effects including drought, fires, and increased carbon releases into the atmosphere because of forest die-back. (Wara et al. 2005) A relatively modest drop in average annual rainfall could bring about changes in average forest moisture levels. Drier forests will return less moisture to the atmosphere and less moisture will in turn lead to lower annual average rainfall, which will have a series of impacts.

One of the unique features of the Amazon region is that its forest ecosystem is responsible for roughly half of the region's total rainfall. Although the rates of deforestation appear to have slowed since a peak in 2005, deforestation remains a key driver of changing precipitation. This decline in average rainfall is forecasted to accelerate the mortality of forests and other vegetation by nearly 600 percent compared to average background rates of change. Already, Amazon forest cover is drying out, and the 2005 drought that affected parts of the Rio Negro in the Manaus region - the worst drought on record in over a century - may presage more prolonged periods of drought.[5] Based on current trends, the IPCC and other assessments warn that the larger Amazon forest ecosystem may "collapse" before the middle of the century.

IMPROVING LOCAL ASSESSMENTS

These preliminary results of the La Plata and Amazon basin programs underscore the urgent need to sharpen climate assessments at the local level. However, several methodological and other challenges exist, which the newly-launched GEF projects will help address. First, while work is advancing at the national level in climate assessments, differences in model parameters often make it difficult to calibrate baselines and data findings. Second, in order to be useful for local planners, climate change models must use scales of at least 1:10,000. Standard climate change models generate a range of scenarios, including projected temperature increases comprising business-as-usual assumptions of projected greenhouse gas increases, emission mitigation targets, and changing temperatures such as increases of 2 C, 4 C and 5 C. These broad scenarios are transferred to the local level, using simple downscaling to include local weather variables by fixed monthly ratios (for precipitation) and fixed monthly shifts (for temperature). However, to ensure robustness, scenarios need to be complemented with detailed data sets generated from Electronic Distanciometers (EDM), Total Stations or GPS triangulations. In addition, information on soil and land-use, rates of land-use change and land degradation[6], are critical to generate maps at a scale of 1:10,000 to 1:1000. These techniques are expensive, as well as labor and time-intensive.

Third, the complex relationship among deforestation, changing surface water temperatures, decreased (or increased) rainfall patterns and other factors makes it necessary to apply general circulation models (GCMs) that estimate dynamic interactions within wider freshwater basins. Although most climate models tend to be static, there have been remarkable advances in recent years, and these advances will be integrated into the Amazon, La Plata and other projects.

Finally, detailed assessments of climate change impacts as the first step towards climate adaptation are technically complex and potentially expensive. Several assessments such as the recently completed vulnerability mapping of the wider harbor area of Halifax, Canada (Runnalls, IISD, 2007) applied remote sensing and geographic information systems for elevation contours and hazard mapping to anticipate the impacts of sea level rise and climate variability events. That single assessment took several years, and its cost exceeded several hundred thousand dollars.

LINKING ASSESSMENTS WITH CLIMATE ADAPTATION

Replicating the level of detail from the Halifax harbor or similar assessments is neither feasible nor necessary, since countries and communities are already advancing from a foundation of work already done. Experience in assessing climate variability and planning for natural disasters and disaster risk mitigation are proving directly relevant to the climate adaptation agenda.

Several key lessons have emerged from existing projects. These include, among others: flood-plain mapping and building floodways around densely populated areas; supporting integrated watershed management, including protecting upper watersheds from deforestation; and supporting a range of critical infrastructure planning targets, including new locating sewage treatment facilitates away from floodplains.

For more information on the work of the DSD, please see **http://www.oas.org/dsd**

DEPARTMENT OF SUSTAINABLE DEVELOPMENT

www.oas.org/dsd

5. Field studies by Woods Hole Research Center suggest that Amazon forest ecosystems may not withstand more than two consecutive years of drought without starting to break down. Severe drought weakens forest trees and dries leaf litter leaving forests susceptible to land-clearing fires, which, in turn, produce smoke that hinders the formation of rain clouds. Logging and deforestation only worsen the effects, which can lead to a feedback cycle that further dries the forest.

6. The transboundary diagnostic assessment prepared for first phase of the La Plata project identifies the strong correlation between land-use change and an increased flooding affecting areas previously immune from floods, particularly in urban area. For example, in 2006, the Government of Argentina declared a state of emergency due to the severe flooding of the La Matanza river, which appears to have been exacerbated by a 50 percent expansion in the residential areas, thus replacing grass and trees that helped check the over-flowing of river banks with cement and asphalt.

DEPARTMENT OF SUSTAINABLE DEVELOPMENT

Adapting to Climate Change: Challenges to Freshwater Management[1]

In recent years, the climate change debate has evolved. Formerly the debate focused on verifying the scientific evidence regarding the causes and consequences of climate change. Increasingly, the debate focuses on identifying credible options to mitigate greenhouse gas emissions, and advancing carbon sequestration projects to include consideration of land-use change and avoided deforestation. At the same time, there is a growing urgency to anticipate and, where possible, adapt to the impacts of climate change. A critical challenge involves translating a growing scientific body of detailed climate change assessments prepared at the global level into information that is useful at the local level.

The findings of the Inter-Governmental Panel on Climate Change (IPCC) in 2007 establish the most authoritative scientific assessment of climate change scenarios. The 2007 IPCC assessments conclude that climate change impacts are highly localized. Determining a plausible range of impacts at the local level represents the first step towards preparing on-the-ground climate adaptation initiatives.

Remarkable advances are being made in bringing robust climate change assessments to a scale that is useful for local planners, communities, the private sector, and others. At the same time, local assessments remain expensive, technically complex and present policy sequence challenges, since climate scenarios - which are based on scenarios decades into the future -- extend beyond the 3-4 year budget planning horizons of central governments, municipal authorities and the private sector.

In the face of these challenges, countries need not begin climate adaptation work from scratch. Ongoing assessments of climate variability - including the use of hazard mapping, establishing early warning systems, increasing the resilience of vulnerable public buildings and critical infrastructure such as safeguarding municipal drinking water supplies from flooding and contamination - provide practical lessons to countries preparing for longer-term climate adaptation work. Climate variability associated with the El Niño Southern Oscillation phenomena resembles the main impacts of projected longer-term climate change impacts. These include dry stationary cells, prolonged periods of severe drought, hurricanes, tropical disturbances, cells with disproportionate humidity and heavy/tropical rainfall, highly organized cold fronts, and other effects. (OAS, 2002)

The Dialogue on Water and Climate, which was supported by the Government of the Netherlands and complemented ongoing work of the Organization of American States Department for Sustainable Development (OAS/DSD), the United Nations Environment Programme (UNEP), the Global Environment Facility (GEF) and the governments of Costa Rica and Nicaragua, provides a useful example of ways to link climate variability assessments with longer-term climate change assessments and adaptation planning. Since the late 1990s, work in the wider San Juan basin - which comprises the largest freshwater body in Central America - have identified the range of climate variability impacts.[2] Specifically, work within the region has focused on modeling extreme weather events such as hurricanes, tropical storms and extreme seasonal drought. Vulnerability assessments were done at a 1:10,000 scale which allowed projected impacts to feed into identifying institutional capacity-building needs in such areas as remote sensing and hazard mapping. Assessments also helped local planners in areas such as land-use planning and municipal zoning, to dissuade families from building in especially vulnerable areas, and to lend urgency to adopting building codes and standards that withstand once-in-a-century Category Four winds. The central conclusion of the wider San Juan basin work is that municipalities that undertake risk assessments, and prepare risk

FLOOD THREAT IN THE SAN JUAN RIVER BASIN (NICARAGUA)

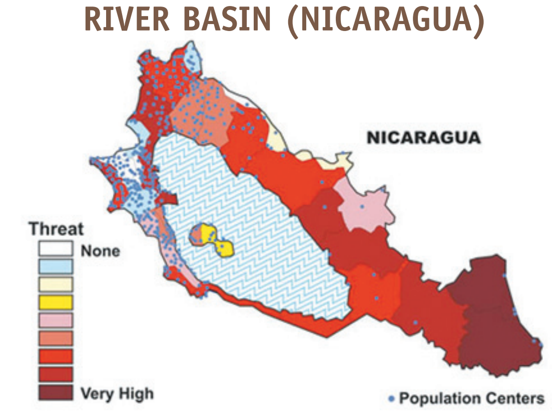


FIGURE ONE: GEF-UNEP-OAS Dialogue on Water and Climate (2002), "Coping with Climate Variability in a Transboundary Basin in Central America: The San Juan River Basin.)

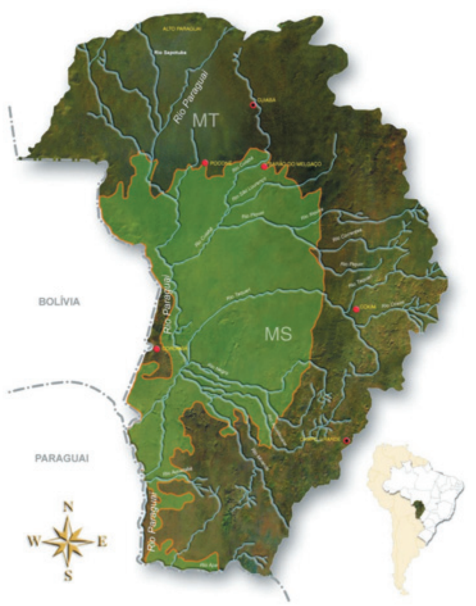
1. The authors are Scott Vaughan, Pablo Gonzalez, Michela Miletto and Enrique Bello of the OAS Department of Sustainable Development. The views expressed in the policy series published by the Department of Sustainable Development do not necessarily reflect formal views of the General Secretariat of the OAS, or of its Member States.

2. Climate variability is closely associated with climate change, and generally entails the examination of extreme atmospheric conditions that far exceed the normal.

reduction measures drawn from climate variability scenarios, have direct experience to help them anticipate and adapt to climate change. (OAS; San Juan, 2002)

WATER AS TRIGGER OF CLIMATE IMPACTS

Key elements of the nearly decade-long work in the wider San Juan basin to anticipate climate variability are being replicated in a number of projects related to critical freshwater basins in Central and South America. Assessing the impacts of climate variability on major freshwater basins in the hemisphere of the Americas poses a unique challenge, since roughly 70 percent of all rivers, lakes, and wider freshwater basin areas are transboundary in nature, shared by two or - in the case of the wider Amazon basin - eight countries. In addition, a 2007 assessment by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the OAS identifies nearly 70 major transboundary aquifers. (UNESCO-IHP/OAS, 2007). Examples include the five-country La Plata basin, the four-country Guarani - which comprises among the largest groundwater aquifers on the planet --- the wider Bermejo basin, the Great Lakes, the Artibonito between Haiti and the Dominican Republic, and others. Cooperation among the countries of the region in the management of trans-boundary basins has created among the oldest precedents in international law, and innovative cooperation at the institutional level.



Cooperation in addressing water management challenges is proving critically important in the context of climate adaptation. One of the central findings of virtually all climate assessments - including the 2007 IPCC reports, the 2005 Millennium Ecosystem Assessment and the 2006 Stern Economic Review as well as numerous assessments of national academy of sciences and academic studies - is that climate impacts are transmitted and mediated primarily through water. In addition to projected increases in average sea level, climate scenarios forecast an increase in the frequency and severity of hurricanes, tropical storms and extreme drought. The bulk of storm-related impacts - indeed over 90 percent of damages from tropical storms - are from flooding.

Climate change is projected not only to increase precipitation in some areas, but also to increase the severity of drought in other areas. Together, heavier rainfall and extended periods of severe drought will affect the lives of millions of people, the most vulnerable of whom will be the poorest in developing countries. Recent estimates by the United Nations Development Programme (UNDP) conclude that climate change is already making the achievement of the Millennium Development Goals more difficult.[3] Over time, it is possible that millions of 'climate refugees' will be forced to abandon pasturelands parched by drought, devastated by forest fires and unusable because of flooding. These impacts accord with the global aggregates compiled by the 2006 Stern Review, which concludes that the economic and developmental impacts of climate change will represent as much as a 10 percent depression in Gross Domestic Product.[4]

IMPROVING LOCAL ASSESSMENTS

Given the magnitude of water-related impacts, there is an urgent need to sharpen our understanding of climate change impacts on the critical hydrological characteristics of freshwater basins. Empirical observations drawn from on-site sensor equipment, together with general circulation models calibrated to identify local impacts, indicate that warmer temperatures are changing the basic hydrological characteristics of some of the most important freshwater basins in the hemisphere. Warmer temperatures may already be altering average river-flows and discharge volumes, in two ways: by changing average precipitation that affects total surface volumes and river flows, coupled with changing rates of evaporation from surface bodies; and by changing transpiration rates from plants adjacent to freshwater basins. Climate models are clear that even marginal shifts in the combined evapotranspiration rates will alter net surface water volumes and total discharge volumes.

For the La Plata basin, given that 75 percent of the region's precipitation evaporates and only 25 percent reaches the rivers of the wider basin, any change in evaporation driven by warmer temperatures could have profound impacts.

LA PLATA BASIN

A major priority of the OAS/DSD is to work with countries in the region and its main partners - the GEF and UNEP - to improve basin-specific assessments of climate change impacts, as the first step towards climate adaptation. In June 2007, the GEF Council approved a full-sized project of almost US$11 million - to be implemented by UNEP and executed jointly by the five countries of the wider la Plata basin and the OAS/DSD - to support the sustainable management of the La Plata basin. In mid-November 2007, the GEF Council approved a similar full-sized, four-year international waters project involving the eight countries of the wider Amazon basin, with the support of UNEP and the OAS.

DISCHARGE SCENARIOS: LA PLATA BASIN

	+ 2 C PERCENTAGE CHANGE	+ 5 C PERCENTAGE CHANGE
Pantanal	-37	- 73
Paraguay	- 34	- 72
Upper Parana	- 15	- 36
Middle Parana	- 23	- 56
Upper Uruguay	- 19	- 47
Total	**- 21**	**- 51**

Source: Vincente Baro, GEF-UNEP-OAS

Since 2004, the five countries of the La Plata basin - Argentina, Bolivia, Brazil, Paraguay and Uruguay - have intensified cooperation in linking average temperature records, changes in rates of rainfall and river discharge flows, with sophisticated general circulation models. The preliminary results from this work, supported by the GEF-UNEP-OAS, show that the effects of warmer temperatures in the region could have dramatic impacts. Specifically, climate change may lead to a reduction in the overall discharge rates of all the principal rivers that comprise the wider basin, although the relative rates of change may differ significantly. In one scenario, the combined effects could be a one-half drop in discharge rates.

The implications of these upper-bound climate scenarios would be unprecedented. For example, in the energy sector, 90 percent of Brazil's electricity supply is from hydro-power. A marginal decline in total discharge volumes will reduce the viability of current and planned hydro-electric dams, and increase the cost per kilowatt hour of electricity. For areas like the Pantanal - which comprises among the largest aquatic and wetlands areas on the planet - an upper bound scenario of 73 percent reduction in river discharge under the 5 degree C scenario would profoundly affect the lives of the approximately three million people living in the Upper Paraguay and Pantanal wider basin limits. Changes in stream-flows would have important and direct impacts on human health because of reduced flushing of sewage and untreated waste, thereby increasing the risk of water-borne diseases. For example, field work by the OAS, in cooperation with the International Development Research Centre (IDRC) and the Pan American Health Organization (PAHO), have found strong correlations between a decrease in water flows and drought, and increased incidence of risks related to malaria, dengue fever and chagas. (IDRC-PAHO-OAS, 2007) Finally, a decline in the average water balance in the Pantanal could place at risk some of the estimated 1,900 plant species, 263 fish species, 85 reptiles, 440 bird species and 195 mammal species located in the region. (ANA/GEF/UNEP/OAS, 2005)

WIDER AMAZON BASIN

A similar, multi-year program to support the sustainable management of the wider Amazon basin, to begin in 2008, will examine the effects of climate change. The differences in initial findings between the La Plata and Amazon basins underscore the importance of implementing climate assessments at the basin-specific level.

Past studies indicate a narrow range in runoff effects, in the vicinity of less than 1 percent to an increase by as much as 3.7 percent (Walker et al, 1995; Polcher and Laval, 1994). However, other studies suggest that warmer temperatures may decrease average precipitation during dry months. (IPCC, 2001). More recent general circulation models suggest that because of the effects of deforestation on the Amazon's rainfall patterns, the region may experience a permanent El Niño Southern Oscillation effect, comprised of extreme climate variability

AN EXAMPLE OF CLIMATE CHANGE ADAPTATION MEASURES

Strategic uses of groundwater for the mitigation of the impacts of extreme drought on humans and ecosystems:
The pilot project of Tres Fronteras in the Amazon Basin

The region of Tres Fronteras (Brazil, Colombia and Peru) with its main towns of Leticia and Tabatinga, is located in the westernmost part of the Amazon basin. It is an area with seasonal wetlands and lakes, rich in fisheries resources and sustaining rural and indigenous communities. In 2005-06 it was severely affected by exceptional droughts: the Rio Solimoes, a major tributary of the Amazon, showed a level drop of 1.5 m, a consequence of the 70% decrease in rainfall (1/5 of the normal values). The loss of freshwater living resources was huge, and indigenous communities dependent on wetlands and lagoon ecosystem services were heavily impacted. The devastating consequences of these exceptional droughts on health, environment and economy in the Tres Fronteras area could have been reduced through a strategic utilization of groundwater, a reliable and less climate dependent resource.

The Tres Fronteras pilot project, which will be executed in the context of the GEF-UNEP-OAS project for the Amazon Basin, will revolve around the application of the concept of conjunctive ground and surface water management to cope with climate variability. Conjunctive management of surface and groundwater, together with local climate forecasting, can in fact be one of the methods of addressing sustainable water resource management in parts of the Amazon Basin in view of increasing climatic fluctuations. Enhancing the use of the aquifer's static reserve during dry periods can be a temporary alternative that would reduce stress on surface water resources. Furthermore, water can be stored in the aquifer for use during droughts by increasing recharge during times of above-average water availability. As such, an aquifer can be a water source during dry periods, and a storage reservoir during wet periods. At times when surface water availability is comparatively plentiful (in winter months and during wet years) the direct use of surface supplies is encouraged. Pumping of aquifers should be comparatively less during these wet periods (restricted to human consumption), allowing them to refill naturally or through deliberate replenishment efforts such as Aquifer Storage and Recovery schemes.

3. IPCC 2007, Summary for Policymakers, in Climate Change 2007: The Physical Science Basis, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge and New York, Cambridge University Press.

4. The Stern Review (2006), "The Economics of Climate Change: Executive Summary," The report notes that "With a 5-6° C warming - which is a real possibility for next century - existing models that includes the risk of abrupt and large scale climate change estimate an average 5-10 percent loss in global GDP, with poor countries suffering costs in excess of 10 percent of GDP" p. 9.