Climate change impacts on water supply and water availability in Latin America. (what is known and what is being done about it)

February 28, 2007
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Concentration of CO2 in the atmosphere during the last 650,000 years (IPCC, 2007)
Global warming has dangerous consequences
(Anticipated impacts as temperatures increase)

- 0.6°C Wholesale Coral bleaching
- 0.6°C West Antarctic losing ice
- 1.0°C Rapid retreat of tropical glaciers in the Andes
- 1.6°C Onset of melting of Greenland
- 2-3°C Onset of changes in the Amazon rainforest ecosystem
- 4°C Possible collapse of Gulf current

Source: Schellnhuber et. al., 2006
## Global GHG emissions

<table>
<thead>
<tr>
<th>Country</th>
<th>Total (BTA)</th>
<th>Ton/GDP per $Mpp</th>
<th>Ton/cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>6.9</td>
<td>720</td>
<td>24.6</td>
</tr>
<tr>
<td>EU-25</td>
<td>4.7</td>
<td>450</td>
<td>10.5</td>
</tr>
<tr>
<td>Germany</td>
<td>1.0</td>
<td>470</td>
<td>12.3</td>
</tr>
<tr>
<td>Japan</td>
<td>1.3</td>
<td>400</td>
<td>10.4</td>
</tr>
<tr>
<td>China</td>
<td>4.9</td>
<td>1020</td>
<td>3.9</td>
</tr>
<tr>
<td>India</td>
<td>1.9</td>
<td>770</td>
<td>1.9</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.5</td>
<td>590</td>
<td>5.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.8</td>
<td>680</td>
<td>5.0</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.3</td>
<td>660</td>
<td>8.1</td>
</tr>
<tr>
<td>Total</td>
<td>33.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total in LAC</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: WRI, 2006
Regional impacts
Since 1970, glaciers in the Andes (Colombia, Ecuador, Peru, Bolivia, Chile, Argentina) have lost 20% of volume with serious immediate implications for water and power supply in the region.

(Source: Thompson, 2005)
Photos of the Qori Kalis outlet glacier taken in 1978, 1991, 1998, 2000 and 2002 show the retreat of the ice margin and the development of a lake. A map showing the position of the glacier terminus indicates that in the period between 1963 and 1978, the glacier was retreating on average 4.7 meters per year. Between 2000 and 2002, the average retreat had increased to over 200 meters per year or 40 times faster, and the retreat continues.

Byrd Polar, 03/24/2005
Temperature in the Andes is increasing faster than at sea level, affecting mountain habitats and water cycles

Global warming in the American Cordillera. Projected changes in mean annual free-air temperatures between (1990 to 1999) and (2090 to 2099) along a transect from Alaska (68°N) to southern Chile (50°S), following the axis of the American Cordillera mountain range.

Source: Bradley, Vuille and Vergara, 2006
Malaria incidence in Colombia has doubled since 1970 and shows linkage to climate changes.

Grey bars are the El Niño years. (INS, 2005)

20 million people, live in areas where mean temperatures range between 15-26°C. Within this area, an increase in mean temperatures of 2°C, is likely to result in a significant increase in the exposure to Malaria and Dengue.
Temperature increase of 4°C is anticipated to lead to collapse of the Amazon Rainforest Ecosystem.

Loss of impacted system

Complete loss of Amazon rainforest with temperature increase by 2100 of 4°C

Partial loss of Amazon rainforest with temperature increase by 2100 of 2°C

Levy et al. (2004)
Since the 1980s, corals in the Caribbean have experienced unprecedented mortality with anticipated lasting impacts on fisheries and tourism (2005 event)

DHW: Heating index, above light green: mass mortality

≥ 4 DHWs → coral bleaching is expected
≥ 8 DHWs → mass bleaching and mortality are expected

(Source: A. Strong, 2006) *(Degree Heating Weeks)*
The Gulf Coast of Mexico is very vulnerable to sea level rise. (Coastal areas subject to flooding with 0.25 m increase in sea level)

(Source: Ortiz Pérez y Méndez Linares. 1999)
Hurricane intensity has steadily increased since the 1970s in tandem with sea surface temperature (landfalls in the Caribbean basin have increased).

(Source: Webster et. al. 2005)
Strategy on climate change challenges in Latin America

- Institutional strengthening, support access to information and linking science to development
  - seeking to empower the region to play an active and influential role in the international climate agenda.

- Carbon finance
  - Maximize the value and synergies of carbon revenues by tightening the linkage between these resources and local environmental and social priorities

- Adaptation
  - Priority number one; Large costs imposed on global community by emission of GHGs. Irreversible impacts and loss of environmental services require immediate action
Earth Simulator

- Runs
  - 550 ppm stabilization
- Architecture
  - 40 Teraflops!!!!!!!!!
  - Joint ocean-atmosphere model.
  - 20 x 20 km grid resolution
  - Future 5 x 5 km grid resolution
  - Program run by MRI
Scope of the Cooperation:

- training in Japan to enable efficient use of ES data
- technical assistance to interpret results
- scientific exchange
- cooperation for dissemination of results in scientific literature
- data storage
- feedback to ES for better future simulation at regional level
Comparison of actual (average 1961-1990 data from 685 weather stations) vs modeled isothermals (run AM from the Earth Simulator) and future temperatures (2080-2099)

Source: (IDEAM report on activities under Partnership MRI-WB, 2006)
Comparison of actual (average 1961-1990 data from 70 years of continuous records) vs modeled isothermals (run AM from the Earth Simulator) and future temperatures (2080-2099).
Projected change in winter precipitation in Mexico by 2080-2099
MEXICO
Extreme events projected for 2080-2099

Decrease of frost days

Increase of Tropical Nights

Increase of Tropical days
PERU
Precipitation intensity, number of consecutive dry days
What is being done?
Monitoring of glaciers and associated moorlands (US$0.8 MM, CCIG)

- Design, install and operate 12 stations in glacierized basins of immediate economic relevance.

- Remote sensing (ALOS)
  - Radiometer with 2.5m spatial resolution
  - Photogrammetry

- Support the operation of the network for three years

ALOS started observations
On October 24, 2006
Characterize climate impacts in moorlands (US$0.4 MM CCI G)

- Characterize water and carbon cycle in moorlands (paramos)
- Estimate loss of water regulation function and carbon release caused by warming
- Focus on humid moorlands in Northern Andes
Building awareness and strengthening knowledge base

- Building Awareness.
- Building monitoring and analysis capability
- Building planning capacity in institutions

MACC
Creating an enabling environment for adaptation

- Developing national policy framework for adaptation.
- Mainstreaming climate change issues into key sector activities.
- Preparation of pilot adaptation projects.
- Further strengthening of awareness and participation.
- Further strengthening of knowledge base

Adaptation

- Policy framework for adaptation in place
- Projects being implemented.
- Awareness and participation high.
- Monitoring, analysis and planning integrated throughout all national and sectoral planning.
Adaptation measures in coastal zones of the West Indies (SPA-US$7 m)

- Measures addressing impacts of climate change on coastal and near-coastal areas.
  
  - Water desalinization using wind energy for the Islands of Bequia and Union (St. Vincent & the Grenadines)
  
  - Strengthened critical coastal infrastructure in the Castries area (St. Lucia).
  
  - Approved: Sept 6, 2006
Colombia: Integrated National Adaptation Plan (US$15 m-SPA)

- Pilot adaptation measures focused on:
  - High altitude moorlands (water regulation, carbon storage, hydro-energy)
    - Riparian belts, reforestation, habitat conservation
  
  Compensate for loss of water availability in insular areas
  - Demand management, rainfall collection

- Approved: April 11, 2006
Mexico: Gulf Coast Wetlands-
US$28m-SCCF

- Assess climate impact on national water budget assessment
- Address impacts from subsidence and salination on the Gulf Coast of Mexico:
  - Restoration of natural surface drainage
  - Rationalization of water use
  - Regeneration of soil cover
  - New set asides
- Scheduled Nov 07

Source: Ortiz Pérez y Méndez Linares, 1999.
Adaptation to climate impacts in Glaciarized basins (Bolivia, Ecuador, Peru) - SCCF, $32 million

- Water supply
  - Development of alternative sources
  - Demand management
  - Engineered storage

- Energy supply
  - Diversification of supply

- Agriculture
  - Alternative crops,
  - Advanced irrigation systems

Scheduled for GEF approval by June 07
Contribution of glacier fusion at Humboldt station (Antizana), daily basis

Source: Cartier, 2007
Projected change in glacier run off as a function of warming rate
Rationale

- Recent research shows that climate change will be even more pronounced in high elevation mountain ranges (Bradley et al. 2006).
- Run-off from tropical glaciers plays a critical role in mountain ecosystem integrity and its reduction would have lasting and pervasive implications for water supply in the Andes.
- The pace of glacier retreat has accelerated and thus requires of urgent actions to understand and address its implications.
- Area of impact covers the entire range of the tropical Andes, home to over 30 million people and host to biodiversity of global importance.
Objective

- The development objective of the proposed project is to implement adaptation measures to meet the anticipated impacts from the catastrophic glacier retreat induced by climate change.
- This will be achieved through: a) identifying ongoing or planned government interventions with outcomes highly vulnerable to rapid glacier retreat and assessing measures and policy options to adapt to the anticipated effects; b) implementing regional and strategic adaptation pilots to address key climate impacts on their economies; and c) supporting continuing observation and assessment of glacier retreat and the associated impacts in the region.
Institutional framework

- **Project to be implemented by CAN on behalf of Bolivia, Ecuador and Peru**
- **Partners:**
  - Meteorological Research Institute (MRI) of Japan and Japan Frontier Research Institute (J AMSTEC). Japanese Space Agency (J AXA-ROSTEC). The support will be geared to the glacier monitoring activities.
  - National Agency for Oceanic and Atmospheric Administration (NOAA)
  - Consortia of Glaciology Institutes. Will provide technical assistance and capacity building targeting the monitoring of tropical glaciers in the region.
  - Global Glacier Monitoring Service. The service, based in Bern, Switzerland, will assist with the dissemination of information obtained through the project.
  - Government of Switzerland. Cofinancing
The economic and social costs of the destruction of tropical glaciers

- **Impact on water supply to Andean cities:**
  - Quito 50% water dependency from glacier basins
  - La Paz 30% dependency

- **Impact on energy**
  - Most countries in the Andes are dependent on hydro energy for power generation

- **Impact on agriculture**
  - Reduced water supply during dry season, extended dry season
The economic and social costs of the destruction of tropical glaciers

Impact on energy
- Most countries in the Andes are dependent on hydro energy for power generation
  - Bolivia: 50%
  - Colombia: 73%
  - Ecuador: 72%
  - Peru: 81%

Ecuador: Share of hydro
CUENCA RIO SANTA - PERU

Yanamarey
- Disminución superfi cie a 1997 65.4 ha.
- Y perdida de volumen 63.5x10^6 m3 de agua
- Retroceso de -20.3 m/año

Uruasraju
- Retroseso de -16,5 mm desde 1980
- Disminución de área hasta 1997 de -22.9 m.

Cuenca del Llanganuco
- Area glaciar 1991 33,7 km2
- % gla 0,39

Cuenca del Rio Quitaracsa
- Area glaciar 1991 30 km2
- % gla 0,08

Cuenca del Rio Yanayacu
- Area glaciar (1991) 1,6 km2
- % gla 0,73

Rio Negro
- Cuenca Olleros
- Area glaciar (1970) 28,5 km2
- % gla. 0,16

Water usage Rio Santa: 500,000 m

Installed power: 300 MW
Quito’s Glaciated Basin and Proposed Water Supply Infrastructure

Figure 1.

The costs of glacier retreat for the power sector in Peru

Table 2. The Cost of Glacier Retreat for Energy Sector, Peru (US$ million/year)

<table>
<thead>
<tr>
<th></th>
<th>Cañon del Pato power plant</th>
<th>National estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reduced melting</td>
<td>No melting</td>
</tr>
<tr>
<td>Wholesale price</td>
<td>5.7</td>
<td>11.5</td>
</tr>
<tr>
<td>Opportunity cost</td>
<td>10.1</td>
<td>20.3</td>
</tr>
<tr>
<td>Rationing cost</td>
<td>71.5</td>
<td>144.0</td>
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</tbody>
</table>
The costs of glacier retreat for water supply to Quito

Investment needs: Rios Orientales project with and without climate change

<table>
<thead>
<tr>
<th>Year</th>
<th>Existing conditions</th>
<th>Investment</th>
<th>Expected conditions</th>
<th>Investment</th>
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<tbody>
<tr>
<td></td>
<td>Creek systems diverted</td>
<td>US$ million</td>
<td>Creek systems diverted</td>
<td>US$ million</td>
</tr>
<tr>
<td>01</td>
<td>Papallacta, Chalpi,</td>
<td>110.</td>
<td>All creek systems are</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>Blanco Grande,</td>
<td>110</td>
<td>required</td>
<td>143</td>
</tr>
<tr>
<td>03</td>
<td>Quiljos, Azufrado</td>
<td>113</td>
<td></td>
<td>144</td>
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<tr>
<td>12</td>
<td>Casanga</td>
<td>10</td>
<td>Reservoirs and minor</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>creeks</td>
<td>40</td>
</tr>
<tr>
<td>17</td>
<td>Antizana - Cosanga</td>
<td>22</td>
<td></td>
<td></td>
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<td>18</td>
<td></td>
<td>22</td>
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<tr>
<td></td>
<td>Total NPV value</td>
<td>298</td>
<td></td>
<td>391</td>
</tr>
</tbody>
</table>

Source: Vergara, Deeb, Valencia, in press
Short list of adaptation measures

• Ecuador:
  – Compensation of water regulation loss for the city of Quito (retreat of Antizana and Cotopaxi glaciers)
  – Wetland conservation program

• Bolivia:
  – Design and management of potable water system to serve communities affected by disappearance of Altiplano Glaciers
  – Integrated management of glaciated basins to adapt to reduced carrying capacity

• Peru
  – Substitution of lost natural reservoir capacity with engineered reservoirs
  – Soil recovery in Mantaro and Vilcanota basins to compensate for loss water retention and regulation capacity
Summary

- The region is very vulnerable to climate impacts
- Climate impacts on water supply and water availability in Latin America are taking place today and are expected to worsen with time
- Climate impacts on water affect more than human populations and activities; these impacts have significant effects on ecosystem integrity and survival of species under stress
- Key concerns:
  - Reduced water regulation in the Andes caused by catastrophic glacier retreat
  - Saline water intrusion into coastal aquifers will render water supply unsuitable for human consumption and agriculture
  - Mountain wetlands will be affected by changes in precipitation patterns with impacts on water supply and regulation
  - Warm sea water in Caribbean basin will destroy corals, fisheries and increase vulnerability of coastal areas
  - Coastal flooding will disrupt functioning of wetlands
- The cost of adaptation is likely to be much higher than the cost of mitigation in energy intensive nations