IPCC WGII Fourth Assessment Report – Draft for Expert Review

Chapter 13: Latin America

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Executive summary

Climatic variability and extreme events, primarily those related to precipitation variability, have been severely affecting the Latin America region over recent years, where severe droughts and flood episodes occurred in most of countries. Moreover, unexpected extreme climatic events were reported, as the Venezuelan intense precipitations of 1999 and 2005 that caused 45 000 casualties; the unprecedented and destructive hail storm in Bolivia of 2002 in which 70 people died 19 were declared missing and there were 130 people wounded, and the extremely rare hurricane Catarina in the South Atlantic during 2004 that destroyed over 4 000 houses.

During the last part of the 20th century clear climatic trends were observed in the region. Important increases in precipitation were evidenced in Argentina, Uruguay, Brazil and Bolivia with impacts on changes in land use, crop yields and flooding. Increases in morbidity and mortality due to flooding, landslides and storms were also reported. Inversely a declining trend in precipitation was observed in Ecuador, Chile and some parts of Central America.

The severe retreat of glaciers reported in the TAR has recently been exacerbated especially in Bolivia, Peru, Colombia and Ecuador. In the next 15 years, 80% of the glaciers of the intertropical Andes will have disappeared with the consequent impacts on the availability of water resources for human consumption, agriculture, hydropower, etc.

Increases of the rate of sea level rise were observed in several countries. For example, in southeastern South America the increase attained 2 mm/year during the last 30 years, and 4 mm/year when considering the last 15 years.

Natural land cover in general continuous to decline at very high rates throughout the Region, in particular rates of deforestation of tropical forests have increased during the last five years (e.g. Brazil 50 %). There is evidence that biomass burning aerosols may change regional climates south of the Amazon.

The emergence of reliable seasonal climate forecasts and the improvement of short range weather forecasts during the last 10 years contributed to the increase in their use and the development of early warning systems for risk analysis in several sectors such as agriculture, human health, water resources, and fisheries increasing the capacity of these sectors for planning and management. Those systems are being rapidly implemented as a means to reduce vulnerability to current climate variability. Other important issue evidenced recently in the region is the participation of stakeholders in the process of decision-making in adaptation strategies and risk management to cope with climate variability.

Adaptation strategies for the maintenance of biodiversity in natural ecosystems on the face of massive species extinctions due to climate change, based on conservation policies have been expanded to include the concept of ecological corridors. Several corridors have been implemented in several zones of the region.

In regard to future climatic conditions, the projected warming for Latin America ranges from 1 to 4 C for emissions scenario B2 and from 2 to 6 C for the A2. Although current GCMs do not produce projections of changes in the hydrological cycle at regional scales with confidence, most model projections indicate rather larger rainfall anomalies for the Tropical portions of Latin America and much less for extra-tropical South America. In addition, many of the current climate change studies indicate that the frequency in the occurrence of extremes will increase in the future.

Under future conditions, there is the likelihood of catastrophic species extinctions in many areas of tropical Latin America, and of the *savannization of portions of Amazonia* due to synergistic effects of both land use and climate changes.

Between 30 and 90 million people in 2025, and between 100 and180 millions in 2055 will suffer from the lack of adequate water supplies, depending on the climate scenario considered.

Decreases in the transmission of malaria are indicated in many areas where reductions in precipitation are projected, such as in Amazonia and Central America. Changes in the geographical distribution of dengue are also projected: increasing transmission areas in Mexico, Brazil, Peru and Ecuador.

With important consequences for the well being of the population by the year 2050, 50% of agricultural lands will be subjected to desertification and salinization processes in many areas of Latin America.

A great variability in crop yields is being projected, this could be attributed to the GCM or the incremental scenario, the time slice and the considered SRES scenario, the inclusion or not of CO2 effects, and the site considered. However some behaviour seems to be consistent all over the region like the projected reduction of rice yields after the year 2010, and the increase in soybean yields when CO2 effects are considered. Other important issues related to coffee are the expected reduction in planted area in Brazil, and in production in Mexico.

Low economic growth and institutional weaknesses decrease the resilience of the social systems to cope with climate variability and change and complicate the implementation of measures to counteract the environmental deterioration provoked erroneously by human (social and economic) actions. These environmental (and socio-economic) stresses already compromise any sustainable development plan and in combination with climate change will complicate further any attempt to achieve such a plan.

13.1 Summary of knowledge assessed in the TAR

There is a positive trend in the observed temperature in Latin America. In northwestern South America and Amazonia this trend is clearer and amounts to 0.63 C over the last 100 years. However, the warming trend is not uniform and there are a few areas presenting a cooling one, such as Chile between 35 S to 45 S. Consistent precipitation trends are hardly seen in the region. Over the last 40 years, there is increasing winter precipitation in Mexico, as opposed to decreasing precipitation in northern parts of Nicaragua. In Amazonia, interdecadal variability in the hydrological record (both in rainfall and streamflow) is more significant than any observed trend. Records suggest a positive trend for the past 200 years at higher elevations in northwestern Argentina. A more consistent analysis of climate in the region is impeded due to the scarcity of long historical time series of research-quality climate data.

Observational evidence of climate change by proxi in the region, although sparse, gives further evidence of positive temperature trends. Cloud forests are migrating to higher elevations and glacier and ice covers have been decreasing and may soon disappear. The latter may pose a danger for local water supply that have to be shared among human consumption, regional agriculture and hydroelectricity. It is believed that tourism, river navigation, hydropower generation, biodiversity, remaining forests mainly the Amazon are threatened by a combination of population increase, land use change and global warming. An increasing number of forest fires in the tropics is expected due to human disturbances, higher temperatures, a decrease of precipitation caused by a reduction in evapotranspiration and to the presence of El Niño as they are affected by climate change. Tree mortality increases under dry conditions that prevail near newly formed edges in Amazonian forests.

ENSO is the dominant mode of climate variability in Latin America and the natural phenomena with the largest socio-economic impacts. During the warm phase (El Niño), winter precipitation increases and summer precipitation decreases in Mexico and in the Pacific coast of Central America. Peru experiences increases in precipitation while western Colombia, northern and eastern Amazonia and Northeast Brazil suffers from decreased precipitation during their rainy season. Southeastern South America experiences precipitation increases as well as the northern Chile. In general, La Niña effects on precipitation are approximately the opposite of those caused by El Niño. If the frequency and/or intensity of El Niño or La Niña were to increase, Latin America would be exposed to these (possibly larger) impacts more often.

In Latin America many diseases are weather and climate related either through the outbreaks of vectors that develop in warm and humid environments. Malaria and dengue are very important. Cholera and diarrhea diseases are caused by poor sanitary conditions and the occurrence of drought or flood sometimes related to El Niño.

Climate change could influence the frequency of outbreaks of these diseases by altering the variability associated with the main controlling phenomena i.e. El Niño (likely). At the same time climate change could affect human health indirectly through the decrease of food production as most of agricultural models' simulations carried out for the region seem to imply.

Agriculture in Latin America is a very important economic activity representing about the 10% of the GDP of the region and it occupies around the 40% of the economically active population. Subsistence agriculture is of vital importance in the region being the only source of subsistence for many families. Studies in Argentina, Brazil, Chile, Mexico, and Uruguay based on GCMs and crop models project decreased yields for numerous crops (e.g., maize, wheat, barley, grapes) even when the direct effects of CO_2 fertilization and implementation of moderate adaptation measures at the farm level are considered.

Studies carried out to assess the potential impacts of climate change on natural ecosystems indicate that neotropical seasonally dry forest should be considered severely threatened in Mesoamerica. In Mexico, nearly 50% of the deciduous tropical forest would be affected. Global warming could expand southward the area suitable for tropical forests in South America, but current land use make it unlikely that tropical forests will be permitted to occupy these new areas. On the other hand, large portions of the Amazonian forests could be replaced by tropical savannas.

Sea-level rise will affect mangrove ecosystems damaging the region's fisheries. Coastal inundation resulting from sea-level in combination with riverine and flatland flooding would affect water quality and availability, exacerbating socioeconomic and health problems in these areas.

Another environmental stress of great importance in Latin America is due to land use and land cover changes. The Amazon region exhibits the highest rates of deforestation all over the world. Most of the deforested area is being converted to pasture and agricultural uses. Deforestation contributes directly to global warming increasing emissions of GHG. For large scale deforestation in Tropical South America, there is relatively high confidence that reduced evapotranspiration and increasing temperatures will lead to less rainfall during the dry season. Greater severity of droughts reinforced by deforestation effects could lead to erosion of the remainder of the forest once a substantial portion of the region had been converted to pasture.

From the TAR it is apparent that studies have concentrated on the impacts of climate and climate variability on the region’s different sectors and activities. Very few studies have considered options for adaptation to the contemplated environmental risks imposed by climate change. Adaptive capacity of human systems in Latin America is low, particularly with respect to extreme climate events, and vulnerability is high as inferred from the studies. Adaptation measures have the potential to reduce climate-related losses in agriculture and forestry but less so for biological diversity.

13.2. Current sensitivity/vulnerability

13.2.1 What is distinctive about the Latin America region?

Latin America is highly heterogeneous in terms of climate, ecosystems, human population distribution and cultural traditions. A large portion of the region is located in the Tropics showing a climate dominated by convergence zones such as the Intertropical Convergence Zone (ITCZ), and the South Atlantic Convergence Zone (SACZ). The summer circulation in tropical and subtropical America is dominated by the North America Moonson System which affects Mexico and parts of Central America and the South America Monsoon System. These monsoon climates are closely interconnected with ocean-atmosphere interactions of the tropical and subtropical oceans. Low Level Jets in South America east of the Andes, and in North America east of the Rockies, Baja California and over the Intra-Americas Seas transport moisture from warm oceans to participate in continental rainfall.. Most of the rainfall is organized in the convergence zones or by topography, leading to strong spatial and temporal rainfall contrasts, such as the expected subtropical arid regions of Northern Mexico and Patagonia, but also the driest desert in the world in northern Chile, a tropical semi-arid region of Northeast Brazil next to humid Amazonia and one of the wettest areas in the world over western Colombia.

Latin America possesses a large variety of ecosystems, ranging from the Amazonian tropical rain forest, cloud forest, Andean Paramos, rangelands, shrublands, deserts, grasslands, and wetlands (Gitay *et al*., 2002); rangelands cover about one-third of the land area and Forest occupy almost 22% of the region. This contains 834 million ha of tropical forest and 130 million ha of other forests, both temperate and dry, coastal and montane, covering 48% of the total land area (FAO 2001). Seven of the world's 25 biologically richest terrestrial ecoregions are found in the region, containing between them more than 46 000 vascular plant, 1 597 amphibian, 1 208 reptile, 1 267 bird and 575 mammal species (Mittermeier, Myers and Mittermeier 1999, Myers *et al* 2000).

Over the last three decades Latin America was subject to climate-related impacts of increased (Trenberth *et al*., BAMS,) El Niño occurrences with two extremely intense episodes (1982-83 and 1997-98), and increased climate extremes (EPA, 2001; **Other** reference must come from

WG I chapter on changing frequency of extremes). That contributed greatly to augmented vulnerability of human systems to natural disasters (floods, droughts, landslides, etc.). The main drivers of this increased vulnerability, in addition to climate, are demographic pressure, poverty and rural migration, being the poorest communities among the most vulnerable group to hydro-meteorological extremes (Geo 2003). Some of these vulnerabilities are their location in the path of hurricanes, unstable lands (erosion and landslides), precarious settlements, low-lying areas settlements and flooding from rivers (BID, 2000; Geo 2003).

13.2.2. Weather and Climate stresses

Climatic variability and extreme events, primarily those related to precipitation variability, have been severely affecting the region over recent years. High temperatures and hot spells are another common weather-related stressor for agriculture, water resources and human health. Table 13.1 summarizes main extreme weather and climate events in Latin America and their impacts over the period 1997-2005.

Table 13.1*: Extreme events and their impacts*

High precipitations, floods and hurricanes
Venezuela, Feb-May 2005. Floods: 175.000 injuries. Loses of 52MUS$.
Bolivia, 2004: Sever snow storm (12 hours) affected the southern provinces of Potosi with severe damages upon livestock and tourism installations. (Gonzales, 2005)
Brazil, 2004. Hurrican Catarina
Argentina (Santa Fe), 2003. Floods: 59 lives lost (10 by heart attacks), 25.550 houses affected, 147.000 evacuated, damage in productivity and infrastructure. Economic losses estimated in 1.1 million dollars. (CEPAL; La Nación, 2003)
Argentina (Córdoba, Santa Fe and Buenos Aires), 2003: Severe wind/rainstorms (tornado like) with winds exceeding 100km/h: 300 evacuees and 14 deaths; houses destroyed and overturned vehicles. The visibility was seriously affected, creating transit problems and risks. (Clarin and Pagina12; Nov 13, 2003)
Bolivia, 2003: Heavy rains affected almost the whole territory and generated several emergency situations. In the locality of Chima in the northern provinces of La Paz landslides almost sheltered the entire town. In the tropical region of Chapare heavy rains destroyed the Tunari bridge which connects the city of Cochabamba. (Gonzales, 2005)
Bolivia, Feb 19 2002: Unprecedented and very intense hail storm affected La Paz. Heavy and cold rain and hail provoked 70 deaths, 19 missing persons and 130 wounded people. Serious economic consequences in houses, commercial stores, restaurants, and public and private transportation were also reported. Aparicio (2005)
Costa Rica, 2001- Hurricane Michelle: Damages in roads, bridges, aqueduct and agriculture. Loses of 2.859 Million of Colones (0.05% PIB). www.mideplan.go.cr
Costa Rica, Dec 2001. High rainfall: Damage in Roads and bridges. Loses of 9,212 Million of colones (0.17% PBI). **(**www.mideplan.go.cr**)**
Argentina, 2001-2002. Frequent heavy precipitation events on the Depressed Pampas with 8 millions ha flooded and estimated economic losses of about [to be completed]. (EPA Report).
Argentina, 2001. Heavy precipitation in the Northwestern Provinces with alluvial landslides (epicenter in Palma Sola, Province of Jujuy): 1,300 evacuees, ten people deaths and about 15 million Arg. Pesos loses. (El Tribuno de Jujuy, Jun 2001; La Nación, Jun 2001)
Bolivia, 2001. Heavy rains and floods affected the locality of Viacha in the highlands of Bolivia, the humidity and the low temperatures increased respiratory diseases and the precarious waste system produced rapidly a difficult infectious situation.50 minutes hail left 70 people died and 100 injured. (Gonzales, 2005)
Venezuela, 1999. Floods and mudslides: More than 45.000 casualties. Loses 1,900 MUS$. (CEPAL-

PNUD, 2000)
Mexico, 1997-98. Floods (El Niño): economic losses estimated in 2 billion dollars. (Magaña, 2004)
Brazil (Patos Lagoon) **Argentina** and **Uruguay** (Rio de la Plata). 1997–98. High rainfall (El Niño): Affected freshwater outflow, hydrology, productivity and fish resources of estuarine Systems in SESA. (Garcia, et al., 2002; Nagy et al., 2002a, 2003)

Low precipitations and droughts
Brazil (south part), 2004-05. Severe drought led to reductions of 65% and 56% in soybean and maize production respectively in Rio Grande do Sul. www.ibge.gov.br
Argentina (Chaco), 2004. Drought: Damage in agriculture and livestock. Loses of 300 M$ including 120,000 cattle, and 10.000 evacuees. (www). La Nación 14/12/04
Bolivia. 2002. Lack of rain produced loses in the range of 70 to 90 % of rain-fed crops (principally maiz) in the middle basin of Rio Grande (Aiquile, Totora, Omereque and Pasorapa), in Cochabamba. Gonzales (2005)
Centro America, 2001. Drought: Affected directly 600.000 persons; adversely affected 70% of Centro American population, losses for 189 million US$. (Ramirez, 2003)
Centro America, 2001. Rainfall reduction (anomalies: 20% and 60% of the mean): Major part of grain crop lost; 1.4 million without enough food supply. Water availability for the following dry season compromised. Population affected: 23.6 million.(Informe IRI pp 16)
Bolivia. 2000. Drought in Santa Cruz damaged 169.400 hectares of the summer campaign 1999-2000. Gonzales (2005)
Rio de la Plata, 1999-00 (La Niña). Low river flow increased primary algal biomass and productivity. Favoured sea-ward displacement of the estuarine front, reducing the accessibility of coastal fishermen to fishing areas. (Nagy et al., 2002 a,b, 2003; Severov et al., 2004; Norbis et al., 2004b)
Centro America, 1997-98 - Drought (El Niño): Forest fire affected more than 2,5 million of ha, (greatest losses in Honduras, Guatemala, Mexico and Nicaragua). (Cochrane in press)
Mexico, 1997-98. Drought (El Niño): 14 445 separate fires. (FAO 2001)

The dominating mode of seasonal to interannual climate variability in Latin America is associated to ocean-atmosphere interactions in the tropical Pacific (ENSO, tropical cyclones and hurricanes), tropical Atlantic (ITCZ variability), and in the Intra-America Seas (tropical cyclones and hurricanes), but also tropical-extratropical interactions and remotely forced atmospheric perturbations such as intraseasonal oscillations and teleconnections patterns (PNA, PSA, AAM).

The impact of ENSO phases on precipitation patterns and crops yield variability in Latin American countries has been well demonstrated (IPCC 2000). In the last years, several studies emphasized factors other than ENSO influencing the local climate as well as crop production (Baethgen and Magrin, 2000; Podesta *et al*., 2002). As an example, in Mexico more than half of the extremes precipitation occurred in non-ENSO years (Cavazos and Rivas, 2004). It was found that subtropical South Atlantic SSTs affect precipitation over SW Amazonia (Ronchail *et al*., 2004), and precipitation and crops yields over SE South America (Doyle and Barros, 2002; Berri and Bertossa, 2004; Travasso *et al*., 2003a,b). Recently it has been demonstrated that high rainfall and environment humidity related to El Niño increases some plant diseases as "*Cancrosis*" in citrus (Canteros *et al*., 2004) and "*Fusarium*" in wheat (Moschini *et al*., xx). In relation to dairy production, it was evidenced in central Argentina that heat weaves reduce by 9.1% milk production in "Holando argentino" dairy cattle, and that animals were not able to completely recover after this event (Valtorta *et al*., 2004).

Low-lying coasts, in several Latin America countries (i.e. part of Argentina, Belize, Colombia, Costa Rica, Panama, Uruguay, Venezuela) and large cities (Buenos Aires, Rio de Janeiro, Recife, etc.) are among the most vulnerable to extreme hydro-meteorological events, with most of their population, economic activities and vital infrastructure located at or near sea-level, making them especially vulnerable to sea-level rise. (Cohen e*t al.*, 1997; Grasses *et al*., 2000; OECD, 2004). Additionally, a sizable proportion of the population of Central America (26%), about 8.4 millions of people is exposed to hurricane risk (FAO, 2004a).

As far as natural ecosystems are concerned, tropical forests of Latin America, particularly those of Amazonia, are increasingly susceptible to fire occurrences due to increased El Niño-related droughts and to land use change (deforestation, selective logging, forest fragmentation) (Nepstad *et al*, 1999; Barbosa and Fearnside, 1999; Fearnside, 2001). Mangroves forests located in low-lying coastal areas in Latin America are particularly vulnerable to sea level rise, increased mean temperatures, and hurricane frequency and intensity (Roth, 1997; Schaeffer-Novelli *et al*., 2002; Cahoon and Hensel, 2002), especially those of Mexico, Central America and Caribbean continental regions (Kovacs *et al*., 2001; Meagan *et al.*, 2004). Moreover, floods accelerate the changes in mangrove areas and in the mangrove-up and interface. (Conde, 2001; Medina *et al.*, 2001; Villamizar, 2004). In relation to biodiversity, in the highland Costa Rica site, 20 species of frogs and toads, including the Golden Toad *Bufo periglenes*, declined or disappeared abruptly in 1988, with subsequent abrupt declines of survivors in 1994 and 1998. Each of these decline events occurred during unusually dry periods when typical periods of cloud-borne mist failed to occur (Pounds *et al.*, 1999). Andean Ecuador was home to the spectacular Jambato Toad *Atelopus ignescens*, which abruptly disappeared from 47 sites from where it was known in the 1980s, just after the two driest years recorded during the period 1962 – 1998 (Ron *et al*., 2003). Similarly, dry weather is correlated with the disappearance of three species and the decline of six species of frogs from the genus *Eleutherodactylus* in Puerto Rico (Burrowes *et al.*, 2004).

Climatic variations, which lead to environmental changes, favor the emergence of endemic diseases that are sensitive to climate, such as malaria, dengue, cholera, leishmaniasis (tegumentary leishmaniasis and visceral leishmaniasis) leptospirosis, hantivirus. The mechanisms of action may be direct, such as the creation of environmental favorable to the development and dispersion of infectious agents and vectors, or indirect due to human migration processes caused by drought and floods, promoting the spatial redistribution of endemics and an increase in social vulnerability of communities (Ministry of Science and Technology, 2004). During extreme events, greater mortality among children and women could be explained by socio-cultural factors, because women depended on male members for a decision to leave their homes (Patz *et al*., 2000). Malaria continues to pose a serious health risk in the region, where 262 million people (31% of population) live in areas with some potential risk of transmission, ranging from an estimated 9% in Argentina, to 100% in the Dominican Republic and El Salvador (PAHO, 2003). Under conditions of low precipitation and high temperature during El Niño years outbreaks of vector borne diseases (malaria and dengue) were reported for Colombia. Under prolonged droughts storage of water increases, increasing the number of mosquito habitats (Poveda *et al*., 1999, 2000 and 2001). Also in Venezuela changes in Malaria vector distribution were observed under periodic droughts (Kovatz *et al*., 2003). Outbreaks of hantavirus pulmonary syndrome were reported for Argentina, Bolivia, Chile, Paraguay and Brazil under prolonged droughts (Pini *et al*., 1998, Espinoza *et al*., 1998; William *et al*., 1997; Hacon, 2004). In the cities of the semi arid north-eastern Brazil, prolonged droughts during early 1980s and 1990s, provoked rural-urban migration of subsistence farmers, and a re-emergence of kala-azar (Confalonieri, 2003). On the other hand, flooding engenders malaria epidemics in the dry northern coastal region of Peru (Gagnon 2002), and outbreaks of spirochetal zoonosis leptospirosis in Nicaragua and Brazil (Ko *et al*., 1999). After hurricanes, flooding and subsequent loss of, and disruption to, lives, property, and community ties may contribute to an increase in parental stress and depression, and thus contribute to an increase in child maltreatment (Keenan *et al*., 2004). In desert areas of northern Mexico heat waves increase mortality, especially for elderly and people with health conditions due to the lack of air conditioning and adequate housing (Meléndez, 2004). In Buenos Aires roughly 10% 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, such as 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.

In global terms, Latin America is recognized as a region with large freshwater resources. However, the irregular temporal and spatial distribution of these resources affects its availability. Almost 13.9% of the population (71.5 million people) have no access to safe water supply; 63% of them (45 million people) live in rural areas (IDB, 2000). Many rural communities rely on limited freshwater and many others on rainwater from catchments being very vulnerable to droughts (IDB**,** 2004). Stress on water availability and quality has been documented where lower precipitations and/or higher temperatures occur. For example, droughts related to La Niña years create severe vulnerability conditions for the water supply and irrigation demands in the Central Western Argentina provinces and in Central Chile regions between 25ºS and 40ºS (Maza *et al.*, 2001), (CONAMA, Chile,2003). While droughts, related to El Niño, impacts on the flows of the Colombia Andean region basins**,** particularly in the Cauca river basin**,** are characterized by 30% reduction in the mean flow, with a maximum of 80% loss in some tributaries (Carvajal *et al.*, 1999). Further the Magdalena river basin also shows a high vulnerability (55% losses) (IDEAM, 2004). The vulnerability to flooding events is high in almost 70% of Latin America (see Table 1). Hydropower is the main electrical energy source for most countries in Latin America and it is vulnerable to large-scale and persistence rainfall anomalies due to El Niño and La Niña, e.g. in Colombia, Venezuela (IDEAM, 2004), Peru, Chile, Brazil, Uruguay, Argentina. A combination of increased energy demand and droughts caused a virtual breakdown of hydroelectricity in Brazil in 2001 that caused a GDP reduction of 1.5% (Kane, 2002).

13.2.3. Non climatic stresses

13.2.3.1 Demographic pressures effects, Social and economical stresses

The 1990s were a decade of radical change in both macroeconomic and sector policy for many Latin American countries. Programs of market liberalization, privatization and deregulation were adopted by most of the continent's larger economies in order to facilitate their integration into regional and global markets. These changes led to significant restructuring of agricultural production. For example in Cordoba (Argentina), small and medium grain and livestock farmers have faced a gradual loss of control over land resources and the technology necessary for competitive production. While there have been regional economic gains resulting from these trends, the impact on family farmers has been largely negative, resulting in the expulsion of 35% of them from the agricultural activities between 1988 and 2002. In Veracruz (Mexico), after profound domestic and international changes in the structure of the coffee market, the survival of smallholder coffee farmers now depends critically on their capacity to diversify and invest technologically in their production. In both cases, sector reforms combine with changing patterns of climate variability to increase the sensitivity of smallholder farmers to extreme events and to reduce their capacity to address their livelihood security (Wehbe *et al*., 2005).

Migration to urban areas in the Region exceeds absorption capacity, resulting in broad unemployment, overcrowding, and the spread of infectious diseases due to lack of adequate infrastructure and urban planning (UNEP, 2003). Latin America is the most urbanized region in the developing world (75% of its population). Most urbanized countries are Argentina, Chile, Uruguay and Venezuela whereas the less urbanized are Guatemala and Honduras (UNCHS, 2001). As a consequence, the Region population faces traditional risks (infectious and transmissible diseases) and modern risks (chronic and degenerative diseases). Modern risks result from urbanization and industrialization; poor and rural areas still suffer from "traditional risks" resulting from malnutrition, lack of drinking water, services and education. For example, the emerging cases of cities like Buenos Aires and Santa Fe, in Argentina, with poverty rates in the order of 50% of the urban and peri-urban population and unemployment rates exceeding 15%, are new sources for disease and infection dissemination (Canziani, 2005).

Despite achievements in macroeconomic management, the countries of the Region do not show significant advances in the reduction of poverty, in closing of the ever-widening gap between rich and poor, nor in the governments´ capacity to offer more basic services. In Countries with poverty rates over 40%, a significant number of non-poor households are subject to such factors as overcrowding, the absence of drinking water supply, air conditioning, the urban heat island effect and lack of sanitation services (CEPAL, 2004).

13.2.3.2. Environmental stresses

Over exploitation of natural resources: The tendency to urbanisation, the large aquaculture developments, the ecotourism and oil industries expansion, the accidental capture of ecologically important species, the introduction of exotic species, and the wrong management of water resources in Latin America, imposes increasing environmental pressures because of the increase in the use of natural resources (UNEP, 2000; IRDB, 2000; Hoggarth *et al*., 2001; CIDAS, 2003; Geo 2003). It is well established that overexploitation is a threat to 34 out of 51 local production systems of particular importance to artisanal fishing along the coastal waters, in LA (CIDEIBER, 1999) and has caused destruction of habitats such as mangroves, estuaries and salt marshes in Central America and Mexico (Suman, 1994; Yañez-Arancibia, *et al.*., 1998; Sullivan and Bustamante, 1999). Aquifer overexploitation and bad management of the irrigation systems (water/phreatic layer/soil, drainage and sanitary pits) are originating severe environmental problems; e.g. salinization of soils and waters in Argentina, (where more than 500.000 ha of the phreatic aquifer presents high levels of salinity and nitrates (IRDB, 2000)), or severe sanitation problems to a great number of cities like Mexico City, San José de Costa Rica; Trelew, Río Cuarto and Buenos Aires in Argentina. In rural areas, the same problems represent an added stress for many subsistence economies. (Chilton, 1997) (GEO-LAC 3, 2003).

Land use changes: Agricultural expansion has intensified the use of natural resources and exacerbated many of the processes of land degradation (FAOSTAT, 2001). In the region almost three quarters of the dry lands are moderately or severely affected by degradation processes and droughts (Malheiros, 2004). Approximately 16% of 1,900 Mha of degraded lands all over the world are located in Latin America (UNEP, 2003). In Brazil 1 Mkm^2 are facing desertification processes, including the entire semi arid region where 23 millions people live (Malheiros, 2004). Deforestation in South American is the dominant transformation that threatens biodiversity (Fearnside, 2001).

*Pollution: S*evere problems of pollution of natural resources like natural arsenic contamination of freshwater affect almost 2 million people in Argentina, 450.000 in Chile, 400.000 in Mexico, 250.000 in Peru and 20.000 in Bolivia (Pearce, 2003). In the Puyango river basin (Ecuador) suspended sediment load and metal contamination increase significantly during ENSO events (Tarras-Waldberg *et al.*, 2003). In the Pilcomayo basin (SE Bolivia, Southwest Paraguay and Northwest Argentina) ENSO phenomenon influence strongly annual discharges creating siltation of river bed. Pollution by heavy metals from mining districts in Potosí affect migration and catching of Sabalo (Prochilodus lineatus), very important for commercial fishing in the region (Smolders *et al.*, 2002). As a result of the Salado del Norte (Argentina) river flood of 2003, 60.000 tons of solid wastes were disseminated all over the city of Santa Fé; 135 cases of hepatitis, 116 of leptospirosis and 5000 lung affections were officially recognized (La Nación, 2003).

Air pollution due to the burning of fossil fuels is a problem-that affects many urban areas of the region. Transport is-the main contributor (eg. Mexico City, Santiago de Chile) followed by the production of electricity in thermoelectric plants. It is well known that severe pollution events are related to weather conditions like-the occurrence of thermal inversions.

13.2.4 Past and current trends

13.2.4.1 Climate trends and variability

During the last part of the 20th century clear climatic trends were observed in the region. Some of them that were informed in the TAR are currently been confirmed, while others were recently evidenced. In some cases impact for several sectors were also reported (see Table 2a). Important increases in precipitation were reported for Argentina, Uruguay, Brazil and Bolivia with impacts on changes in land use, crop yields and flooding. Increases in morbidity and mortality due to flooding, landslides and storms were also reported for Bolivia (Ministry of Sustainable Development and Environment, 2000). Inversely a trend to decline precipitation was observed in Ecuador and Chile.

Table13.2a: *Current Climatic trends*

	Period	Change / Reference	Impacts
Maximum Temperature			
Argentinean Pampas (7 sites)	1950-2000	-0.7 to -2.3ºC (Jan-Feb) (Magrin *et al.*, 2005)	
Uruguay	1930-2000	-0.023ºC/yr (Dec-Jan-Feb) LA27	
Brazil (South East)	1930-2000	+0.026 to -0.033ºC/yr (Dec-Jan-Feb) LA27	
Minimum Temperature			
Argentinean Pampas (7 sites)	1950-2000	+0.1 to +1.0ºC (Magrin *et al.*, 2005)	
Uruguay	1930-2000	+0.019 to +0.048ºC/yr (Dec-Jan-Feb) LA27	
Brazil (South East)	1930-2000	+0.018 to +0.052ºC/yr (Dec-Jan-Feb) LA27	
Brazil (Campinas and Sete Lagoas)	1890-2000	+0.02 ºC/yr (Pinto *et al.*, 2002)	
Brazil (Pelotas)	1890-2000	+0.008 ºC/yr (Pinto *et al.*, 2002)	
Mean Temperature			
Montevideo, Uruguay	1883-2003 1971-2003	+ 0.8 °C (Bidegain et al., 2005) + 0.9 °C (Bidegain et al., 2005)	
Ecuador	1930-1990	+0.5ºC to +1.6ºC (Ecuador, 2000)	
Precipitation			
Bolivian Amazonia	Since 1970	+15% (Roinchail *et al.*, 2004)	floodings in the Mamore basin
Argentinean Pampas (7 sites)	1900-2000	Up to +50% (Magrin *et al.*, 2005)	Increases in crops yield: Soybean 38%, Maize 18%, Wheat 13%, Sunflower 12%.
Argentina (Santiago del Estero)	before1955 and after 1975	+25% (Acuña *et al.*, 2004)	Increases in deforestation and changes in land use.
Uruguay	1930-2000	Up to +50% (Dec-Jan-Feb) LA27	
Uruguay	1961-2002	+ 20% (Bidegain et al., 2005)	
Brazil (Santa Catarina)	1930-2000	Up to +30% (Dec-Jan-Feb) LA27	
Ecuador	1930-1990	Greater tendency to decline(Ecuador, 2000)	
Chile		Decline Add information LA26	
Annual discharges			
River Amazon at Obidos	1903-1999	+9% (Callède *et al.*, 2004)	Increases of 10% in floods

Streamflow			
River Uruguay at Salto/Concordia	1921-2003	+ 40% (Bidegain et al, 2005)	
Sea level rise			
Guyana	Last century	from 1.0 to 2.4 mm/yr (Douglas, 1995; Smith et al 1999).	Increases in flooding, inland penetration of salt water and estuaries' salinity. Shoreline retreat
Montevideo (Uruguay)	Last 100/ 30/15 yrs	+1.0/+2.5/+4.0 mm/yr (Nagy *et al.*, 2005)	
Buenos Aires (Argentina)	Last ~100 yrs	+1.7 mm/yr (Barros et al., 2003)	
Several ports in Brazil	1960-2000	+4.0 mm/yr (Mesquita, 2000)	
Southwestern Atlantic at 33-37°S	1992-2004	>10.0 mm/yr (Miller et al., 2005)	
Caribbean coast of Panamá	1909-1984	+1.3 mm/yr (Republic of Panamá, 2000)	

Table 13.2b: *Glaciers trends*

Glaciers	Period	Change / Reference	Impacts
Peru (coastal region)	When??	22% reduction in glacier total area (García Vargas, 2003)	Reduction of 12% in fresh water in the coastal zone (60% of country population)
Peru	Last 30 years	Reduction up to 80% of glacier surface from small rangers like Huagoruncho, Huaytapallana and Raura (Republica del Peru, 2001).	Loss of 188 000 000 m^3 in water reserves during last 50 years, will leave less water to Santa y del Hural basin. Small glaciers will be more vulnerable along the present decade under current climate conditions.
Colombia	1990-2000	82% reduction in Colombian glaciers, showing a linear withdrawal of the ice of an average of 10-15 m yearly (Republica de Colombia, 2001).	Under the current climate trends, glaciers of the country will disappear completely within the next 100 years, as happened to other glaciers between 1940 and 1985.
Ecuador	1956-1998	Measurements of the alpha 15 glacier on the snow-capped summit of Mount Antisana indicate there has been a gradual decline in the length of the glacier. (Republica del Ecuador, 2000).	Reduction on water supply for irrigation (country's central valleys), clean water supply for the city of Quito, and hydropower generation for the cities of La Paz and Lima.
Bolivia Chacaltaya glacier	Since midst	Lost half of its surface and two thirds of its	

	of the 1990’	volume. It could disappear by 2010 (WWF, 2002)	
Bolivia: Zongo glacier	Since 1991	Lost 9.40% of the surface. It could disappear by 2045-2050 (Francou *et al*., 2003; Ramirez., *et al*., 2001).	
Bolivia: Charquini glacier	Sine 1940	Lost 47.39% of the surface. (Francou *et al*., 2003; Ramirez., *et al*., 2001).	
Northern and Southern Patagonia (largest 63 glaciers)	1968/75-2000 1995-2000	+0.042 mm/year (*[1]) +0.105 mm/year (*[1]) (Eric Rignot *et al*.,)	

The severe retreat of glaciers reported in the TAR has recently been exacerbated especially in Bolivia, Peru, Colombia and Ecuador (see Table 13.2b). During last years glaciers smaller than 1 km^2 have lost between 0.8m and more than 1.0m of water per year. In the next 15 years, 80% of the glaciers of the intertropical Andes will have disappeared (Geology news, 2001, Mendoza and Francou, 2004). A probable extinction of these glaciers in the near future could seriously affect the hydrological regime and the water resources of the river basins.

13.2.4.2. Environmental trends

Over the last three decades Latin America was subject to an agricultural intensification - increases in arable land, irrigated areas and the use of pesticides and fertilizers (see Table3) (WRI, 2001; GEO 2003).

Deforestation: Total forest area in Latin America was reduced by around 46.6 Mha between 1990 and 2000 (GEO3, 2003); corresponding 9.7 Mha to Meso-America and 37.1 Mha to South America (Table 13.3). The expansion of the agricultural frontier, mechanized agriculture, livestock expansion, financing of big scale projects like construction of dumps for energy generation, construction of roads and increased links to commercial markets have been one of the main causes of deforestation (FAO, 2001; Laurance *et al*., 2001; FAO, 2005). Expanding livestock production is one of the main drivers of the destruction of tropical rain forests in Latin America. FAO (2005) estimates that forest cover in Central America will be reduced by 1.2 Mha until 2010, in South America the forest area will decrease by 18 Mha, from them 62% in South America and 69% in Central America will be used for pasture. Deforestation had been rapidly progressing in Brazilian Amazonia, from 1.8 Mha in 2000, 2.3 Mha in 2002, to 2.6 Mha in 2004 (INPE and MMA, 2005). Over 60 Mha have been deforested to date in Brazilian Amazonia alone and roads are the main vector of deforestation in Amazonia (Alves, 2002), but not the only one any longer (Laurence *et al*., 2005; Camara *et al*., 2005).

Biodiversity: Changes in land use led to biodiversity fragmentation and habitat loss. The analysis of Myers *et al.*, 2000 found that in the Latino American area are located 7 of the most 25 critical places with highest endemic species concentrations and these areas are suffering their habitat loss. Climate Change will increase the actual extinction rate, which is documented in the Red List of Endangered Species (UICN 2000), e.g. amphibian populations and changes on reproductive characteristics of some birds (UICN, 2001). The majority of the endangered ecoregions are located in the north and middle of the Andes, in Central America, in South American steppes and other cloudy forests, in the Cerrado and other dry forests located in the South of the Amazon Basin (GEO 3; Dinerstein *et al.*, 1995).

Coral Reefs: The Panama and Belize Caribbean case's studies and inter-ocean contrasts help to illustrate both the consistencies and the variations in coral reef responses to complex environmental changes (Gardner *et al*., 2003, Buddemeier *et al*., 2004). Cores taken from the Belizean barrier reef show that *A. cervicornis* dominated this coral reef community continuously for at least 3,000 years, but was killed by white band disease (WBD) and replaced by another species after 1986 (Aronson *et al*., 2002). Dust transported from Africa to America (Shinn *et al*., 2000), and land-derived flood plumes from major storms transport materials from the Central American mainland to reefs that are normally considered remote from such influences likely are sources of pathogens, nutrients, and contaminants. Also, human involvement is very likely evidence in the spread of the pathogen that killed Caribbean *Diadema;* the disease began in Panama, suggesting a possible link to shipping through the Panama Canal (Andréfouët *et al*., 2002).

Table 13.3: *Environmental trends*

	Period	**Change / Reference**
Deforestation		
Latin America Region	1990-2000	4.4 Mha/year, 0.51% deforestation rate (FAO 2001)
Central America	1990-2000	0.97 Mha/year (FAO 2001)
Non.tropical South America	1990-2000	0.3 Mha/year (FAO 2001)
Tropical South America	1990-2000	3.4 Mha/year (FAO 2001)
Total South America	1990-2000	3.7 Mha/year (FAO 2001)
Mexico	1990-2000	1.1% deforestation rate; 0.63 Mha/year
Argentina	1990-2000	0.8% deforestation rate; 0.285 Mha/year
Brazil	1990-2000	0.4% deforestation rate; 2.54 Mha/year
Bolivia	1990-2000	0.3% deforestation rate; 0.161 Mha/year
Colombia	1990-2000	0.4% deforestation rate; 0.19 Mha/year
Ecuador	1990-2000	1.2% deforestation rate; 0.137 Mha/year
Paraguay	1990-2000	0.5% deforestation rate; 0.123 Mha/year
Peru	1990-2000	0.4% deforestation rate; 0.269 Mha/year
Venezuela	1990-2000	0.4% deforestation rate; 0.218 Mha/year (FAO , 2001)
Argentina (Sgo. del Estero)	1975-2003	From near zero to 500.000 ha (Boletta *et al.*, 2004)
Changes in Land use		
Argentina (Sgo. del Estero)	1973-2003	From 850 ha to 1 Mha*[1] (Acuña *et al.*, 2004)
South America	1972-1999	+30.2 Mha (35.1%)*[1]
Meso-America	1972-1999	+6.3 Mha (21.3%)*[1] (FAOSTAT, 2001).
Ecuador	1990-2000	+5.7%/yr: Rate of increase in agricultural lands (National Communication, 2000)
Use of fertilizers	1970 to 2000	+4% per year (71% in Brazil, México and Argentina) (IFA, 2001, 2002a, b).

*[1] = Increase in arable land and grassland at the expense of forests

13.2.4.3. Trends in socioeconomics factors

From 1950 to the end of the 1970's Latin America benefited from a GDP growth of an average of 5% annual. This remarkable growth rate permitted the development of national industries, urbanization, and the creation of national education and public health services. The strategy for economic development was based on the import substitution model which consisted on imposing barriers to imports and developing the national industry to produce what was needed. Nevertheless, this model produced a weak industry not able to compete in international markets and had terrible consequences for other sectors (agriculture in particular) which funded the industrial development.

In the 1980's the region faced the great debt crisis which forced the region's countries to make a tour de force to implement rigorous macroeconomic measures regarding public finances and to the liberalization of the economy. Control of inflation and public deficit became the main targets of most governments. Deterioration of economic and social conditions, unemployment, the extension of the informal economy and poverty characterized this decade.

During the 1990's the liberalization of economies, the privatization of public sector enterprises and the macroeconomic stability attained through the implementation of severe measures attracted foreign capitals to Latin American countries. Although the 1990's began with a recovery of economic growth, the region never reached the growth rates previous to the 80's crisis. At the end of the decade the economic growth began to slow down and even to reach negative growth rates. This, in addition to the effects of the Asian crisis in South America, ended the region's recuperation period. Since 1998 the region as a whole has experienced a continuous reduction of GDP per capita and the lowest levels of investment in recent history (CEPAL, 2003).

A recent study conducted by CEPAL concludes that given the current conditions for the region, the possibilities for the poorest Latin American countries to reach the 7% GDP growth they need are almost null in the medium term. Even for wealthier countries in the region it will be hard to reach a 4.1% GDP growth target. Predictions for GDP growth in the region range from 2.1% to 3.8%, which are very far from the 5.7% average estimated to reduce poverty in Latin America.

Latin American countries have always had high levels of social inequity. Although the adoption of democratic regimes has brought progress regarding some social and political rights, income distribution has worsened since the 1980's. In the region the wealthier 10% of the population obtains between the 40% and 47%while the poorest 20% only between the 2% and 4%. This type of income distribution is only comparable to some African and ex-USSR countries (World Bank, 2004). The lack of equity in education, health services, justice and access to credit can restraint economic development, reduce investment and extend poverty.

The combination of low economic growth and high levels of inequity can make large parts of the region's population very vulnerable to economic and natural stressors which would not necessarily have to be very big to cause great social damage. If no structural economic changes are made to promote investment, employment and productivity, economic and social future scenarios for the region do not hold the economic growth needed for its development; unless a lucky combination of external positive shocks occur.

13.2.5 Current adaptation

Weather and Climate Forecast
The strong El Niño of 1982-83 set in motion an international effort to understand and predict this ocean-atmosphere phenomenon (reference to TOGA project). The result was the emergence of reliable seasonal climate forecasts for many parts of the world, especially for Latin America. Such climate forecasts found early applications starting in the late 80´s, e.g., for fisheries and crops in Peru (Lagos, ???) to subsistence agriculture in NE Brazil (Funceme, ???). Climate forecasts became even more reliable with the use of the TOGA observations of the upper tropical Pacific from the mid-90's. The mega-El Niño of 1997-98 brought to sharp focus the need to practically use climate forecasts in many sectors. For instance, impacts associated with the occurrence of strong ENSO events (i.e. 1997), which have important consequences for fisheries, could be anticipated by applying appropriated observations and models such as those developed for the Eastern Pacific and Southwest Atlantic Oceans (Suárez-Sánchez *et al*., 2004; Severov *et al*., 2004a, respectively).

In Latin America, use and reliability of short range weather forecasts also increased dramatically in the last 10 years and made possible the development of Early Warning and Risk Prevention Systems for extreme weather and climate-related natural hazards. Those systems are being rapidly implemented in many countries and regions of Latin America as a means to reduce vulnerability to current climate variability (Ministerio de Medio Ambiente Colombia, 2002; Aparicio, 2000, Magaña and Vázquez, 2005; Comunidad Andina, 2004). Early warning systems proved to be a very practical tool for adapting the response of riverine communities to flood events in the Río de la Plata Basin based on the COAH "Centro Operativo de Alerta Hidrológico" (Argentina) predictions (IRDB, 2000) and Mexico (Magaña, 2004), and in other important basins of Latin America.

As a result there have been the emergence of networks to mitigate and prevent natural hazards (Regional Disaster Information Centre –Latin America & Caribbean (CRID, 2005), International Center for Research on El Niño Phenomenon (Ecuador) and the Permanent Commission of South Pacific (CIIFEN, 2005; CPPS, 2005)) and even to influence behavioural changes to diminish social vulnerability (e.g., Social Studies Network for Disaster Prevention in Latin America (ITDG, 2005)), for instance by including more effectively women in risk prevention activities (Anderson cited in Briseño, 2002).

Agriculture is the sector leading the use of ENSO-based climate forecasts for planning productions strategies as adaptive measures in several countries. Changes in crop management practices (planting date, fertilization, irrigation, hybrid, among others) could lead to optimize crop yields and net returns during extreme ENSO phases. Increases in net return attributable to the use of ENSO-based forecast could attain up to 10% in potato and winter cereals in Chile (Meza *et al.*, 2003); 6% in maize and 5% in soybean in Argentina (Magrin and Travasso 2001); and more than 20% in maize in Santa Julia Mexico (Collado & Villalobos, 2001). Adjusting crop mix to ENSO phases in Argentina could produce benefits averaging 9%, depending on site, farmers' risk aversion, prices, and the preceding crop and ENSO phase (Messina *et al*. 1999). Benefits of an ENSO early warning system for commercial agricultural areas of Mexico are approximately US$ 10 million annually when a forecast skill of 70% is assumed, representing an internal rate of return of 30% (Adams *et al*., 2003). Applications of climate forecasts in the health sector are increasing. Institutional support for early warning systems may help to facilitate early, environmentally sound public health interventions. For instance, the Colombian Ministry of Health developed a contingency plan to control epidemics associated with the 1997-98 El Niño event (Poveda *et al*., 2000).

One of the newest technological efforts in improving our understanding of the Earth and how it works is the Global Earth Observation System of Systems (GEOSS). The aim is to observe, predict and protect the planet, providing the science on which sound policy and decision-making must be built (EPA, 2005). This technology will improve the understanding of the effect of environmental factors on several sectors.

Other adaptation practices

13.2.5.1 Natural ecosystems

A new option to promote mountainous forests conservation in the region consists in compensating forests owners by environmental services those forests give to society. The compensation is often financed by charging a small overload to water users, for the water originated in forests. Such schemes are being taken into account in various countries of Latin America and were put to test in Costa Rica (Campos and Calvo, 2000). Sustainable development plans of land use which bring income generating opportunities from environmentally friendly options, like ecotourism, organic agriculture and coffee planted under shade (World Bank, 2002) have been implemented, successfully in the Mesoamerican Biological Corridor.

13.2.5.2 - Agriculture and forestry

Some adaptive measures have been traditionally and are actually used in the agricultural sector to cope with climatic variability. These include: changes in land use, diversification, sustainable management, technology, irrigation, adapted genotypes and changes in agronomic crop management, among others. An example of traditional adaptation is provided by the farmers located in the board of Mexico that by changes in irrigation technology, crop diversification and market orientation were able to continue farming in the valley despite the crisis with the local aquifers derived of droughts and over-exploitation (Vasquez Leon *et al*., 2003). Sustainable land management based on familiar practices (contour barriers, green manures, crop rotation and stubble incorporation) allowed smallholders in Nicaragua to better cope with the impacts of Hurricane Mitch than their conventional neighbours (Holt-Gimenez, 2002). Agricultural technology improvement in Brazil (Evenson *et al*., 2004) is likely to be much more important in changing crop productivity than changes registered in climate during the last part of the 20th century.

For small-scale farmers socio-economic and political factors (e.g. lack of credit and access to resources and information) could seriously reduce their capability to implement adaptive options. For example, for small-holders in dry zones of Mexico who have rainfed crops or non efficient irrigation system, adaptation measures only involve incremental, low-input and short term investments that help “to get by” during periods of drought. Inversely, commercial farms can implement efficient irrigation systems and combine livestock with agriculture (Vasquez Leon *et al*., 2003).

As a response to deforestation, degradation and forest fires, Argentina, Brazil, Costa Rica and Peru have adopted new forestry laws and policies that include better regulatory measures, sustainability principles, expanding protected areas, certifying forestry products and expanding forest plantations in non-forest areas (BOLFOR, *et al*., 1998; Tomaselli, 2001). In Costa Rica, the concept of payment for environmental services (PSA) include reducing, absorbing, fixing and storing carbon to lessen the greenhouse effect; protecting water for urban, rural or hydropower use; protecting ecosystems to conserve them and make them fit for sustainable use (GEO 3, 2003).

Most countries provide incentives for managing their native forests: exemption from land taxes (Chile, Ecuador, Uruguay), technical assistance (Ecuador), and subsidies (Argentina, Mexico, Colombia)(GEO 3, 2003). Chile and Guyana demand prior studies on environmental impact before approving forestry projects of any importance; Mexico, Belize, Costa Rica and Brazil are already applying forestry certification. Argentina, Chile, Paraguay, Costa Rica and Mexico have established model forests designed to demonstrate the application of sustainable management, taking into account productive and environmental aspects, and with the wide participation of the civil society, including community and indigenous groups.

13.2.5.3 Water resources

Current adaptation of socioeconomic systems in Latin America to floods and droughts is limited by low GNPs, the increasing population in vulnerable (flood prone) areas and poor-developed political, institutional and technological support systems. Nevertheless, several communities and cities have organized themselves, becoming active in disaster prevention (Fay *et al*, 2003). Many poor inhabitants were organized to resettle from their unsuitable lower location in flood prone areas, building themselves their new houses in safer locations with the aid of IRDB and IDB loans, e.g. resettlements in Argentina, Parana basin, after the 1992 flood (IRDB, 2000). In some cases, the adaptation potential of Latin American natural systems to the impact of floods, in rural areas are proving to be possible; for example, in rural areas affected by floods during the 90´s in the Salado basin of the Buenos Aires province of Argentina, some livestock producers reconverted their activities during years of great inundation to commercial fishing of Pejerrey (odontesthes bonareriensis) (La Nación, 2002). Another example, but in this case related to the adapting capacity of people to water stresses, is given by programs of in self organization for water supply systems in very poor communities. The organization Business Partners for Development Water and Sanitation Clusters has been working in four “focus” plans in Latin America: Cartagena (Colombia), La Paz and El Alto (Bolivia) and some underprivileged districts of Gran Buenos Aires (Argentina) (Water 21, 2002) (The Water Page, 2001). Rainwater catchment and storage systems are seen as important factors of sustainable development in the semi-arid tropics. Particularly, a joint project elaborated in Brazil by the NGO Network ASA Project called P1MC- Project for 1 million cisterns to be executed by the civilian society in a decentralized manner (at the community, municipal, micro region, state and regional levels) are planning to supply drought proof drinking water to one million rural households in the Brazilian Semi-Arid Tropics (BSATs). At first stage, 12,400 cisterns were built by ASA and the Ministry of Environment of Brazil and further 21,000 planned until the end of 2004 (Gnadlinger, 2003). In Argentina, national safe water programs for local communities in arid regions of Santiago del Estero province installed 10 rainwater catchments and storage systems between 2000 and 2002. (Bazán Nickisch, 2002).

In Latin America only 4 countries have more than 90% drinking water (Uruguay, Costa Rica, Chile, Colombia) and sanitation services (Uruguay, Costa Rica, Chile, Panama) (CEPIS, 2001). Mexico, Argentina, Ecuador, Bolivia, Peru and Guatemala have strongly improved these services from 1990 to 2000.

13.2.5.4 Coasts

A planned adaptation is the common adjustment implemented by LA countries in response to actual climate variability (Hoggarth, *et al*., 2001; GEO-LAC, 2003). Among these**,** the Caribbean Planning for Adaptation to Global Climate Change project is promoting actions to assess vulnerability (especially regarding the rise in sea level), plans for adaptation and development of appropriate capacities. Since 2000, some countries have been improving the legal framework on matters related to establishing restrictions on air pollution and integrated marine and coastal regulation (e.g. Venezuela's integrated coastal zone plan since 2002). Due to the strong pressure of human settlement and economic activity, a comprehensive policy design is now within the "integrated coastal management" modelling in some countries like Venezuela (MARN, 2005).

Several countries in Latin America have enacted legislation which sets aside a narrow strip landward of the shoreline as public jurisdiction, varying from 50 m or less in Mexico, Brazil, Colombia, to 50-200 m in Costa Rica and 250 m in Uruguay (Lemay, 1996).

13.2.5.5 Human Health

Prevention actions for malaria and dengue can be identified as adaptation measures. It is important to build technical malaria control capacity at decentralized levels of the health system, monitoring and evaluation of drug efficacy, promotion of resource networks and control of transmission. In the case of dengue, chemical vector control, surveillance, public education and environmental management are the main identified actions (PAHO, 2002).

Adaptation measures for Bolivia include: biological and chemical control; reservoirs control; community participation; climatological surveillance; health education and avoidance of contact with vectors. Other actions considered are: establishment of an epidemiological surveillance system, including meteorological variables; develop governmental programmes focused on high risk areas for malaria and leishmaniasis transmission, including climate change issues; promotion of entomological studies focused on transmission; strengthening sanitary services in order to cope with climate change (droughts, flooding, storms, etc.); strengthening research centres dealing with tropical diseases (including vulnerability studies) (Ministry of Sustainable Development and Environment, 2000). Adaptation measures in Colombia include strengthening prevention and control of malaria through activities related to application of chemical pesticides and treatment of ill people, measures for environmental management in urban and rural areas, improved early diagnosis, better access to health services and treatment, health education, and community protection (Ministry of the Environment).

13.3 Assumptions about future trends

13.3.1 Climate

13.3.1.1. Climate change scenarios

Even though climate change scenarios can be generated by several methods (IPCC, TAR, 2001), the use of GCMs outputs based on SRES scenarios is currently the more relevant methodology. Projections of average temperature and rainfall anomalies throughout the current Century derived from a number of Global Climate Models (GCM) are available at the IPCC Data Distribution Center (IPCC DDC, 2003; http://ipcc-ddc.cru.uea.ac.uk

/asres/scatter_plots/scatterplots_region.html) at typical model resolution of 300 km, and for two different GHG emissions scenarios (IPCC, 2000) (A2 and B2 emissions scenarios). Additionally, Chapter 11 of WGI presents regional projections for many parts of the world. For Latin America, climate scenarios for 2070-2090 for A2 emissions scenarios are presented for three regions: Central America, tropical South America and southern South America. Analyses of these scenarios reveal larger differences in temperature and rainfall changes among models than among emission scenarios for the same model. As expected, the main source of uncertainty for regional climate change scenarios is that one associated to sharply different projections from different GCMs. The projected temperature warming for Latin America ranges from 1 to 4 C for emissions scenario B2 and from 2 to 6 C for A2. The analysis is much more complicated for rainfall changes. Different climate models show rather distinct patterns, even with almost opposite projections. In sum, current GCMs do not produce projections of changes in the hydrological cycle at regional scales with confidence. That is a great limiting factor to the practical use of such projections for active adaptation or mitigation policies. Most model projections indicate rather larger rainfall anomalies for the Tropical portions of Latin America and much less for extratropical South America.

General Circulation Models-derived scenarios were then downscaled using Statistical DownScaling Model (SDSM) to generate site-specific scenarios for South America (Bidegain; Camilloni 2004) and for the Caribbean region (Chen; Rhoden *et al*. 2004). For Mexico, regional climate change scenarios have been generated (Conde 2003: Morales R. 2002), using the outputs of the GCMs: HADCM3, ECHAM4, GFDL and CSIRO, considering A2 and B2 SRES scenarios.

13.3.1.2 Changes in the occurrence of extremes

Many of the current climate change studies indicate that the frequency in the occurrence of extremes will increase in the future. Many impacts of climate change will be realized as the result of a change in the frequency of occurrence of extreme weather events such as windstorms, heavy precipitation or extreme temperatures over a few hours to a few days (Mearns *et al*., 1997).

13.3.2 Land use changes

Deforestation in Latin America tropical areas is now and will be one of the most serious environmental problems that the regions faces, with long term impacts and consequences over biodiversity, loss of economic opportunities, social problems and its contribution to Climate Change. If the deforestation rate in 2002-2003 (2.3 Mha per year) in Brazilaan Amazonia continues indefinitely, then 100 Mha of forest will have disappeared by the year 2020. This is about 25% of the original forest in Brazilian Amazonia (*Laurance et al*., 2005). Other analysis estimates that by 2050 for a Business as Usual Scenario 269.8 Mha will be deforested in Brazilian Amazon (Moutinho *et al*., 2004). One question that arises is whether the large-scale deforestation in Amazonia might affect the regional climate with consequent implications for the biota of the region.

Projected to be one of the main drivers of future land use change, soybean planted area in South America is expected to increase from 38 Mha in 2003/04 to 59 Mha in 2019/20 (Maarten Dros, 2004). Total production of Argentina, Brazil, Bolivia and Paraguay will rise 85% to 172 million tons or 57% of the world production. Direct and indirect conversion of natural habitats to accommodate this expansion amounts to 21.6 Mha. Habitats with greatest predicted area losses are the Cerrado (9.6 M ha), dry and humid Chaco (6.3 M ha), Amazon transition and rainforests (3.6 M ha), Atlantic forest (1.3 M ha), Chiquitano Forest (0.5 M ha), and Yungas Forest (0.2 M ha).

13.3.3. Development.

13.3.3.1 Demographics and societies

The population of the Latin American region has continued to grow and its population is expected to double by the year 2015. Its annual population growth rate has decreased and is expected to reach a value of 1.2 by 2015 which is smaller than 1.9, the rate for the 1975-2002 period. The population has continued to migrate from the country side to-the cities and will reach the 80% by the same 2015 in compassion to the 60% urban population of the period 1975-2002. The population under 15 years will decline and at the same time the population over 65 years of age will increase. Total fertility rate (births per woman) has decreased from 5.1 to 2.5 from periods 1970-75 to 2000-05 respectively and is expected to decrease to 2.2 by year 2015 (http://www.eclac.cl/publicaciones/Poblacion/0/LCDEMG180/lcgdem180i.pdf).

According to ECLAC the number of people in a range of age that would make them dependant (between 0 to 14 and more than 65 years) will increase from 54.8% in present date to almost 60% in year 2050. This will increase pressures on the social security systems in the region and enlarge the size of contributions population in working age will have to make to maintain the availability of health and educational services. Life expectancy at birth has increased from 61.2 years in the 1970's to 72.1 years in the 2000-2005 quinquennia and is expected to increase to 74.4 years by year 2015. Crude mortality rate is expected to remain 7.8 (per thousand) and increase to almost 12 by year 2050.

According to the Human Development Index (http://hdr.undp.org/reports/global/2004/pdf / hdr04. HDI.pdf) all countries in the region are classified within high and medium development ranks. In particular Latin American Countries are ranked within the upper half of the Human poverty index and have shown a positive trend since 1975 to 2002. It is difficult to ignore that although there are not Latin American countries classified in the low development rank, there are large contrasts among and between countries. There are those with important levels of technological development, sophisticated financial sectors and important export capacities and those that lack these. Countries also vary in regards to equality from those where income is shared more evenly among-the people to those where the accumulation of wealth is rather evident.

13.3.3.2 Economic scenarios

Analysts from the World Bank forecast that the real per capita GDP of Latin America will have a very low growth, about 0.3 percent per annum in the period that goes from 2001 to 2005. However in the long term, from 2006 to 2015 it is expected that Latin American economies experience a real growth of their per capita GDP of about 2.6 per cent. These figures can be considered a rather robust forecast for the next 12 years. Nevertheless this growth forecast will be conditioned to the evolution of several factors such as the evolution of the North-American economy, the competitiveness of the manufactures, the conduction of the economic policies and the application of new economic reforms oriented to strengthen internal markets and their position in the international environment. In other words in spite of all the required changes by these economies the majority of the analysts expect that in the long term Latin America will have a relatively stable economic performance This due to the fact that the economic reforms that were carried out during the past decade, have permitted the stabilization of the macroeconomic foundations. The latter situates the region in a good position for the management of its external debt and allows both investors and people with savings to plan with certitude. It also permits the growth of the economy and employment.

13.4 Summary of expected key future impacts and vulnerabilities.

13.4.1 Natural ecosystems

Tropical plant species are especially vulnerable to even small variations of climate since biological systems' respond with difficulty to rapid climate change. This fact might lead to a decrease of species diversity. Based on Hadley Centre AOGCM projections for A2 emissions scenarios, there is a potential of extinction of 24% of 138 tree species of the Central Brazil savannas (Cerrados) by 2050 for a projected increase of 2º C in surface temperature (Thomas *et al*., 2004; Siqueira & Peterson, 2003). By the end of the Century, 43% of 69 tree plant species studied could become extinct in Amazonia (Miles *et al*., 2004). Larger impact would happen over northeast Amazonia and least impact over western Amazonia in terms of species and biome redistributions. Analysis of possible biome redistribution towards the end of the Century in face of a number of AOGCM scenarios indicate a tendency of 'savannization' of eastern Amazonia and the semi-arid vegetation of Northeast Brazil to be replaced by vegetation of arid regions (Nobre *et al*., 2004).

Forty percent of the Amazonian forests could react sensibly to a slight reduction of precipitation; this could mean that the tropical vegetation, hydrology and climate system in South America, may change very rapidly to another steady state not necessarily producing gradual changes between the actual and the future situation (Rowell and Moore, 2000). It is more probable that forests will be replaced by ecosystems that have more resistance to multiple stresses caused by temperature increase, droughts and fires. In Amazonian rainforests, there are signs of an increase in lianas dominance (Phillips *et al.*, 2002). This could be a consequence of high water stress and signs of forest degradation.

The mountain tropical cloudy forests if they will suffer a temperature increase between 1 to 2ºC until the middle of the century will be threatened due to the changes during the dry season in the altitude of the clouds level, which will be arising its level by 2m per year. Therefore, the places where the mountains are isolated and they won't have the enough altitude to adapt to the change in the increase of the clouds level, some plants will become extinct (FAO, 2002). For example, in the mountain cloudy forest of Monteverde Costa Rica, these changes already happens. Declines in the frequency of mist days have been strongly associated with synchronous population declines of birds, reptiles and amphibians on plots at Monteverde (Pound *et al*., 1999).

Modeling studies show that the ranges occupied by many species will become unsuitable for them as the climate changes (IUCN, 2004). Using modeling projections of species distributions for future climate scenarios, Thomas *et al.,* (2004), show that global warming projected for the year 2050 could sharply increase species extinction in Mexico. For mid-range expected climate change scenario, 8 %(with dispersal) and 26% (without dispersal) of Mammals species, 5% or

8% (with or without dispersal) of Birds species, 7% or 19% (with or without dispersal) of Butterflies species are expected to become extinct. For minimum expected climate change scenario 13% (with dispersal) of Frogs species and 9% (with dispersal) of Reptiles species are projected to become extinct in Mexico.

The biodiversity in many vulnerable areas of the region as dry Puna in Bolivia, Chile and Argentina will be affected by a foreseen modifications of its particular climate conditions, leading to the possibility of a catastrophic disappearance of species (WWF, 2002). The reduction of tropical forests area, especially in the tropical rain forests, will probably imply the loss of many species.

13.4.2 Agriculture

Several studies using crop simulation models and future climate scenarios were carried out in the region for commercial annual crops (Table 13.4). According to a global assessment, in Latin America grain yields reduction (wheat, rice, maize and soybean) could attain up to 30% by 2080 under the warmer scenario (HadCM3 SRES A1F1). However when CO2 effects are considered, yield changes could range between 30% of reduction in Mexico and 5% of increase in Argentina (Parry *et al*., 2004). More specifics studies considering individual crops and countries are also presented in Table 4. The great variability in yield projections could be attributed to the GCM or incremental scenario used, the time slice and SRES scenario considered, the inclusion or not of CO2 effects, and the site considered. However some behaviour seem to be consistent all over the region like the projected reduction of rice yields after the year 2010, and the increase in soybean yields when CO2 effects are considered. Other important issues related to coffee are the expected reduction in planted area in Brazil, and in production in Mexico. For non commercial farmers (Table 13.4) it could be expected a mean reduction of 10% in maize yields by the year 2055. Although in some countries, such us Colombia, overall yields are essentially unchanging to 2055, while in others, such as the Venezuelan piedmont, yields are predicted to decline almost to zero (Jones & Thornton, 2003).

Furthermore, the effects of Climate Change and Land Use Change on food production and food security in the region are related to natural degradation resulting on a larger degradation of lands and a change on erosion patterns (FAO, 2001). By year 2050 desertification and salinization will affect 50% of agricultural lands in Latin America and the Caribbean zone (FAO, 2004a). According to World Bank Report (2001), some developing countries are loosing 4-8% of their Gross Domestic Product, caused by productive and capital loss related to environmental degradation (World Bank, 2001). Related to soil conditions, at the tropical zone climate change will result in the general degradation of the soil structure in lands devoted to agriculture if a reduction in the mean annual precipitation is produced. For example in southern Bolivia a reduction of rainfall will be more dangerous for agriculture than for forest or scrub covered areas due to the low aggregate resistance and the lower organic matter content (Cerda, 2000).

Table 13.4: *Future Impacts in the agricultural sector*

Study	Climate Scenario	Yield Impact (%)					
		Wheat	**Maize**	**Soybean**	**Rice**	**Sugar**	**Potato**
Latin America (Parry et al., 2004)	HadCM3 A1F1 ($1CO_2$) HadCM3 B1 ($1CO_2$) HadCM3 A1F1 ($2CO_2$) HadCM3 B1 ($2CO_2$)	-5 to -2.5 (2020) -10 to -2.5 (2020) -5 to +2.5 (2020) -5 to -2.5 (2020)	-30 to -5 (2050) -10 to -2.5 (2050) -10 to +10 (2050) -5 to +2.5 (2050)	-30 (2080) -30 to -10 (2080) -30 to +5 (2080) -10 to +2.5 (2080)			
Guyana (Guyana 2002)	CGCM1 2020-2040 (2CO2) CGCM1 2080-2100 (3CO2)				-3 -16	-30 -38	
Panamá (Panama 2000)	HadCM2-UKHI (IS92c-IS92f) 2010/2050/2100 ($1CO_2$)		+9/-33.5/-21				
Ecuador *[1] (Ecuador 2000)	+1ºC + 20% pp, 2010/2030 +2ºC - 15% pp, 2010/2030		surplus surplus	surplus/deficit surplus/deficit	surplus/deficit deficit		surplus deficit
Costa Rica (Costa Rica 2000)	+2ºC -15% pp ($1CO_2$)				-31		reductions
Guatemala (Guatemala 2001)	+1.5ºC +5% pp +2ºC +6% pp +3.5ºC -30% pp		+8 to -11 +15 to -11 +13 to -34		-16 -20 -27		
Bolivia (Bolivia 2000)	GISS and UK89 ($2CO_2$). I Incremental ($2CO_2$) +3ºC -20% pp optimistic-pessimistic ($1CO_2$) optimistic-pessimistic ($2CO_2$) IS92a ($1CO_2$) *[2] IS92a ($2CO_2$) *[2]		-25 +50	 -3.3 to -19.6 +59 to +12	-2 -15		 +4.6 to+1.7*[3] +6.6 to+4.6*[3]
Brazil (de Siqueira et al., 2000)	GISS (550 CO_2)	-31	-16	+27			
SESA (LA27)	Hadley CM3-A2 (500ppm) Hadley CM3-A2 (500ppm). I	+9 to +13 +10 to +14	-5 to +8 0 to+2	+31 to +45 +24 to +30			
Argentina (Magrin, Travasso, 2002)	+1/+2/+3ºC (550 CO_2). I UKMO (+5.6ºC) (550 CO_2). I	+11/+3/-4 -16	0/-5/-9 -17	+40/+42/+39 +14			
Latin America (Jones & Thornton, 2003)	Hadley CM2 (smallholders)		-10				

México,Veracruz (Gay et al., 2004)	HadCM2 ECHAM4 (2050)	**Coffee:** 73% to 78% reduction in production
Brasil, Sao Pablo (Pinto et al., 2002)	+1ºC + 15% pp +5.8ºC + 15%pp	**Coffee:** 10% reduction in suitable lands for coffee 97% reduction in suitable lands for coffee
Costa Rica (Costa Rica 2000)	Sensitivity analysis	**Coffee:** Increases (up to 2ºC) in temperature would benefit crop yields

I= Irrigated crops; pp= precipitation; SESA= South East South America (Argentina's Pampas Region, Uruguay and south Brazil); *[1] = Results are presented in term of food security, *[2] = Values correspond to soybean sowing in winter and summer for 2010 and 2020; *[3] = Increases every 10 years.

Some studies report that the demand of water for irrigation is projected to rise in a warmer climate, bringing increased competition between agriculture and drinking as well as industrial users. Falling water tables and the resulting increase in the energy used for pumping will make the practice of agriculture more expensive (Maza *et al*., 2001. In the state of Ceará (Brazil) large scale reductions in the availability of stored surface water would lead to an increasing imbalance between water demand and water supply after 2025 (ECHAM scenario) (Krol & van Oel, XX).

An increase of heat stress, and more dry soils, may reduce yields to a third in tropic and subtropics areas where harvests are near the maximum heat tolerance. Both prairies/meadows productivity and pastures will be affected, with loss of carbon stock in organic soils and also organic matter as well as shifts on interactions and balance between species, including plagues and diseases incidence on cultivated plants. (FAO, 2001).

Regarding to beef cattle production, it has been reported for Bolivia that future climatic scenarios would have slight impacts on animal weight when CO2 effects are not considered. Doubling CO2 lead to decreases in weight that could attain up to 20% depending on animal genotype and region (Bolivia, 2001).

13.4.3 Water resources

The current vulnerabilities observed in many regions of Latin American countries will be increased by the joint negative effect of growing demands due to an increasing population rate for water supply and irrigation, and the expected drier conditions in many basins. The impact of climate change in safe water supply in Latin America may be estimated in the numbers of people with an increase in water stress. By the 2025s, 30 million people in scenarios A1 and B1, 46 - 90 million in scenario A2 and 70 million people in scenario B2, would be living in water stresses watersheds. By the 2050s, people living in water stresses watersheds may be estimated in 100 million in scenarios A1 and B1, 180 million in scenario A2 and 120 million in scenario B2 (Arnell, 2004). In zones where severe water stresses could be expected (east Central America, in the plains, Motagua valley and Pacific slopes of Guatemala, east and western regions of El Salvador, the Central Valley and Pacific region of Costa Rica, in the northern, central and western Intermountain regions of Honduras and in the Peninsula of Azuero in Panama) water supply and hydroelectric generation would be seriously affected (Ramirez, 2003).

As vulnerability studies performed foresee the ongoing reduction of glaciers, a much stressed condition is projected between 2015 and 2025 in the water availability of at least ten counties of Colombia and impact on the availability of water supply for the 60% of the population of Peru. (IDEAM, 2004) (García Vargas, 2003). The potential reductions in the glaciers would impact the hydroelectrical generation in some regions such as Colombia and Peru where one of the more affected rivers would the Mantaro, where an hydroelectric plant represents the 40% of the peruvian electrical generation and the energy supply for the 70% of the industries, concentrated in Lima (García Vargas, 2003). (See case study 2).

In Ecuador, projected water balances foresee that 7 of the 11 principal basins would be affected by a decrease in annual runoffs, varying monthly decreases up to 421% in year 2010 with the scenario of +2ºC and P-15% (Cáceres, 2004). In Chile, recent studies assessed ratify the TAR reference about potential damages in water supply and sanitation services in coastal cities, as well as groundwater contamination by saline intrusion. In the Central region river basins, changes in the streamflows would oblige to retrofit many water regulation works (CONAMA, 2004).

Agriculture malpractices (soil erosion, herbicides, pesticides, fertilisers) will probably impact in the deterioration of surface and groundwater availabilities; under more severe dry conditions. That would be the case of areas currently degraded as Leon, Sebaco valley, Matagalpa and Jinoteca in Nicaragua, metropolitan and rural areas of Costa Rica, Central Valley rivers in Centro America, Magdalena river in Colombia, Rapel river basin in Chile, Uruguay river in Brazil, Uruguay and Argentina. (GEO-LAC, 2003).

Ninety seven percent of landslides in Latin America are generated by intense precipitations (heavy rains); since almost 20% of the Region is vulnerable to landslides, the exacerbation of extreme events would bring increasing risks/hazards to local populations (Fay el al, 2003).

Vulnerability of human settlements is an increasing consequence of the accelerated urban growth related to rural migrations, urbanisation of poverty and low investments in water supply, sanitation and urban drainage facilities. The results of these negative circumstances can be resumed as follows: water shortages in many cities as a main problem, high percentages of urban population without access to sanitation services, absence of treatment plants, high groundwater pollution, lack of urban drainage systems, storm sewers used for domestic waste disposal, occupation of flood valley without control during drought seasons and high impacts during flood seasons (Tucci, 2001) (IRDB, 2003).

The impact of future shortages of water will also be severe in the industry, particularly in arid and semi-arid regions of Argentina and Brazil, in the oil sector in Venezuela and in the mining regions of Peru, Bolivia, Chile and Argentina.

13.4.4 Coasts

The most significant impacts of climate change on the Latin America coastal areas are projected to be on its coastal resources and people. Projected impacts include floods, localized salinization of low-land areas, and coastal storm regime modification as a result of climatic change causing mainly increased erosion and altered coastal morphology (Conde *et al.*, 2001; Schaeffer-Novelli *et al*., 2002;Villamizar, 2004) and the possible salinization of the main source of drinking water, which would entail serious socio-economic consequences (Ubitaran Moreira *et al.*, 1999;). Other factors such as the artificial opening of littoral bars, pressures from tourism and excessive afforestation with foreign species likely will add impacts along the littoral lagoon bars and wetlands (CIDAS, 2003; Grasses *et al.*, 2000; Rodríguez Acevedo, 2001).

It is reasonable to expect that in the worst SLR scenario (SRES A2: 38-104 cm) mangroves from Latin America could disappear from more exposed and marginal environments (low-lying coastlines from Brazil, Ecuador, Colombia, Guyana, El Salvador, Venezuela), and that the greatest development would occur in the more optimal high sedimentation, high tide, and drowned river-valley environments (Medina *et al.*, 2001; Hensel and Proffit, 2002).
The coastline of El Salvador will be exposed to an area loss in the next 100 years ranging from 10% of the total area (141 km^2) under the optimistic scenario (SLR: 13 cm) and up to 27.6% (400.7 km^2) under a pessimistic scenario (SLR: 110 cm). The expected changes in the flooded areas show that the mangroves, salt and shrimp production will be the most affected with the consequent drop in production and GDP share (República de El Salvador, 2000).

Over 90 % of the population and the most important economic activities are located in the coastal areas of Guyana where is expected that to retreat as much as 2.5 km with a rise of 100 cm in the sea level projected by AOGCMs (i.e. 5 mm yr -1; range 2-9 mm yr -1) (Guyana, 2002).

Warmer sea surface temperatures in the Gulf of Mexico - between 1º and 3ºC by the 2080s under IPCC SRES scenarios - may threaten the existence of the Mesoamerican coral reef and mangroves, home to a number of endangered species: the green, hawksbill and loggerhead turtles, the West Indian manatee and the American and Motelet's species of crocodile (CLR-UEA, 1999; Cahoon and Hensel, 2002)

Costa Rica assessed the vulnerability to SLR (+ 0.3 and 1.0 m) at Punta Arenas Province on the central Pacific coast. Under +0.3 SLR seawater should penetrate 150 m affecting 60% of urban areas, whereas under a SLR of +1.0 m seawater should penetrate 500 m affecting 90% of urban areas (Republic of Costa Rica, 2000).

A comprehensive assessment of future vulnerability and impacts for the lower basin and estuary of Guayas river system and associated coastal zone under SLR scenarios (no-change: LANM0, moderate: LANM1, and severe changes: LANM2) and two socioeconomic scenarios (without and with development respectively) estimated economic losses - for areas varying from 43 to 539 km^2 that include shrimp cultures, mangroves, urban and recreation areas, supply of drinking water to Guayaquil, as well banana, rice and sugar cane cultures- of US$ 1 305 whereas US$ 1 040 should be under risk. Evacuated and under risk population should rise 327 000 and 200 000 people respectively. Of the 1,214 km^2 of Guayaquil's mangroves existing at present, it is estimated that 532.7 km^2 will be affected by LANM2 scenario, which accounts for 44% of the total area (Republic of Ecuador, 2000) (Republic of Ecuador, 2000).

Impacts and vulnerability assessments in Peru emphasized on the intensification of ENSO events and increases in SST, wind stress, hypoxia and deepening of thermocline, and their impacts on the marine ecosystem (i.e. plankton and larvae) and fisheries sector, i.e., reduction of spawining areas and fish catch of anchovy (Republic of Peru, 2001). The effects of a potential SLR will cause the flooding of coastal infrastructure, houses and fisheries accounting US$ 168 250 000. Also, the global losses on 8 coastal regions from Peru will raise US$ 1 000 000 000.

Low lying-areas in the western region of Montevideo (estuarine wetlands and sandy beaches very rich in plant and bird diversity) are highly vulnerable to SLR > 0.30 m, and storm surge (Republic of Uruguay, 2004; Nagy *et al*., 2005).

The effects of a potential SLR of 1.0 meter in some coastal areas from Colombia, could be a permanent flooding of 4.900 km^2 of low lying coast. About 1.4 million people live in the coastal area which would be affected. In terms of social vulnerability of Caribbean coastal homes 29% would be highly vulnerable; the analysis of the coastal agricultural sector concluded that of 7 208 299 hectares of crops and pasture reported, 4.9% would be exposed to different degrees of flooding. In the coastal industrial sector it was found that between 75.3% (475 hectares) and 99.7% (877 hectares) should be under high-vulnerability. The 44.8% of the coastal roads network would be highly vulnerable (Republic of Colombia, 2001).

Flood maps for medium and extreme scenarios show that very low-lying areas from Buenos Aires, which will be likely permanently flooded by 2070/2080, are now scarcely populated because they are frequently flooded by storm surges**.** Also, SLR would promote quick erosion with its consequent coastline backward, depending on geologic characteristics of the area. As a result of this adaptation to present storm surge conditions, the social impact of future permanent flooding will be small. Then, climate change vulnerability in this coastal zone is mostly conditioned by future exposure to extreme surges (Kokot, 2004; Menéndez, Ré and Kind, 2004).

The increase in yearly rates and non-global eustatic factors (i.e. increase in southeastern winds and freshwater inflow) suggest an acceleration of SLR in the Rio de la Plata which should have diverse environmental and societal impacts on both the Argentinean and Uruguayan coasts over the next few decades (Barros *et al.*, 2003; Nagy *et al.*, 2004 a,b; Natenzon *et al.*, 2004). For instance, loss of land from SLR would have a major impact on the tourist industry which accounts for about 3.8% of Uruguay's GDP (Ramos Mañé *et al*., 1998).

13.4.5 Human health

The regional assessment of health impacts due to climate change in the Americas have indicated that the main concerns are heat stress, malaria, dengue, cholera and other water-borne diseases(Githeko and Woodward, 2003)

Some Latin American countries have begun to consider climate change in their environmental and health policies. For example, Colombia has recognized the increasing of vulnerable areas where malaria and dengue vectors live due to climate change making, increasing the probability of transmission and the number of cases (Ministerio de Medio Ambiente, 2002). As a result, the authorities are aware of the importance to strengthen the epidemiological surveillance system in order to identify cases in susceptible areas.

Forest fires have significant sanitary, economic and environmental effects. Climate change is likely to affect the risk of forest fires, which in some countries, such as Brazil, have been associated with the increase risk of outpatient visits for respiratory disease (Haines and Patz, 2004), and increased risk of respiratory disease, eye problems, injuries and fatalities (Haines *et al*., 2000; Patz, 2004).

The production of various air pollutants and of allergenic spores and pollens would be affected by warmer and wetter conditions. On the other hand, climate change could increase the geographical distribution of vectors (such as malaria and dengue vectors) in parts of Latin America (Haines and Patz, 2004; Martens and McMichael, 2001), and it is expected affect health via various indirect pathways, including the patterns of infectious diseases (McMichael, 2003).

Based on SRES emission scenarios (A1F1, A2, B1 and B2) and socio-economic scenarios, some projections regarding population at risk of malaria due to climate change have been developed. Decreases in the transmission season of malaria are indicated in many areas where reductions in precipitation are projected by the Hadley Center Model, such as the Amazon and Central America. The results report additional population at risk in areas around the southern limit of the distribution in South America (Lieshout *et al*., 2004).

In Bolivia, climate can increase the presence of malaria in 27% (11.3% for *P. vivax* and 43.6% for *P. falciparum*). Based on the IS92a scenario, malaria (*P. vivax*) will present seasonal variation (with peaks in April-May) in 2010. The malaria due to *P. falciparum* will increase the seasonal variation, showing three peaks (January, April-May, and August-September) (Ministry of Sustainable Development and Environment, 2000).

Climate change scenarios have predicted a possible increase in malaria cases from 2-6% to 3-9% of the Nicaraguan population in 2030, to 3-10% in 2050, and 5-15% for 2100. The increase in malaria cases could impact costs in health services, including treatment and social security payments. Depending on scenario and region, increase in temperature would increase 38-150% of malaria cases (MARENA, 2001).

Based on projections for 2010 in Bolivia, an increase in leishmaniasis is expected, increasing the incidence between July-September. Morbidity due to leishmaniasis could be increased due to temporal migration patterns (labor migration) in high risk areas (Ministry of Sustainable Development and Environment, 2000).

The results of different models show a change of geographical distribution of dengue transmission increasing the probability in the east and west cost of Mexico east and southern region of Brazil, and west region of Peru and Ecuador (Hales *et al*., 2002). Climate changes under global warming scenarios are therefore likely to increase the potential for dengue epidemics (Gagnon *et al*., 2001.Hoop and Foley 2001)

Based on FUND model, it was examined the various factors thought to determine potential infectivity of malaria, and its actual outbreak in the context of a dynamic integrated assessment model. For Latin American, assuming population and income as is today, 1,101 (mean) additional deaths due to malaria and -114 (mean) deaths due to schistosomiasis for a 1°C global warming is reported However, if the costs of emission reduction are high, implementation of the climate policy can increase malaria mortality in regions close to the income threshold in which malaria can be eradicated (Tol and Dowlatabadi, 2001).

There is predicted a 0.22% change in cumulative climate change induced vector borne mortality in Latin America due to a 1% emission reduction in 2000-2009. However, if the costs of emission reduction are high, implementation of the climate policy can increase malaria mortality in regions close to the income threshold in which malaria can be eradicated (Tol and Dowlatabadi, 2001).

13.5. Adaptation

13.5.1. Practices and options

13.5.1.1- Natural ecosystems

Some options to reduce the ecosystem degradation in Latin America are the improvement of policy, planning and management. According to Millennium Ecosystem Assessment (2005); FAO, (2004b); Laurance *et al.,* (2001), these options basically are:

- Integrate decision-making between different departments and sectors, as well as international institutions, to ensure that policies are focused on protection of ecosystems.
- Empowerment of marginalized groups to influence on the decisions, which affect the ecosystem services, and recognize in law local communities ownership of natural resources. This option is the key to reduce forests fires incidence.
- Include sound management of ecosystem services in all regional planning decisions and in the poverty reduction strategies being prepared by many developing countries.
- Establish additional protected areas, particularly the biologic or ecological corridors for preserving the connections between protected areas, with the aim to prevent the

fragmentation of natural habitats, as for example had been happening in the Meso-American Biological Corridor, natural corridor projects under way in Brazil's Amazon and Atlantic forests, the Andean Corridors of Ecuador, Bolivia and Peru, and some smaller initiatives in Argentina.

- Use all relevant forms of knowledge and information about ecosystems in decision-making, including the knowledge of local and indigenous groups.

13.5.1.2- Agriculture and forestry

In the region there was only limited analysis of adaptation in the agricultural sector. In many cases, the studies identified potential adaptations but did not analyze them. For example in Ecuador several options such as: agro-ecological zoning and appropriate sowing and harvesting seasons, introduction of higher-yield varieties, installation of irrigation systems, adequate use of fertilizers, and implementation of a system for controlling pests and disease, were proposed (Ecuador, 2001). In Guyana several adjustments related to: crop variety (thermal and moisture requirements and shorter-maturing varieties), soil management, land allocation to increase cultivable area, using new sources of water (recycling of wastewater), harvesting efficiency, and purchases to supplement production (fertilizers and machinery) were identified (Guyana, 2000).

In other countries, adaptation measures were assessed by mean of crop simulation models. For example in the Pampas region of Argentina anticipating planting dates and the use of longer genotypes of wheat and maize would allow taking advantage of projected longer growing seasons as a result of the shortening in frost's period (Magrin & Travasso, 2002).

A global study (which includes Northern Argentina and Southeastern Brazil) concludes that in Northern Argentina occasional problems in water supply for agriculture under the current climate may be exacerbated by climate change, and may require timely improvements in crop cultivars, irrigation and drainage technology, and water management. Inversely, in Southeastern Brazil, future water supply for agriculture appears to be plentiful (Rosenzweig *et al*., 2004).

Carbon-sequestration opportunities in the agriculture, livestock, and forestry sectors, which are responsible for more than 80% of GHG emissions in Uruguay has enacted a number of sector policies that were driven by conservation or economic development objectives, which have already had significant climate change benefits (Agrawala *et al*., 2004). For example, the Soil Management Law passed in 1982 has resulted in the sequestration of 1.8 million ton C/year over the last 20 years; the application of Forestry Promotion Policy of 1987, increased from about 200km^2 in 1987 to over 6,500 km^2 in 2000 and the cumulative net carbon sequestration during 1988 to 2000 was estimated at of 27.4 Mt CO2 (Agrawala *et al*., 2004)

13.5.1.3 Water resources

Water management policies in Latin America are the central point of the adaptation criteria to be established in order to strengthen the countries capacities to manage water resources under climate changing conditions. Principal actions for adaptation must include: improve and further develop legislation relating land use on floodplains, ensuring compliance with existing regulations of risk zones, floodplain use and building codes; re-evaluate the design and safety criteria of structural measures for water management; develop ground water protection and restoration plans to maintain water storage for dry seasons; public awareness campaigns to highlight the value of the rivers and wetlands as buffers against increased climate variability and improve participation of vulnerable groups in flood adaptation and mitigation programs, (Bergkamp, G. *et al*., 2003), (IRDB, 2000).

Adaptation to drier conditions in 60% of the territory of Latin America would produce a great increase in the amounts of the inversions in water supply systems, additionally to the 17.7 billion dollars necessary to accomplish the incorporation of 121 million persons to safe water systems, attaining the Millenium Declaration for Safe Water goals by 2015 (even leaving 10% of the population of Latin America without access to safe water) (IDB**,** 2004).

Transbasin diversions have been the hallmark of efficient solutions for water development in some regions of the world, particularly in California. In Latin America, transbasin transfers in Yacambú Basin (Venezuela), Catamayo-Chira basins (Ecuador, Peru), Alto Piura and Mantaro Basins (Peru), Sao Francisco River (Brazil) would be an option to mitigate the likely stress of water supply for the population (García Vargas, 2003).

The use of urban and rural groundwater needs to be controlled and rationalised, taking account of the quality distributions and trends identified in each region. To develop a sustainable groundwater and aquifer management the rules to comply would be: limit or reduce the consequences of excessive abstractions, slow down growth of abstractions, explore possibilities for artificial aquifer recharge and evaluate options for planed mining of groundwater storage (The World Bank Group, 2002). (IRDB, 2000).

13.5.1.4 Coasts

Since the TAR was published most Latin American countries have presented their National Communications to the UNFCC (NC) including assessments of impacts, vulnerability and adaptation measures of their coastal zones. However, approaches, concerns and detail of the assessments are very different. Many countries based their adaptation assessments on the most accepted scenarios of SLR (from 0.3 to 1.0 m), in some cases combined with coastal river floodings. Some of them included a cost-benefit analysis without and with measures (i.e., Ecuador, El Salvador, Costa Rica). Long-term and recent trends of SLR, floodings, storm surges and impacts are not always analyzed or are not available. Some other countries (i.e. Chile and Peru) prioritized their assessment on the impacts of ENSO events and increase in SST on fisheries. Most countries focus their adaptation on integrated coastal zone management (i.e., Colombia, Costa Rica, Venezuela, Uruguay).

Ecuador and Guyana, i.e, are planning a total protection option for the combined severe climatic (i.e., LANM2 in Ecuador) and development socioeconomic scenario which includes coastal defence of Guayas river basin and acreation development on low-lying vulnerable coastal strip 77 km wide in the east and 26 km wide in the western Essequibo region, respectively. The cost of these measures in Ecuador is less than US$2 billion dollar and the benefit is the protection of capital goods two to three times greater (Republic of Ecuador, 2000).

Colombia prioritizes adaptation measures to recover and strength resiliency of natural systems in order to facilitate natural adaptation to SLR as well as a program of coastal zone management which emphasize on wetland preservation, areas prone to be flooded and those of high socieconomic value (Republic of Colombia, 2001).

Panama assessed both autonomous and planned adaptation measures to protect the loss of beaches based mainly on soft engineering practices (Republic of Panama, 2000).

Peru is focusing in adaptation options to climate change related with ENSO event and increase in SST that include: modern satellite observation systems of sea and continent similars to international programs TOGA and CLIVAR, and capacity building for at least 50 scientists in: Oceanic, atmospheric and hydrologic modelling and GIS´s systems (Republic of Peru, 2001).

Uruguay evaluated several adaptation options to climate change in coastal resources and proposed a list of priority measures, such as: i) Integrated Coastal Zone Management, ii) coastal development planning and monitoring iii) assessment of economic, environmental and social impacts, iv) identification of government agencies that should take up the various tasks (Ramos-Mañé *et al*., 2002) and v) a Program of General Measures for Mitigation and Adaptation to Climate Change (PEMEGEMA) which involved a wide range of stakeholders and was an effective instrument for both dissemination and raising of awareness (Republic of Uruguay, 2004; OACD, 2004).

Flood risk maps for future conditions (i.e. 2070) were developed for Buenos Aires based on SLR trends, storm scenarios records and a two-dimensional hydrodynamic model (Kokot, 2004; Menéndez, Ré and Kind, 2004). These maps will be useful for early warning to extreme events.

Flooding under LANM2 scenario (+1.00 m) would cover-an area of 1,204.01 km^2, endangering the mangroves and shrimp farms installed in floodable sectors from Coastal areas of Ecuador. The measure intends reforest the mangroves of the areas affected by the LANM2 with different mangrove species and preserve current mangrove areas (Republic of Ecuador, 2000).

The Adjustment of Shrimp-Farming Activities of Ecuador (the shrimp industry is the country's third largest export item) will involve the rehabilitation of the retaining walls to withstand flooding caused by the rising sea level, because the impact caused by LANM2 would cover close to 355.2 km2 of water farming production areas, leading to huge losses for the sector (Republic of Ecuador, 2000).

Most fishing countries in the region have regulations governing access to their main fishing ground (i.e., Chile and Ecuador), and several countries have been including new legislation to control the uses of the coastline and fishing resources and to then propose adaptation measures (Costa Rica, Guyana, Panama, Peru, Venezuela). A number of agreements have also been signed by specific countries at regional level (Ecuador in smaller areas) on matters such as protecting the marine environment, prevention of pollution from marine or terrestrial sources, and the management of commercial fisheries (CAPP, 2000; CIDEIBER, 1999; Sullivan and Bustamante, 1999; CIDAS, 2003). Implementation of the provisions of the Convention United Nations Convention on the Law of the Sea, relating to the conservation and management of straddling fish stocks and highly migratory fish stocks (in force as from 11 December 2001), ratified by Brazil and Costa Rica (UNCLOS, 2005)

Coastal biodiversity can be maintained and even improved through sustainable use by promoting community management to make conservation part of sustainable development of coastal resources like mangroves and its artisanal fisheries. (e.g. Mexico, Ecuador, Guatemala, Brazil and Nicaragua initiatives well-stablished the critical local community participation in the managed forest) (Windevoxhel and Sención, 2002; Ubiratan-Moreira, 1999; Kovacs, 2000).

13.5.1.5 Human health

The health toll taken by global warming will depend to a large extent on the steps taken to prepare for the dangers. The ideal defensive strategy would have multiple components. One would include improved surveillance systems that would promptly spot the emergency or resurgence of infectious diseases or the vectors that carry them. A second component would focus on predicting when climatological and other environmental conditions could become conductive to disease outbreaks so that the risks could be minimized (Epstein, 2001).

The improved predictive capability can enhance the planning and decision processes for control of malaria, dengue fever and other vector borne diseases, helping to prevent disease and the associated social and economic troubles. Further research on climatic patterns and weather parameters may be useful for developing public health priorities. Among other adaptation policies, Colombia has reported that the epidemiological surveillance system will be strengthened in order to identify cases of malaria and dengue in susceptible areas (Poveda *et al*., 2000).

In Brazil, some studies of vulnerability and adaptation are planning to be developed. Different institutions are planning to conduct a retrospective study of social-environmental vulnerability of the population when subject to extreme climatic events and to endemic diseases sensitive to climatic oscillations (Ministry of Science and Technology, 2004).

In order to cope with future needs and outbreak in Guyana, a project will be focus on routine surveillance of diseases and the establishment and maintenance of a database, which will include health and climate change information along with socioeconomic data in Guyana (National Task Force, 2001).

Adaptation measures in Panama include the improvement of statistical information, knowledge and surveillance of future projections focus on human and environmental health. Implementation of a pro-active integrated surveillance system in order to forecast outbreaks is recommended. Identify high vulnerable areas to climate change and high risk populations in order to apply sanitary measures and identify resources needed. Education, technology and financial assistance would be included in order to understand and implement research project and measures in climate and health (ANAM, 2000).

In Colombia, the recommended adaptation measures for dengue are the ones most commonly used to combat it: stronger action such as chemical control to eliminate adult mosquitoes, environmental measures to prevent them from breeding; and clean-up campaigns organized with the aid of community organizations and health workers (Ministry of the Environment).

13.5.2. Constrains

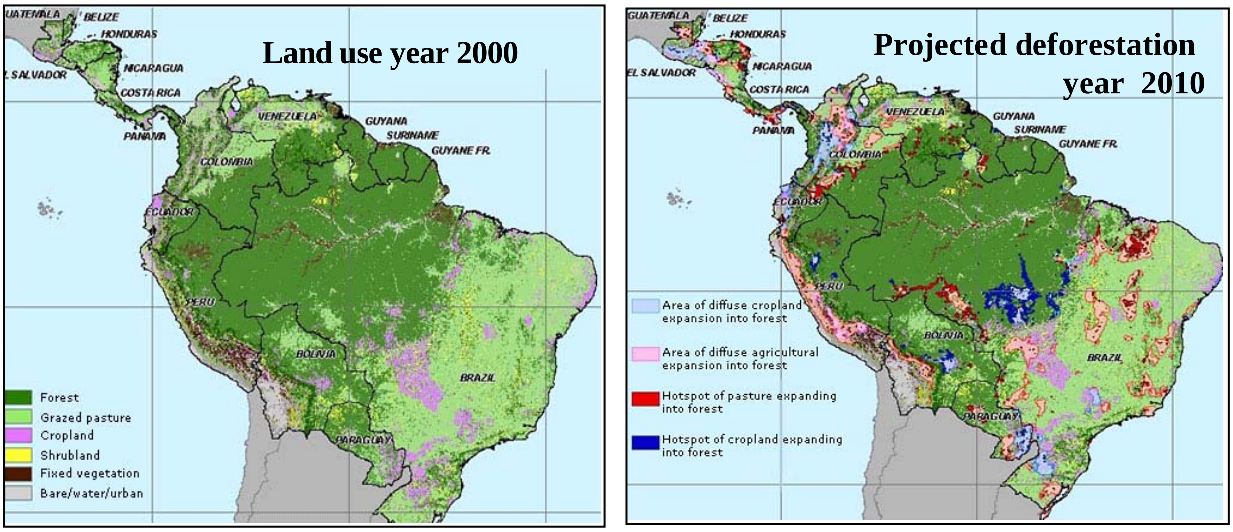
Lack of awareness, technical knowledge or appropriate monitoring, and difficulties in the dissemination of data and information are the main constrains in several sectors to adapt to current climate trends in Argentina (Barros, 2005). Some constrains reported for adaptation in the agricultural sector in Ecuador include: lack of centralized and available information; lack of awareness, dissemination, and training on the importance of climate change in the sector and lack of resources (Ecuador, 2001). Political and socio-economics uncertainties are yet and will be important constrains for small farmers to cop with climate change and variability. If, for example, small farmers believe that domestic maize production is necessary for household food security, adaptation measures that emphasize the benefits of alternative crops are not likely to be widely adopted. Furthermore, farmers are likely to have difficulty implementing any mitigation measures that require the purchase of inputs at a particular time if they are constrained by lack of credit and rising prices (Eakin, 2000).

For the health sector, many constraints are identified. Several Latin American countries have not identified clearly the different health effects due to climate change due to lack of awareness and information. All countries have epidemiological surveillance systems for infectious diseases and vector borne diseases but the information is not analyzed regarding meteorological/environmental conditions. There is lack of multidisciplinary research focus on the identification, understanding and modeling of health impacts. There is a lack of tools to address cross-cutting issues, ecologically complex, and long-term public health challenges. (Patz, *et al*., 2000). There are not statistical correlations to forecast outbreaks and developing health early warning systems. For many countries, there is a lack of intersectorial work between the health sector and other sectors such as, the environment, water resources, agriculture, climatological/meteorological services.

As a result of the study in the coastal areas from Latin America, various constraints and obstacles that affect the implementation of adaptation measurements to climate change are being detected. Among the most important and common between countries the following can be indicated: Shortage of bibliographical material, since existing material is scattered. Another constraint is the ddifficulty in conducting an economic assessment of measures because of the shortage of available information. Also the Insufficiency of the equipment and material used for gathering the information is a limiting factor. The existence of a limited number of specialists working on the topic of climate change complicates the assessment of the coastal environment. The impossibility of gaining access to experiences and technologies of other countries that have conducted LANM studies is a limitation And finally shortage of education and public awareness-raising programs on the subject of climate change. Insufficient participation of higher education centres in climate change programs. Restrictions on accesses to new technologies and information related with systemic climate observation, factors of emission of GHG, their mitigation and financial limitations are the main constrains in Peru. Other obstacles are restrictions on legal, institutional, governance and financial aspects. For instance, the measures proposed to adapt to the scenario LANM-2 and the impacts on the quality of the supply of drinking water to Guayaquil (Ecuador) are considered unfeasible.

13.6 Case studies:

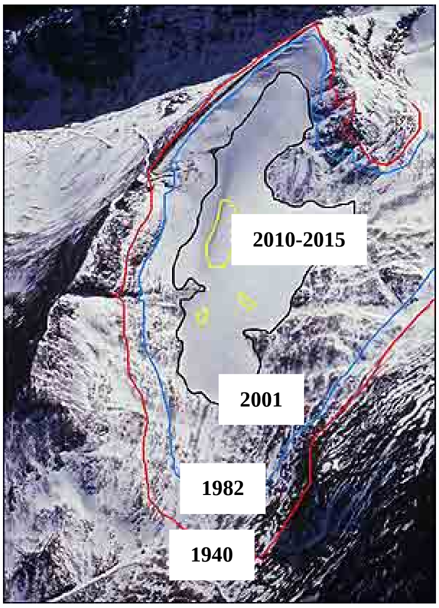
Amazonia



The Amazon Basin contains the largest, contiguous extent of tropical forest on Earth, almost 5.8 million km^2. It harbours perhaps 20% of the planet's plant and animal species. There is abundance of water resources and the Amazon river accounts for 18% of the freshwater input to the global oceans. Over the past 30 years almost 600,000 km^2 have been deforested in Brazil alone due to the rapid development of Amazonia, making the region one of 'hot spots' of the planet. Field studies carried out over the last 20 years clearly showed local changes in the water, energy, carbon, and nutrient cycling, and in the atmospheric composition caused by deforestation, forest fragmentation and biomass burning. More recently, research of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) is uncovering novel features of the complex interaction of vegetated land surface and the atmosphere in many spatial and temporal scales. The LBA Experiment is producing new knowledge on the physical, chemical and biological functioning of Amazonia, its role for our planet and the impacts in that functioning due to changes in climate and land use.

There are observational evidences of sub-regional changes in surface energy budget and boundary layer cloudiness and regional changes in the lower troposphere radiative transfer due to biomass burning aerosol loadings. Large number of cloud condensation nuclei (CCN) due to biomass burning has led to the speculation of their possible direct and indirect role in cloud formation and rainfall, possibly reducing dry season rainfall. During the rainy season, in contrast, there are very few amounts of CCN of biogenic origin and the Amazonian clouds show characteristics of oceanic clouds. Carbon cycle studies of the Large Scale Biosphere-Atmosphere Experiment (LBA) indicate that the Amazonian undisturbed forest may be a sink of carbon of about 100 to 400 Mton C/year, roughly balancing CO_2 emissions due to deforestation, biomass burning, and forest fragmentation of about 300 Mton C/year. On the other hand, the effect of deforestation and forest fragmentation is increasing the susceptibility of the forest to fires. Observational evidence of changes in the hydrological cycle due to land use change is inconclusive at present, though observations have shown reductions of streamflow and no change of rainfall for a large sub-basin (Tocantins river basin), highlighting the effect of deforestation on streamflows. Modelling studies of large-scale deforestation indicate a likely drier and warmer post-deforestation climate. Reductions of regional rainfall might lead to atmospheric teleconnections affecting the climate of remote regions. In sum, deforestation may lead to regional climate changes that would lead to a 'savannization' of Amazonia. That factor is likely to be greatly amplified by global warming. The synergistic combination of both regional and global changes may severely affect the functioning of Amazonian ecosystems, resulting in catastrophic species disappearance.

Adaptation of Altiplano's indigenous communities to climate change



Chacaltaya Glacier

Established in different regions of the American continent, the subsistence of indigenous groups was, as it is nowadays, based in the rather limited resources cropped, under compatible climate conditions, in the area of a few hundred square kilometers around their settlements. Climate also defines the population ´security levels. Worshiping the Pachamama[1] and minor goddesses (i.e. Apus) (La Nación, 2005), these representing the "spirit" of the more than 600 glaciers in the Altiplano[2], these communities had recognized the value of the environment well before than many modern ones. In this regard, they also developed an excellent information and knowledge on local environmental conditions and wealth. Ancestral habits include a historical continuity of such local resources knowledge and use practices as well as the local climate (GadgilM *et al*, IPGRI 2002), so to crop their foodstuff, medicine or even products for leisure.

To do this in a sustainable manner, they managed their water requirements and protected their environs. For this purpose, they articulated irrigation practices and different adaptation techniques, developing some capacity to cope with the adverse effects of the weather and climate vagaries. Focusing the attention on the pre-Colombian cultures of the Andean Altiplano[1], as known they were capable to foretell climate variations, particularly those associated to El Niño processes (Canziani & Mata, 2004). The better the information on traditional or indigenous knowledge of pre-Colombian communities would enable a better understanding of local problems and also help us to reconcile empiricism and science (Iaccarino, 2003).

Additionally to this capacity to foretell climatic conditions, the paper of reference (La Nación, 2005) also includes information on the Altiplano's cultures engineering capacities. A book of the American Association of Civil Engineers (Wright, *et al*., 200) also shows these capacities, that are largely confirmed by the recent discovery of a 7,6 kilometer canal, in the Cajamarca valley to divert water from the Pacific basin to the Atlantic basin. An important segment of 4,5 kilometer has been stone-cut through the mountain range (www). Further, the name "Andes" given to the South American cordillera is a deformation of the Spanish word "andenes", meaning the water-stopper platforms built to minimize water erosion, in cropping lands of steep mountain slopes. These engineering capacities are also shown in different aqueducts, in the musical fountain built in Cusco, the capital town of the Inca Empire and the stone-paved road linking this capital with another one in Quito, in the wild Andean environment. These developments aimed to bring water for human consumption and irrigation, to easy terrestrial communications. This experience will be of high value to develop appropriate adaptation measures for coping climate change adverse impacts. In this regard, extreme climate conditions, as they affect to day different parts of the world, they will impact these highly vulnerable communities.

Depending on the local climate, it is evident, as it happened with the droughts that brought the collapse of the Maya Culture (Hunt & Elliot, 2005; Peterson & Haug, 2005), and the non-foretold huge flood originated by an unforeseen El Niño event which started the decay of the Moche Culture, in Peru, in 1,000 AD (Nials *et al*., 1979), that climate change may bring additional hazards. In addition to the already observed exacerbated glaciers ´retreat (see Table 2b) and the hazardous conditions created by the about 374 Andean glacier lakes (Carey, 2004), the increasing global warming, enhancing climate variability and extreme events, will enhance the vulnerability of these indigenous populations. Therefore, to mitigate the disastrous effects of new avalanches and outburst floods, it is of great importance to improve immediately the underdeveloped glaciers ´watch. In the near future this protection of human life also requires the improvement of studies on the environmental, social and economic shortcomings stemming from the already observed effects of climate change in this region, having the largest indigenous population in South America. Moreover, the preservation of the regional biodiversity wealth has to be urgently added to the measures to safeguard these indigenous communities, which high was pointed out in TAR (IPCC, 2001). This demand urges decision making levels, official and private, to develop the necessary observation, monitoring and watching systems and calls scientists to improve regional climate change projections and the evaluation of climate change integrated environmental impacts, for the sake of this peculiar South American region. The consideration of climate change impacts on the Altiplano species undoubtedly have a global importance, hence their protection is a must, as it is shown by the scientific and technical issues related to the new field of Ethnoecology (Martin, 2004).

1. Pachamama: Earth Goddess ; Apus: minor goddess representing the snowed mountain spirits.
2. Altiplano: The high level Andean plateau, its deep fertile valleys –Yungas - and the neighbour foothill lands.

13.7 Implications for sustainable development

The World Commission on Environment and Development presided by the Norwegian Prime minister Gro Brundtland in 1987 produced a report on sustainable development with the title "Our Common Future." This report provides the now classic definition of sustainable development:" Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The concerns that lead to the Brundtland report were based on the complicated relationship between human activities and nature translated in unintended damage to the atmosphere, soils, water, and the relationship between plants and animals at a pace very difficult for science to catch up. (World Commission on Environment and Development, Our Common Future, Oxford University Press, Oxford, 1987). Among other things the idea in the case of natural resources is: that-the extraction of resources occur at a rate that allows nature itself of helped by humans to regenerate (Carabias, Julia…). The declaration implies the future generations and this is the link with climate change as recognized in the Delhi Ministerial Declaration (COP 8), “that climate change could endanger future well-being, ecosystems and economic progress in all regions”. The concept of sustainable Development has evolved and now is linked to ideas of equity that have been reinforced by the potential impacts of climate change either when mitigating (reducing emissions) or when confronting increased costs for adaptation. One approach to deal with these issues is discussed by Gay and Estrada, (2001) that propose to use-the Kyoto mechanisms to reduce the costs of confronting climate change in an equitable manner. Most of the countries of the Latin American region have adopted programs and projects on sustainable development some off them raising them to ministerial level. All the countries of the region have singed the Climate Convention and-the Biodiversity Convention and the Kyoto Protocol (GEO America Latina y el Caribe 2003).

In Latin America the “first wave” of legal and institutional reforms is associated with the influence of the Stockholm Conference in 1972 on the Human Environment, shortly after the first governmental agencies on the environment were established. Colombia was the regional pioneer establishing the National Code on Renewable and Protected Natural Resources, (1974). Later, Venezuela passed a decree on Organic Law on the Environment (1976) which led to the creation of the Ministry of the Environment and Renewable Natural Resources, and was followed by Ecuador, Cuba, Brazil, Guatemala, Mexico, Peru and Bolivia. The content of these laws is similar: national environmental policy, legal instruments to apply it and protection of certain natural resources (Brañes, 2001).

On a regional scale, there was a second wave” of reforms associated with the Earth Summit 1992 creating more ministries of the environment. Until nearly 1990, only one such ministry existed in the region, the Ministry of the Environment and Renewable Natural Resources of Venezuela, created in 1976.

After the 1992 Summit, Bolivia established the Ministry of **Sustainable Development** (including environmental administration with economic planning), a national comptroller’s office for the environment, and biodiversity, forestry and mining superintendents (with the exceptional attribute of being under parliamentary control). In addition, countries in the region have been ratifying or approving international treaties, conventions or agreements dedicated to the environment (Morán, 1996).

Ministers of the Environment of Latin America and the Caribbean, held within the framework of the Johannesburg Summit, the Latin America and Caribbean Initiative for **Sustainable Development** (ILAC) that was approved and included in the Summit’s implementation plan. Its objectives are to:

- increase the use of renewable energy sources until 10 % of the regional energy requirements are met
- increase natural protected areas and forest lands
- improve management of watersheds and marine and coastal zones, and reduce the discharge of pollutants
- adopt regulatory frameworks for access to genetic resources, according to the fair distribution of benefits principle
- reduce emissions into the air and increase coverage of drinking water services and sewage treatment

- implement plans and policies to reduce urban environmental vulnerability in the face of anthropogenic disasters and those caused by natural phenomena, including the formulation of a regional early warning system
- implement the Kyoto Protocol
- develop technologies, to ensure the quality and proper management of water
- advance in areas such as health, the eradication of poverty and equity and sustainability of production and consumption patterns. In the 30 years under review, the state of the environment in Latin America and the Caribbean has reflected the ideas and policies that have prevailed in the region since 1972.

However in the Prologue to GEO 2003 Klaus Toepfer (executive Director of the UNE P says that policies in the region, including those dealing with pollution in cities, have had some success. Nevertheless, the environment is still not fully integrated into economic decision making. Indeed, of the three pillars of **Sustainable Development**, (Environmental, Economic and Social) it is the economy that is driving development. Social issues such as poverty and inequality and environmental problems such as biodiversity loss and resources contamination have taken a back seat.

13.8 Key uncertainties, confidence levels, unknown gaps and priorities

[To follow in Second Order Draft]

References:

Acuña L.; Juan Minetti y Cristina Angueira. La expansión agrícola en Santiago del Estero y clima asociado. 2004. Actas de la "X Reunión Argentina y IV Latinoamericana de Agrometeorología". AADA (Asociación Argentina de Agrometeorología, www.aada.com.ar). [Latin America; current trend]

Adams Richard M., Laurie L. Houston, Bruce A. McCarl, Mario Tiscareño L. , Jaime Matus G., Rodney F. Weiher. The benefits to Mexican agriculture of an El Niño-southern oscillation (ENSO) early warning system. Agricultural and Forest Meteorology 115 (2003) 183-194. [Latin America; adaptation, agriculture]

Alves, D. 2002. An analysis of the geographical patterns of deforestation in Brazilian Amazonia the 1991-1996 period. In C. Wood and R. Porro (eds.) Patterns and Processes of Land Use and Forest Change in the Amazon . Gainesville, University of Florida Press.

Andréfouët, S., P.J. Mumby, M. McField, C. Hu, and E. Muller-Karger. 2002: Revisiting coral reef connectivity. *Coral Reefs* 21, 43-48.

Aparicio, M. 2005, Health Direct Impact of Climate Variability in La Paz. www.mds.gov.bo

Aparicio, M. 2000. *Vulnerabilidad y Adaptación a la Salud Humana ante los Efectos del Cambio Climático en Bolivia*. Ministerio de Desarrollo Sostenible y Planificación. Viceministerio de Medio Ambiente, Recursos Naturales y Desarrollo Forestal. Programa Nacional de Cambios Climáticos. PNUD/GEF.

Aronson, R.B., and W.F. Precht. 2002: White-band disease and the changing face of Caribbean coral reefs. *Hydrobiologia* 460, 25-38.

Baetghen W.E., Magrin G.O. 2000. Applications of Climate Forecasts in the Agricultural Sector of South East South America. *In* Sivakumar, M. V. K. (ed) Climate Prediction and Agriculture. Proceeding of the START/WMO International Workshop held in Geneva, Switzerland, 27-29 September 1999. Washington DC, USA: International START Secretariat. (pp 249-265). [Latin America; agriculture]

Banco Mundial. 2002. Desarrollo en riesgo debido a la degradación ambiental. Comunicado de prensa No. 2002/112/S.

Barbosa, R.I.; Fearnside, P.M. 1999. Acta Amazonica 29, 505.

Barros V. 2005. Adaptation to climate trends: lessons from the Argentine experience. AIACC adaptation synthesis.

Bazán, Nickisch, M. : Sistemas de captación y manejo de agua. INTA. Est. Exp. Santiago del Estero. Available online at www.inta.gov.ar/santiago/info/documentos/agua/0001res_sistemas.htm

Berger, L.; Speare, R.; Daszak, P.; Green, D.E.; Cunningham, A.A.; Goggin, C,L.; Slocombe, R.; Rgan, M.A.; Hyatt, A.D. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forest of Australia and Central America. Proceedings of the National Academy of Sciences of the United States of America 95:9031-9036.

Berri Guillermo J., Germán I. Bertossa. 2004. The influence of the tropical and subtropical Atlantic and Pacific Oceans on precipitation variability over Southern Central South America on seasonal time scales. International Journal of Climatology. Vol 24 (4). [Latin America; climate variability]

Bidegain M, R.M. Caffera, F. Blixen, V. Pshennikov, J.J. Lagomarsino, E.A. Forbes, G.J. Nagy, 2005. Tendencias Climáticas, Hidrológicas y Oceanográficas en el Río de la Plata y Costa Uruguaya. In: El Cambio Climático en el Río de la Plata. Eds. Barros V., A. Menéndez, G.J. Nagy, Capítulo 14: 137-143, CIMA-CONICET-UBA, Buenos Aires, Mayo, 2005.

Bidegain, M. and I. Camilloni: Climate change scenarios for southeastern South America. [Available online from http://www.aiaccproject.org/meetings/Buenos_Aires_04

/Day2/Aug_25Bidegain.ppt]

Branes, R., 2001. El desarrollo del derecho ambiental latinoamericano y su aplicacion. PNUMA, Mexico DF Mexico.

Briceño, S. 2002. *Gender mainstream in a disaster reduction*. Panel presentation. Commision in the Status of Women, March 2002. Geneva. Secretariat of the International Strategy for Disease Reduction.

Buddemeier, R.W., A.C. Baker, D.G. Fautin, and J.R. Jacobs. 2004. In press. The adaptive hypothesis of bleaching. In: *Coral* . In: Coral Reefs and Global Climate Change. Potential Contributions of Climate Change to Stresses on Coral Reef Ecosystems. Pew Center on Global Climate Change, 56p. 2004.

Burrowes, P.A., Joglar, R.L. and Green, D.E. 2004. Potential causes for amphibian declines in Puerto Rico. *Herpetologica* 60: 141–154.

Cahoon, D.R., and Hensel, P., 2002: *Hurricane Mitch: a regionalperspective on mangrove damage, recovery and sustainability*:USGS Open File Report 03-183, 31 p.

Callede *et al*., 2004. [Latin America; current trend]

Campos, J.J.; Calvo, J.C. 2000. Compensation for environmental services from mountain forest. In M. Agenda (ed.), Mountain of the World: Mountain Forest and Sustainable Development. Berne, Mountain Forum.

Canteros B.I., Zequeira L., Lugo J. [Latin America; ENSO, crop deseases]

Canziani O, L.J. Mata: The fate of indigenous populations under climate change. The Andean Communities. COP-10, Buenos Aires, December 2004.

Canziani O. Personal communication.

CAPP (Centro de Análisis de Políticas Públicas), 2000: *Informe País. Estado del Medio Ambiente en Chile - 1999*, Centro de Análisis de Políticas Públicas, Universidad de Chile, Santiago, Chile.

Carabias, J. and H. Guerrero, 1996. Que se entiende por desarrollo sustentable. In Energia Ambiente y Desarrollo Sustentable (El caso de Mexico) Garcia-Colin, L. and M. Bauer. Coord. 25-46. El Colegio Nacional, PUE UNAM, Mexico.

Carey, M. Living and dying with glaciers: people historical vulnerability to avalanches and outburst flood in Peru. Global and Planetary Change, Elsevier, 2004.

Cavazos, Tereza, David Rivas. 2004. Variability of extreme precipitation events in Tijuana, Mexico. Climate Research, Vol.: 25 (3). [Latin America; extreme events]

Centro Panamericano de Ingeniría Sanitaria y Ambiental (CEPIS). 2001. *Water and Health: A toast for Life*. Inter-American Water Day. PAHO. http://www.cepis.ops-oms.org/bvsadiaa/i/2001/dia2001.pdf

CEPAL-PNUD, 2000: Los efectos socioeconómicos de las inundaciones y deslizamientos en Venezuela en 1999. Documento LC/MEX/L.421. Febrero 2000.

Cerda A. Aggregate stability against water forces under different climates on agriculture land and scrubland in southern Bolivia. Soil & Tillage Research 57 (2000) 159-166. [Latin America; future impacts, soils].

CIDEIBER (Centro de Información y Documentación Empresarial sobre Iberoamérica), 1999: *Chile. Actividades del sector primario. Sector pesquero*, CIDEIBER, Madrid, Spain.

Cochrane, M. (in press). Spreading like Wildfire: Tropical Forest Fires in Latin America and the Caribbean - Prevention, Assessment and Early Warning. Mexico City. United Nations Environment Programme.

Cohen, J. E., C. Small, A. Mellinger, J. Gallup, J. Sachs, 1997: "Estimates of Coastal population", in *Science*, Washington, D.C., US, volume 278, 1211-1212.

Collado J., Villalobos A. 2001. Comparative assessment of agricultural uses of ENSO-based climate forecast in Argentina, Costa Rica and Mexico. (pp16). [Latin America; current adaptation, agriculture]

Comunidad Andina de Naciones. 2004. *Estrategia Andina para la Prevención y Atención de Desastres*. Secretaría General. Decimotercera Reunión Ordinaria del Consejo Andino de Ministros de Relaciones Exteriores. 10 de julio del 2004. Quito, Ecuador.

Conde, C., 2003: Cambio y Variabilidad Climáticos. Dos Estudios de Caso en Mexico., Posgrado en Ciencias de la Tierra., Posgrado en Ciencias de la Tierra. UNAM.

Conde, C., R. Seiler, and M. Vinocur, 2004: Agriculture impacts of cimate in Mexico and Argentina.

Conde, J. E. 2001. The Orinoco River Delta, Venezuela. Pages 61 – 70. in: U. Seeliger, and B. Kjerfve, editors, Coastal marine ecosystems of Latin America. Ecological Studies 144. Springer-Verlag, Berlin.

Confalonieri, U. 2003. Variabilidade climática, vulnerabilidade social e saúde no Brasil. *Terra Livre* I(20), 193-204.

Contreras-Hermosilla, A. 2000. The Underlyng Causes of Forest Decline. Occasional Paper No. 30. Jakarta, Center for International Forestry Research.

Chen, A., C. Rhoden, and A. Owino: Climate scenario and uncertainties in the Caribbean. [Available online from http://www.aiaccproject.org/meetings/ Buenos_Aires_04/Day2/Aug_25Chen.ppt.]

De Garín, A. and R. Bejarán. 2003. Mortality rate and relative strain index in Buenos Aires city. *Int J Biometeorol* 48: 31-36.

de Siqueira Otávio João Wachholz, Sílvio Steinmetz, Mauro Fernando Ferreira, Andréia Castro Costa e Marcos Antônio Wozniak. Mudanças climáticas projetadas através dos modelos giss e reflexos na produção agrícola brasileira. Revista Brasileira de Agrometeorologia, Santa Maria, v. 8, n. 2, p. 311-320, 2000. [Latin America; future impacts, agriculture]

Dinerstein, E.; Olson, D.; Graham, D.; Webster, A.; Primm, S.; Bookbinder. M.; Ledec, G. 1995. A conservation Assessment of the Terrestrial Ecoregions of Latin America an the Caribbean. Washington DC. World Bank.

Doyle, M., Barros, V., 2002. Midsummer low-level circulation and precipitation in subtropical South America and related sea surface temperature anomalies in the South Atlantic. Journal of Climate 15, 3394-3410. [Latin America; climate variability]

Eakin, H. Smallholder maize production and climatic risk: A case study from Mexico. Climatic Change 45: 19-36, 2000. [Latin America; adaptation constrains, agriculture]

Economic Commission for Latin America and the Caribbean (ECLAC). 2004. Social Panorama of Latin America. United Nations. http://www.cepal.org/publicaciones /DesarrolloSocial/0/LCL2220PI/PSI2004_Summary_Web.pdf

Ecoplata, 2001: Recursos naturales y actividades económicas en la zona costera del Río de la Plata, Montevideo, Uruguay.

Environmental Protection Agency. 2005. Global Earth Observation System of Systems. http://www.epa.gov/geoss/

EPA 2001. [Latin America; climate variability]

Espinoza, R., P. Via, L.M. Noriega, A. Johnson, S.T. Nichol, P.E. Rollin, R. Wells *et al*. 1998. Hantavirus pulmonary syndrome in a Chilean patient with recent travel in Bolivia. *Emerg Infect Dis* 4(1), 93-95.

Evenson R. E., Denisard C.O. 2004. Agricultural technology change and climate change. www.som.yale.edu/faculty/nok4/files/seminar/evenson.pdf. [Latin America; current adaptation, agriculture]

FAO. 2003. Situación de los bosques 2003. FAO. Roma, Italia. pp. 12-31

FAO. 2004b. La participación de la comunidades en la gestión forestal es decisiva para reducir los incendios. FAO: Sala de prensa: Ultimas noticias: 2004.

FAO. 2001. Global Forest Resources Assessment 2000. FAO Forestry Paper 140. Rome, Food and Agricultural Organization http://www.fao.org/forestry/fo/fra (Geo-2-399)

FAO. 2001b. Variabilidad y cambio del clima: Un desafío para la producción agrícola sostenible. 16° periodo de sesiones FAO, Roma, 26-30 de marzo de 2001. Roma, Italia. 13 p.
FAO. 2002. El cambio climático y los bosques. Boletín electrónico Julio 2002. www.ecosur.net/cambio_climatico_y_los_bosques.html
FAO. 2004a. 28ava Conferencia regional de la FAO para América Latina y el Caribe. Seguridad Alimentaria como estrategia de Desarrollo rural. Ciudad de Guatemala (Guatemala), 26 al 30 de abril de 2004.
FAO. 2005. Cattle ranching is encroaching on forests in Latin America Causing severe environmental degradation - FAO model predicts land use up to 2010. http://www.fao.org/newsroom/en/news/2005/102924/index.html
FAOSTST. 2001. FAOSTAT Statistical Database. Food and Agriculture Organization. http://www.fao.org (GEO 2, 1999).
Fay,M., Ghesquiere,F. and Solo,T.,2003: Natural disasters and the urban poor. IRDB."en breve", 32, October 2003, 4p.
Fearnside, P.M. 2001. Soth American Natural Ecosystems, Status of. Encyclopidia of Biodiversity. Volume 5: 345-359.
Francou, B., M. Vuille, *et al*. (2003). "Tropical climate change recorded by a glacier in the central Andes during the last decades of the twentieth century: Chacaltaya, Bolivia, 16 S." Journal of Geophysical Research 108(doi: 10.1029/2002JD002959): 12.
Francou, B.; Ramírez, E.; Cáceres, B.; Mendoza, J. 2000. " Glacier evolution in the Tropical Andes during the last decades of the 20th Century: Chacaltaya, Bolivia, and Antizana, Ecuador". Ambio, vol. 29, Nº 7, Nov. 2000.
Gadgil M *et al*, Indigenus knowledge for Biodiversity Conservation, Ambio, Vol Xxii, Nº 2-3, May 1993.
Gagnon, A.S., A.B.G. Bush, and K.E. Smoyer-Tomic. 2001. *Dengue epidemics and the El Niño-Southern oscillation*. *Climate Res* 19: 35-43.
Gagnon, A.S., K.E. Smoyer-Tomic, and A. Bush. 2002. The El Niño southern oscillation and malaria epidemics in South America. *Int J Biometeorol* 46, 81-89.
García Vargas, J. : El fenómeno El Niño en Peru y Bolivia. Experiencias en participación local.Agosto 2003. Available on line at www.itdg.org.pe/archivos/desastres /memoria%20fen.pdf
Gardner, T.A., I.M. Côté, J.A. Gill, A. Grant, and A.R. Watkinson. 2003. Long-term region-wide declines in Caribbean corals. *Science* 301: 958-960.
Gay, C. and M. Estrada, 2001. Climate change: Sustainable Development, Equity and Market Mechanisms. World Resource Review Vol. 13 (3) 397-405.
GEO 2003: *Latin America and the Caribbean: Environment Outlook 2003*. UNEPUnited Nation Environment Programme. UNEP Regional Office for Latin America and the Caribbean, Mexico. Costa Rica, 366p.
GEO-3. 2003. Global Environment Outlook, pasado, presente y futuro. UNEP http://www.unep.org/geo3
Gitay, H.; Suárez, A.; Watson, R.; Dokken, D.J. 2002. Climate Change and Biodiversity. IPCC Technical Paper V. Geneva. 85 p.
Githeko, A., and A. Woodward. 2003. International consensus on the science of climate and health: The IPCC Third Assessment Report. In: Climate Change and Human Health. Risks and Responses (Michael, A.J., D.H. Campbell-Lendrum, C.F. Corvalán, K.L. Ebi, A. Githeko, J.D. Scheraga, and A. Woodward (eds.)). WHO/WMO/UNEP. Pp. 43-60
Glynn, P.W., Maté J.L., Baker, A.C. & Calderon, M.O. ,2001: Coral bleaching and mortality in Panama and Ecuador during the 1997–98 El Niño-Southern Oscillation event: spatial/temporal patterns and comparisons with the 1982–1983 event. *Bulletin Marine Sciences* 69: 79–109.

Gonzales, J.O. 2005 Promoting Social Adaptation to Climate Change and Variability through Knowledge, Experiential and Co-learning NetworksIn Bolivia. Report. Shell Foundation. La Paz, Bolivia. 23 p.
Grasses, J.P., J. Amundaray, A. Malaver, P. Feliziani, L. Franscheschi and J. Rodríguez. 2000. Efectos de las lluvias caídas en Venezuela en diciembre de 1999. CAF-PNUD. CDB Pub. Caracas. 224p.
Guzman, H.M., C. A. Guevara and O. Breedy, 2004: Distribution, diversity, and conservation of coral reefs and coral communities in the largest marine protected area of Pacific Panama (Coiba Island) *Environmental Conservation* , 31:111–121.
Hacon S. 2004. Personal communication.
Haines, A., A.J. McMichael, and P.R. Epstein. 2000. Environment and health: 2. Global climate change and health. *JMAC* 163(6), 729-734.
Haines, A., and J.A. Patz. 2004. Health effects of climate change. *JAMA* 291(1), 99-103.
Hales, S., N. de Wet, J. Maindonald, and A. Woodward. 2002. Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. *Lancet* 360, 830-834.
Hoggarth, D. D., K. Sullivan, L. Kimball, 2001: *Latin America and the Caribbean Coastal and Marine Resources, background paper prepared for GEO-3*, United Nations Environment Programme Regional Office for Latin America and the Caribbean, Mexico, D.F., Mexico.
Holt Gimenez E. 2002. Measuring farmers'agroecological resistance after Hurricane Mitch in Nicaragua: a case study in participatory, sustainable land management impact monitoring. *Agriculture, Ecosystems and Environment* 93: 87-105. [Latin America; current adaptation, agriculture].
Hopp, M.J., and J.A. Foley. 2001. Global-scale relationships between climate and the dengue fever vector, *Aedes aegypti*. *Climate Change* 48, 441-463.
http://www.crid.or.cr/crid/CD_EIRD_Informa/ing/No2_2001/index_No2e.htm
Hunt B.G. and T.I Elliot. A simulation of the Climatic Conditions Associated with the Collapse of the Maya Civilization. Climate Change, Volume 69, Nº 2-2, 2005.
Iaccarino M. Science and Culture, Reports, Vol 4 Nº 3, 2003. EMBO-European Molecular Biology Organization.
IDEAM, 2004: *Boletín Julio 12 al 16 de 2004.* (en lugar de INEA)
IIASA y FAO. 2002. Global agro-ecological assessment for agriculture en the 21st century. G. Fischer, M. Shah, H. Van Velthuizen and F.O. Nachtergaele. Luxenburg, Austria and Roma.
INE, SEMARNAT (Instituto Nacional deEcología; Secretaría de Medio Ambiente y Recursos Naturales), 2001: *México. Segunda comunicación nacional ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático*, INE and SEMARNAT, Mexico, D.F., Mexico.
INPE (INSTITUTO NACIONAL DE PESQUIZA ESPACIAIS); MMA (MINISTERIO DE MEIO AMBIENTE DO BRASIL 2005. Deforestation in Amazonia has its second worst recorded history. www.amazonia.org.br.
INPE (INSTITUTO NACIONAL DE PESQUIZA ESPACIAIS); MMA (MINISTERIO DE MEIO AMBIENTE DO BRASIL 2005. Deforestation in Amazonia has its second worst recorded history. www.amazonia.org.br.
International Center for Research on El Niño Phenomenon. 2005. http://www.ciifen-int.org/index.php?newlang=english
International Disaster Database (IDD*), 2005*. EM-DAT. OFDA/CRED www.em-dat.net consulted on April 12, 2005.
IPCC 2001. TAR
IPCC TAR WG II SPM, paragraphs 2.2 and 2.8, Climate Change 2001.

IPGRI, International Plant Genetic Resources Institute Symposium on " Managing crop diversity in traditional agrosystems. Mexico,February2002.
Jones Peter G., Philip K. Thornton. The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global Environmental Change 13 (2003) 51-59. [Latin America; future impacts, agriculture]
Keenan, H.T., S.W. Marshall, M.A. Nocera, and D.K. Runyan. 2004. Increase incidence of inflicted traumatic brain injury in children after a natural disaster. *Am J Prev Med* 26(3), 189-193.
Ko, A., R.M. Galvão, D. Ribeiro, C.M. Dourado, W.D. Johnson Jr., and L.W. Riley. Urban epidemic of severe leptospirosis in Brazil, Salvador. Leptospirosis Study Group. *Lancet* 354(9181), 820-825.
Kovacs, J.M. 1999. Assessing mangrove use at the local scale. Landscape and Urban Planning 43:201-208.
Kovats, R.S., M.J. Bouma, S. Hajat, E. Worral, and A. Haines. 2003. El Niño and health. *Lancet*. http://image.thelancet.com/extras/02art5336web.pdf
Krol M.S., van Oel P. Integrated assessment of water stress in Ceará, Brazil, under Climate change forcing. [Latin America; future impacts]
La Cultura Cajamarca, Website Lo nuevo to enjoy Peru, July 2005.
La Nación, El calentamiento global espanta a los dioses andinos. Buenos Aires,18 Junio 2005.
La Nación. Buenos Aires. 13 de marzo de 2002
La Nación. Buenos Aires. 30 de mayo de 2003
Laurance, W.F.; Cochrane, M.A.; Bergen, S.; Fearnside, P.M.; Delamonica, P.; Barber, C.; D'Angelo, S.; Fernandes, T. 2001. Environment – The future of the Brazilian Amazon. Science. 291, 438-39.
Laurance, W.F.; Fearnside, P.M.; Albernaz, A.K.M.; Vasconcelos, H.L.; Ferreira, L.V. 2005. Response Camara *et al.*, 2005 – The future of the Brazilian Amazon. Science. 307, 1043-44. www.sciencemag.org
Lieshout van, M, R.S. Kovats, M.T.J. Livermore, and P. Martens. 2004. Climate change and malaria: analysis of the SRES climate and socio-economic scenarios. *Global Environmental Change* 14, 87-99.
Maarten Dros, J. 2004. Managing the Soy Boom; two scenarios of soy production expansion in South America. Commissioned by WWF Forest Conversion Initiative. AID Environment. 67p.
Magaña, R.V., and J.L. Vázquez. 2001 . The use of El Niño forecasting in Latin America and the Caribbean. Disaster in the Region. ISDR Informs – Latin America and the Caribbean. 2: 8.
Magrin, G.O., M. I. Travasso. 2002. An Integrated Climate Change Assessment from Argentina (Chapter 10) *In*: Effects of Climate Change and Variability on Agricultural Production Systems. Otto Doering III; J.C.Randolph; J.Southworth and R.A.Pfeifer (Eds). Kluwer Academic Publishers, Boston. pp193-219. [Latin America; climate variability agriculture]
Magrin, G.O., M.I. Travasso, G.R. Rodríguez. 2003. Changes in climate and crops production during the 20^{th} century in Argentina. Aceptado en Climatic Change. [Latin America; climate variability agriculture]
Magrin, G.O., M.I. Travasso, G.R. Rodríguez. 2005. Changes in climate and crops production during the 20^{th} century in Argentina. *Climatic Change*
Magrin, G.O.; M.I. Travasso. 2001. Economic value of ENSO-based Climatic Forecasts in the Agricultural Sector of Argentina. pp. 139-140. In: Proc. 2nd International Symposium "Modelling Cropping Systems". Florence, Italy. [Latin America; climate variability agriculture]
Malheiros, J.O. 2004. 17 puntos que ayudan a explicar lo que es la desertificación, la convención de la ONU y el proceso de construcción del PAN-CCD Brasilero. RIOD

BRASIL. 11p. http://ww.aspan.org.br/riodbrasil/pt/index.htm

Martens, P., and A.J. McMichale. 2001. Vector-borne diseases, development and climate change: An editorial comment. *Integrated Assessment* 2, 171-172.

Martin G.J. Ethnobotany, a Methods Manual, Earthscan, 2004.

McMichael, A.J. 2003. Global climate change and health: and old story writ large. In: Climate Change and Human Health. Risks and Responses. In: Climate Change and Human Health. Risks and Responses (Michael, A.J., D.H. Campbell-Lendrum, C.F. Corvalán, K.L. Ebi, A. Githeko, J.D. Scheraga, and A. Woodward (eds.)). WHO/WMO/UNEP. Pp. 1-17.

Medina, E.; H. Fonseca; F. Barboza, and M. Francisco. 2001. Natural and man-induced changes in a tidal channel mangrove system under tropical semiarid climate at the entrance of the Maracaibo lake (Western Venezuela). Wetlands Ecology and Management 9:233-243.

Meléndez, Ó. 2004. Personal communication

Mendoza and Francou, 2004

Mesquita, A, 2000. Sea level variations along the Brazilian coast: A short review. Brazilian Symposium on Sandy Beaches: 15 p.

Millennium Ecosystem Assessment. 2005. Living beyond our means: Natural assets and human well-being. 22p. www.maweb.org

Miller, L. B.C. Douglas, B. Cheney (2004). Sea Level Observing System Issues. www.oco.noaa/docs/presentation_miller.ppt.

Ministerio de Medio Ambiente y Recursos Naturales (MARENA). 2001. Primera Comunicación Nacional. Managua, Nicaragua.

Ministry of Science and Technology. 2004. Brazil´s initial national communication to the United Nations Framework Convention on Climate Change. Brasilia.

Mittermeier, R.A.; Myers , N.; Mittermeier, C.G. 1999. Hotspots. Earth´s Biologically Richest and Most Endangered Terrestrial Ecoregions. Mexico City, CEMEX and Conservation International.

Moutinho, P.; Santilli, M.; Schwartzman, S. 2004. Compensated reduction of deforestation. Amazon Intitute of Environmental Research. www.ipam.org.br

Moutinho, P.; Santilli, M.; Schwartzman, S. 2004. Compensated reduction of deforestation. Amazon Intitute of Environmental Research. www.ipam.org.brMARNR. Ministerio del Ambiente y los Recursos Naturales (MARN). República Bolivariana de Venezuela. Vice-Ministerio de Aguas. Informe sobre lluvias de Febrero 2005.

MRI-PC. Ministerio de Relaciones Interiores-Defensa Civil y Prevención de Desastres. República Bolivariana de Venezuela Informe sobre las lluvias de Febrero y Marzo 2005.

Morales R., V. M., C. Millán, J.L. Pérez., 2002: 2002. Efectos del Calentamiento Global en la Disponibilidad de los Recursos Hidráulicos de Mexico. Proyecto HC-0112. CAN, IMTA, CCA -UNAM. 151 pp. (http://hdr.undp.org/ reports/global/2004/pdf / hdr04. HDI.pdf)

Moran, A.E., 1996. Situación de la politica ambiental en algunos paises de America Latina. Contribuciones Ciedla 1, 7-17.

Meza, F. J.., D. S. Wilks , S.J. Riha , J. R. Stedinger 2003. Value of perfect forecasts of sea surface temperature anomalies for selected rain-fed agricultural locations of Chile. Agricultural and Forest Meteorology ,116:117–135. [Latin America; adaptation, agriculture]

Messina *et al*. 1999 "El fenómeno ENSO: Su influencia en los sistemas de producción de girasol, trigo y maíz en la región pampeana. Análisis retrospectivo y evaluación de estrategias para mitigar el riesgo climático". Tesis de Maestria UBA.

Moschini *et al*., xx

Myers , N.; Mittermeier, R.A.; Mittermeier, C.G.; Da Fonseca, G.A.B.; Kent,J. 2000. Biodiversity hotspots for conservation priorities. Nature. 403, 853-58.

Nagy GJ, A. Ponce,V. Pshennikov, R. Silva, E.A. Forbes, R. Kokot (2005). Desarrollo de la

Capacidad de Evaluación de la Vulnerabilidad Costera al Cambio Climático: Zona Oeste de Montevideo como caso de estudio. In: El Cambio Climático en el Río de la Plata. Eds. Barros V., A. Menéndez, G.J. Nagy, Capítulo 18: 173-180, CIMA-CONICET-UBA, Buenos Aires, Mayo, 2005.

Nepstad, D.C.; Moreira, A.G.; Alencar, A.A. 1999. Flames in the Rain Forest: Origins, Impacts and Alternatives to Amazonian Fire. Pilot Program to Conserve the Brazilian Rain Forest, Brasilia (Brazil).

Nials F.L. *et al*. Field Museum Nat Hist Bull,50(7) and 50(8), 1979.

Oldeman, L.R. 1994. The global extent of soil degradation. In Greenland, D.J. and Szaboles, T. (ed.) Soil Resilience and Sustainable Land Use. Wallingford, Commonwealth Agricultural Bureau International. http://www.isric.nl/GLASOD.htm

Pan American Health Organization*. 2002. RAVREDA-AMI: PAHO's* Amazon Network for the Surveillance of Antimalarial Drug Resistance *(RAVREDA)*

Pan American Health Organization. 2003. Status Report on Malaria Programs in the Americas (Based on 2002 data). 44th Directing Council 55th Session of the Regional Committee. Washington, D.C., USA, 22-26 September 2003. CD44/INF/3 (Eng.) 17 September 2003.

Parry M.L., C. Rosenzweig, A. Iglesias, M. Livermore, G. Fischer. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environmental Change 14 (2004) 53-67. .[Latin America; adaptation]

Pearce, F., 2003: Arsenic´s fatal legacy grows. *New Scientist*. 9 August, 4-5.

Phillips. O.L.; Vásquez , L.; Arroyo, L.; Baker, R.; Killeen, T.; Lewis, S.L.; Malhi, Y. 2002. Increasing dominance of large lianas in Amazonian forests. Nature 418: 770-774.

Pounds, J.A. and Crump, M.L. 1994. Amphibian decline and climate disturbance: the case of the golden toad and the harlequin frog. Conservation Biology 8:72-85.

Pounds, J.A., Fogden, M.P.L. and Campbell, J.H. 1999. Biological response to climate change on a tropical mountain. *Nature* 398: 611–615.

Patz, J.A. 2004. Global warming. Health impacts may be abrupt as well as long term. *BMJ* 328, 1269-1270

Patz, J.A., D. Engelberg, and J. Last. 2000. The effects of changing weather on public health. *Annu Rev Public Health* 21, 271-307.

Permanent Commission of South Pacific. 2005. http://www.cpps-int.org/english/

Peterson L.C., G.H.Haug, Climate and the collapse of Maya Civilization. Amercian Scientist, July-august 2005.

Pini, N.C., A. Resa, G. Del Jesús Laime, G. Lecot, T.G. Ksiazek, S. Levis, *et al*. 1998. Hantavirus infection in children in Argentina. *Emerg Infect Dis* 4(1), 85-87.

Poveda, G.J., N.E. Graham, P.R. Epstein, W. Rojas, D.I. Vélez, M.L. Quiñónez, and P. Martnes. 1999. *Climate and ENSO variability associated to malaria and dengue fever in Colombia*. In: 10th Symposium on Global Change Studies, Dallas, January 10-15. American Meteorological Society, Boston. P. 173-176.

Poveda, G.J., W. Rojas, M.L. Quiñones, D.I. Vélez, R.I. Mantilla, D. Ruiz, J.S. Zuluaga, and G.L. Rua. 2001. Coupling between annual and ENSO theme scales in the malaria climate association in Colombia. *Environ Health Perspect* 109 (5), 489-493

PNUMA y CMNUCC, 2003. Cambio climático: Compendio informativo. PNUMA y CMNUCC, Traducido por la Unidad de Cambio Climático de Uruguay, Dirección Nacional de Medio Ambniente. 70 p.

Pinto Hilton S., Eduardo D. Assad, Jurandir Zullo Jr e Orivaldo Brunini. Mudanzas climáticas. O aquecimento global e a agricultura. http://www.comciencia.br/ [Latin America; current trends, future impacts coffe]

Podesta Guillermo, David Letson, Carlos Messina, Fred Royce, R. Andres Ferreyra, James Jones, James Hansen, Ignacio Llovet, Martin Grondona, James J. O'Brien. Use of

ENSO-related climate information in agricultural decision making in Argentina: a pilot experience. Agricultural Systems 74 (2002) 371-392.

Ramirez, 2003

Ramirez, E., B. Francou, *et al*. (2001). "Small glaciers disappearing in the tropical Andes: a case study in Bolivia: Glaciar Chacaltaya (16 S)." Journal of Glaciology 47(157): 187-194.

Ramos Mañé C, Giordano S, Víctora C, 1998: Development of climate change action plans in Uruguay. Final report of the second phase of the Uruguay Climate Change Country Study. Comisión Nacional sobre el Cambio Global, Montevideo, Uruguay.

Regional Disaster Information System. 2005. http://www.crid.or.cr/crid/esp/sistema_informacion_desastres.html

República de Bolivia. Primera Comunicación Nacional sobre cambio Climático. 2000. www.climate.org/CI/latam.shtml revised on July 12 2005

República de Colombia. Primera Comunicación Nacional sobre cambio Climático. 2001. www.climate.org/CI/latam.shtml revised on July 12 2005.

República de Costa Rica. Primera Comunicación Nacional sobre cambio Climático. 2000. www.climate.org/CI/latam.shtml revised on July 12 2005.

República de Chile. Primera Comunicación Nacional sobre cambio Climático. 2000. www.climate.org/CI/latam.shtml revised on July 12 2005.

República del Ecuador. Primera Comunicación Nacional sobre cambio Climático. 2000. www.climate.org/CI/latam.shtml revised on July 12 2005.

República de Guatemala. Primera Comunicación Nacional sobre cambio Climático. 2001. www.climate.org/CI/latam.shtml revised on July 12 2005

República de Guyana. Primera Comunicación Nacional sobre cambio Climático. 2002. www.climate.org/CI/latam.shtml revised on July 12 2005

República de Panamá. Primera Comunicación Nacional sobre cambio Climático. 2000. www.climate.org/CI/latam.shtml revised on July 12 2005.

República del Perú. Primera Comunicación Nacional sobre cambio Climático. 2000. www.climate.org/CI/latam.shtml revised on July 12 2005.

República del Uruguay. Segunda Comunicación Nacional sobre cambio Climático. 2004. M.V.O.T.M.A. Proyecto URU/00/G31, GEF-UNDP.

Rodriguez-Acevedo, R. 2001. Sustainable arrangement of tourism territory in conditions of high physiographic and environmental vulnerability: Study case Vargas State-Venezuela. The Bureau of Tourism Research (BTR) Australia. Universidad Simón Bolívar-Venezuela (Abstract derived from current research).

Ron, S.R., Duellman, W.E., Coloma, L.A. and Bustamante, M.R. 2003. Population decline of the Jambato Toad *Atelopus ignescens* (Anura: Bufonidae) in the Andes of Ecuador. *Journal of Herpetology* 37: 116–126.

Romieu, I., F. Meneses, S. Ruiz, J.J. Sienra, J. Huerta, et al. 1996. Effects of air pollution on the respiratory health of asthmatic children living in Mexico city. *Am J Respir Crit Care Med* 154(2), 300-307.

Ronchail J., Bourrel L., Cochonneau G., Vauchel P., Phillips L., Castro A., Guyot J.L., Oliveira E. 2004. Inundations in the Mamoré basin (south-western Amazon-Bolivia) and sea-surface temperature in the Pacific and Atlantic Oceans. Journal of Hidrology XX (2004), 1-16. [Latin America; extreme events].

Rosenzweig *et al*., 2004

Travasso, M.I.; G.O. Magrin and G. R. Rodríguez. 2003 (a). Crops yield and climatic variability related to ENSO and South Atlantic Sea Surface Temperature in Argentina. Preprint Volume The Seventh International Conference on Southern Hemisphere Meteorology and Oceanography (7ICSHMO). Wellington, New Zealand, 24-28 March 2003. pp. 74-75. [Latin America; climate variability, crops yield]

Travasso, M.I.; G. O. Magrin and G. R. Rodríguez. 2003 (b). Relations between Sea Surface Temperature and crop yields in Argentina. *Int. J. Climatol*. 23: 1655-1662. [Latin America; climate variability, crops yield]
Sedjo, R.; Sohngen, B. 1998. Impacts of Climate Change on Forests (Washington. D.C.: Resources for the future. 1998).
Schaeffer-Novelli, Y., G. Cintron-Molero and M.L.G. Soares, 2002: Mangroves as indicators of sea level change in the muddly coasts of the world. In: *Muddy Coasts of the World; Processes, Deposits and Function* [Healy, T, Wang, Y. and Healy, J.A. (eds.)] Elsevier Science, 245-262.
Shinn, E.A., G.W. Smith, J.M. Prospero, P. Betzer, M.L. Hayes, V. Garrison, and R.T. Barber, 2000: African dust and the demise of Caribbean coral reefs. *Geophysical Research Letters* 27: 3029-3032.
Sullivan, K., G. Bustamente, 1999: *Setting geographic priorities for marine conservation in Latin America and the Caribbean*, The Nature Conservancy, Arlington, Virginia, US.
Suman, D. O., 1994. *Status of mangroves in Latin America and Caribbean Basin. In: Suman*, D.O., ed., El Ecosistema de manglar en America Latina y La Cuenca delCaribe: su manejo y conservacion. Miami, Fla, University of Miami. p. 11-20.
Szlafsztein, C.F, 2005. Climate Change, Sea-level rise and Coastal Natural Hazards: A GIS-Based Vulnerability Assessment, State of Pará, Brazil. Human Security and Climate Change, An International Workshop, Oslo, June 2005, GECHS-UNEP-IHDP-CICERO-CSCW.
Tol, R.S.J., and H. Dowlatabadi. 2001. Vector-borne diseases, development & climate change. *Integrated Assessment* 2, 173-181.
Thomas, C.D.; Cameron, A.; Green, R.E.; Bakkenes, M.; Beaumont, L.J.; Collinggham, Y.C.; Erasmus, B.F.N.; Siqueira de, M.F.; Grainger, A.; Hannah, L.; Hughes, L.; Huntley,B.; Jaarsveld Van, A.S.; Midgley, G.F.; Miles, L.; Ortega-Huerta, M.A.; Peterson, A.T.; Phillips, O.L.; Williams, S.E. 2004. Extinction risk from climate change. Nature/Vol 427/8 Jannuary 2004/www.nature.com/nature
Ubiratan Moreira dos Santos, J., I. de Sousa Gorayeb, M. de Nazaré do Carmo Bastos, 1999. Avaliação e ações prioritarias Pará a conservação da biodiversidade da zona costeira e marinha. Diagnóstico da situação Pará a conservação da biodiversidade da zona costeira e marinha amazônica. Ministerio do Meio Ambiente and Projecto de Conservação e Utilização Sustantável da Diversidadie Biológica Brasiliera. Belém, Pará, Brazil.
UNCLOS (United Nations Convention on the Law of the Sea), 2001: Status of the United Nations Convention on the Law of the Sea, of the Agreement relating to the implementation of Part XI of the Convention and of the Agreement for the implementation of the provisions of the Convention relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. Table recapitulating the status of the Convention and of the related Agreements, as at 20 April 2005 http://www.un.org/ Depts/los/convention_agreements/convention_overview_fish_stocks.htm
UNEP (United Nations Environmental Program), 2000: GEO Latin America and the Caribbean: Environment Outlook 2000, UNEP Regional Office for Latin America and the Caribbean, Mexico, D.F., Mexico.
UNEP-CEP (United Nations Environment Programme; Caribbean Environment Programme), 2003: *Convention and Protocols Status Page,* UNEP and CEP, Kingston, Jamaica.
UNEP/ROLAC (United Nations Environment Programme Regional Office for Latin America and the Caribbean), 2002: *Latin American and Caribbean Initiative for Sustainable Development,* First Special Meeting of the Forum of Ministers of the Environment of Latin America and the Caribbean, Johannesburg,
UNEP. 2001. World Atlas of Coral Reefs. United Nations Environment Programme. Nairobi,

Kenya.
UNEP & WCMC. 2001. GEO3 Endangered Animals Snapshot. United Nations Environment Programme - World Conservation Monitoring Center http://valhalla.unep-wcmc.org/isdb/geo3.cfm 10 October 2001 (Geo-2-094).
United Nations Centre for Human Settlements. 2001. The state of the world´s cities 2001. UNCHS, Nairobi, Kenya.
United Nations Environment Programme. 2003. GEO Latin America and the Caribbean, Environment Outlook. UNEP, Mexico.
UNMSM, Universidad Nacional Mayor de San Marco, Peru, Boletín Destacados. Available online at www.unmsm.pe/Destacados/contenido.php?mver=11. Downloaded on 18 may 2005.
Villamizar, A. 2004. Informe Técnico de Denuncia sobre Desastre Ecológico en el Desparramadero de Hueque. Edo. Falcón. Presentado ante La Fiscalía General y la Defensoría del Pueblo. República de Venezuela. 25p.
Watson, R.T.; Noble, I.R.; Bolin, B.; Ravindranath, N.H.; Verardo, D.J. 2001. Special report on Land Use, Land-Use change and Forestry. IPCC. UNEP/WMO. http://www.wcmc.org.uk/trees/index.html
Windevoxhel, N., and G. Sención. 2000. Mangrove forests in Nicaragua and subtropical forest in Guatemala. In: Sustainable forest management and global climate change: selected case studies from Americas. Mohamed H.I. Dore, Rubén Guevara (Eds.), Edward Elgar Pub. Ltd. 281pp.
World Bank: "The international economy and prospects for developing countries". Global Economic Prospects 2003.
WWF. 2002. Ecuador, Peru y Bolivia amenazados por deshielo de glaciares. WWF. Ginebra (Suiza).
Williams, R.J., R.T. Bryan, J.N. Mills, R.E. Palma, I. Vera, F. De Velásquez, *et al*. 1997. An outbreak of hantavirus pulmonary syndrome in western Paraguay. *Am J Trop Med Hyg* 57(3), 274-282.
The Geological Society. 2001. Small Andean glaciers will have vanished in 15 years. http://www.geolsoc.org.uk/template.cfm?name=AndeanGlacier
Valtorta [Latin America; heat waves, milk production]
Vasquez-León Marcela, Colin Thor West, Timothy J. Finan. A comparative assessment of climate vulnerability: agriculture and ranching on both sides of the US-Mexico border. Global Environmental Change 13 (2003) 159-173. [Latin America; adaptation, agriculture]
Wehbe *et al*., 2005
Wright M , A.V.Zegarra, Machu Picchu, a civil engineering wonder, CIAS, Washington, 200?
-----------. 2000. Perceptions of environment al change in a tropical coastal wetland. Land Degradation and Development 11:209-220.
-----------; M. Blanco C., and F. Flores V. 2001. A logistic regression model of hurricane impacts in a mangrove forest of the Mexican Pacific. Journal of Coastal Research 17:30-37.