 13S	77 50W	2,546
84455	TARAPOTO	06 27S	76 23W	282
84721	SAN JUAN	15 23S	75 10W	60
84752	AREQUIPA	16 17S	71 33W	2,539

Country (Area)   SURINAME / SURINAM

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
81002	NICKERIE	05 57N	57 02W	2

Country (Area)   URUGUAY

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
86350	ARTIGAS	30 23S	56 30W	120
86440	MELO	32 22S	54 11W	100
86480	MERCEDES	33 15S	58 04W	17
86565	ROCHA	34 29S	54 18W	18

Country (Area)   VENEZUELA

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
80403	LA ORCHILA	11 48N	66 10W	3
80415	GUIRIA	10 35N	62 19W	12
80425	MENE GRANDE	09 49N	70 56W	36
80438	MERIDA	08 36N	71 11W	1,498
80450	SAN FERNANDO DE APURE	07 54N	67 25W	48
80453	TUMEREMO	07 18N	61 27W	181
80462	SANTA ELENA DE UAIREN	04 36N	61 07W	907

Country (Area)   COLOMBIA / COLOMBIE (SAN ANDRES AND PROVIDENCIA ISLANDS / ILES SAN ANDRES ET PROVIDENCIA)

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78801	SAN ANDRES ISLA (SESQUICENTENARIO)	12 35N	81 43W	6

Country (Area)   COSTA RICA

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78767	PUERTO LIMON	10 00N	83 03W	3

Country (Area)   CUBA

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78367	GUANTANAMO ORIENTE	19 54N	75 08W	23

Country (Area)   EL SALVADOR

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78560	ACAJUTLA	13 34N	89 50W	

Country (Area)   MEXICO / MEXIQUE

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
76833	SALINA CRUZ, OAX.	16 10N	95 11W	

Country (Area)   PUERTO RICO AND US POSSESSIONS IN THE CARIBBEAN AREA / PORTO-RICO ET POSSESSIONS DES ETATS-UNIS DANS LA REGION DES CARAIBES

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78526	SAN JUAN/INT., PUERTO RICO	18 25N	65 59W	4

Country (Area)   MEXICO / MEXIQUE

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
76311	CHOIX, SIN.	26 44N	108 17W	
76393	MONTERREY, N.L.	25 44N	100 18W	
76405	LA PAZ, BCS	24 10N	110 18W	
76458	COLONIA JUAN CARRASCO MAZATLAN, SIN.	23 12N	106 25W	
76577	GUANAJUATO, GTO.	21 00N	101 17W	
76644	AEROP.INTERNACIONAL MERIDA, YUC	20 59N	89 39W	
76654	MANZANILLO, COL.	19 03N	104 19W	
76680	MEXICO (CENTRAL), D.F.	19 24N	99 11W	
76833	SALINA CRUZ, OAX.	16 10N	95 11W	

B. GCOS Upper-Air Network (GUAN)

Country (Area)	ARGENTINA / ARGENTINE			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
87155	RESISTENCIA AERO	27 27S	59 03W	52
87576	EZEIZA AERO	34 49S	58 32W	20
87860	COMODORO RIVADAVIA AERO	45 47S	57 30W	46

Country (Area)	BRAZIL / BRÉSIL			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
82193	BELEM (AEROPORTO)	01 23S	48 29W	
82332	MANAUS (AEROPORTO)	03 09S	59 59W	
82397	FORTALEZA	03 46S	39 36W	
83378	BRASILIA (AEROPORTO)	15 62S	47 55W	
82779	MARTE	23 30S	46 38W	

Country (Area)	CHILE / CHILI			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
85442	ANTOFAGASTA	23 29S	70 26W	
85469	ISLA DE PASCUA	27 09S	109 26W	
85586	SANTO DOMINGO	33 37S	71 36W	
85799	PUERTO MONTT	41 26S	73 07W	
85934	PUNTA ARENAS	53 40S	70 35W	

Country (Area)	COLOMBIA / COLOMBIE			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
80222	BOGOTA/ELDORADO	04 42N	74 09W	2,546

Country (Area)	ECUADOR / ÉQUATEUR			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
84008	SAN CRISTOBAL (GALAPAGOS)	00 54S	89 37W	6

Country (Area)	FRENCH GUIANA / GUYANE FRANÇAISE			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
81405	ROCHAMBEAU	04 50N	52 22W	9

Country (Area)	ISLANDS / ILES (98: 990 - 998)			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
88889	MOUNT PLEASANT AIRPORT	51 49S	58 27W	74

Country (Area)	PERU / PÉROU			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)

Country (Area)	PERU / PÉROU			
IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
84629	LIMA/CALLAO	12 01S	77 07W	12

Country (Area)   BARBADOS / BARBADOS

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78954	GRANTLEY ADAMS	13 04N	59 29W	56

Country (Area)   COSTA RICA

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78762	JUAN SANTAMARIA INT. AIRPORT	09 59N	84 13W	908

Country (Area)   CURACAO AND BONAIRE / CURACAO ET BONAIRE

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78988	HATO AIRPORT, CURACAO	12 12N	68 58W	54

Country (Area)   MEXICO / MEXIQUE

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
76654	MANZANILLO, COL.	19 03N	104 19W	

Country (Area)   PUERTO RICO AND US POSSESSIONS IN THE CARIBBEAN AREA / PORTO-RICO ET POSSESSIONS DES ETATS-UNIS DANS LA REGION DES CARAIBES

IndexNbr	Station Name	Latitude	Longitude	Elevation (m)
78526	SAN JUAN INT., PUERTO RICO	18 26N	65 59W	4

Annex V

Climate scenarios and an evaluation of their advantages and disadvantages

The role of some types of climate scenarios and an evaluation of their advantages and disadvantages according to the five criteria listed below the Table. Note that in some applications a combination of methods may be used (e.g. regional modelling and a weather generator). (Modified from Mearns et al. 2001).

Scenario type or tool	Description/Use	Advantages*	Disadvantages*
Climate Model based Direct AOGCM outputs	Starting point for most climate scenarios Large-scale response to anthropogenic forcing	Information derived from the most comprehensive, physically based models (1, 2) Long integrations (1) Data readily available (5) Many variables (potentially) available (3), (2, 4) information	Spatial information is poorly resolved (3) Daily characteristics may be unrealistic, except for very large regions (3) Computationally expensive to derive multiple scenarios (4, 5) Large control run biases may be a concern for use in certain regions (2)
High resolution/ stretched grid (GCM)	Providing high resolution information at global/continental scales	Provides highly resolved information (3) Information is derived from physically-based models (2) Many variables available (3) Globally consistent and allows for feedbacks (1,2)	Computationally expensive to derive multiple scenarios (4, 5) Problems in maintaining viable parameterizations across scales (1,2) High resolution is dependent on SSTs and sea ice margins from driving model (AOGCM) (2) Dependent on (usually biased) inputs from driving AOGCM (2)
Regional models	Providing high spatial/temporal resolution information	Provides very highly resolved information (spatial and temporal) (3) Information is derived from physically-based models (2) Many variables available (3) Better representation of some weather extremes than in GCMs (2, 4)	Computationally expensive, and thus few multiple scenarios (4, 5) Lack of two-way nesting may raise concern regarding completeness (2) Dependent on (usually biased) inputs from driving AOGCM (2)

Statistical downscaling	Providing point/high spatial resolution information	Can generate information on high resolution grids, or non-uniform regions (3) Potential for some techniques to address a diverse range of variables (3) Variables are (probably) internally consistent (2) Computationally (relatively) inexpensive (5) Suitable for locations with limited computational resources (5) Rapid application to multiple GCMS (4)	Assumes constancy of empirical relationships in the future (1, 2) Demands access to daily observational surface and/or upper air data that spans range of variability (5) Not many variables produced for some techniques (3, 5) Dependent on (usually biased) inputs from driving AOGCM (2)

(*) Numbers in parentheses under advantages and disadvantages indicate that they are relevant to the numbered criteria described. The five criteria are:

1) Consistency at regional level with global projections
2) Physical plausibility and realism, such that changes in different climatic variables are mutually consistent and credible, and spatial and temporal patterns of change are realistic
3) Appropriateness of information for impact assessments (i.e. resolution, time horizon, variables)
4) Representativeness of the potential range of future regional climate change
5) Accessibility for use in impact assessments.

<u>Annex VI</u>

National communications to the UNFCCC submitted by
Latin American countries

Current situation of National communications to the UNFCCC submitted by Latin American countries (Non-Annex I Countries). Source: UNFCCC (<www.unfccc.int>). E=English, S=Spanish, P=Portuguese, F=French

Non Annex I countries	Initial (First) National Communication	Date of submission	Second National Communication	Date of submission
ARGENTINA	E, S	25/07/97		
ARGENTINA (Addendum)	E, S	11/03/99		
BOLIVIA	E, S	16/11/00		
BRAZIL	E, S, P	10/12/04		
CHILE	E	08/02/00		
COLOMBIA	S	18/12/01		
COLOMBIA (Executive Summary)	E	18/11/00		
COSTA RICA	S	28/09/01		
CUBA	S	04/06/03		
DOMINICAN REPUBLIC	S	15/11/00		
ECUADOR	E, S	10/04/00		
EL SALVADOR	E, S	01/02/02		
GUATEMALA	S	16/05/02		
GUYANA	E	03/01/02		
HAITI	F	03/01/02		
HONDURAS	S	15/11/00		
JAMAICA	E	21/11/00		
MEXICO	E, S	09/12/97	S	23/07/01
NICARAGUA	S	25/07/01		
PANAMA	S	20/07/01		
PARAGUAY	S	10/04/02		
PERU	S	21/08/01		
URUGUAY	E, S	15/10/97	S	11/05/2004
VENEZUELA	S	13/10/05		

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