Evaluating Risk to Ramsar Wetlands from Climate Change

CIESIN at Columbia University

I. Description

The goal of this project is to assess the vulnerability of coastal wetland sites designated under the Ramsar Convention on Wetlands from rising sea levels due to climate change. The Center for International Earth Science Information Network (CIESIN) of the Earth Institute at Columbia University developed this project in response to a request by the Ramsar Convention Scientific and Technical Review Panel. Two scenarios are evaluated, 0-1 meter sea level rise, which is close to what the IPCC predicts for this century, and 0-2 meter sea level rise, which is an outer bound for sea level rise in this century if land-based ice sheets respond faster than expected to temperature changes. Vulnerability is first assessed by evaluating proximity to the coast and site elevation to see what percent of a site’s area is at risk under each scenario. The second step in this vulnerability assessment is evaluating a site’s ability to migrate inland. Human land uses are considered to be the primary impediment to landward migration, as well as elevation rise. The variables considered include population density and population growth (both from the NASA Socioeconomic Data and Application Center Gridded Population of the World dataset), and urban extent (from the Global Rural-Urban Mapping Project data set). As a preliminary analysis, the subset of coastal Ramsar wetlands with mapped boundaries was evaluated. A “coastal” wetland was defined as one where some portion of the site’s area was located within 5 kilometers of the coast line. The coastal subset contained 518 sites.

II. Results achieved

We ranked wetland sites by percent land area at risk, and assessed impediments to landward migration using the population data and satellite images from Google Earth to understand built infrastructure in the vicinity of the wetland (see Figures). We found that while almost 90% of coastal Ramsar sites will be affected in some way by a 0 – 1 meter rise in sea level, only 15% of all coastal sites would have greater than 50% of their area at risk, and only 5.6% have greater than 90% of their area at risk. The numbers for 0 – 2 meter sea level rise are similar: 92% of coastal sites would be affected, but only 19% of sites would have greater than 50% of their area at risk and 8% of sites would have greater than 90% of their area at risk. The percent of the total area at risk across all coastal Ramsar sites as a result of 0-1 meter sea level rise would be about 7% of the total area. The total area at risk as a result of 0-2 meter sea level rise is about 10.3%. To assess vulnerability beyond using area at risk, population density, population growth, and urban extent were considered on an individual basis. Population density and population growth were evaluated within a 5 kilometer buffer around each site to look at general population trends. Maximum, average, and minimum population density statistics within the buffer zones were generated. Urban extent was evaluated in a 1 kilometer buffer around each site, where the percent of buffer area classified as urban was calculated. A 1 kilometer buffer was used for urban extent to obtain a more focused evaluation of impediments to migration that currently exist, compared to the 5 kilometer buffer that was used for a more general analysis of population distribution and trends.

III. Challenges

The biggest challenge has been the lack of boundary data for the complete set of Ramsar sites. Of a total 1,890 sites, only 1,050 had boundary data. The sites with complete boundary data tend to be located in developed countries, with disproportionately few sites with boundary data in developing countries. As a
next step, we will apply point buffers to geographic coordinates to approximate the area covered by Ramsar sites without digitized boundaries. However, the analysis derived from these buffered points will have large uncertainty since Ramsar sites, especially along the coast, tend to be irregular in shape.

IV. Lessons learned

While a global assessment based on the total percentage of site area at risk from sea level rise provides a good first cut in identifying vulnerable sites risk, a more meaningful assessment will still need to be done at the site level. So far, population data and urban extent have been evaluated on a case by case basis to understand the risks from impediments to migration. The next step in assessing vulnerability will be to develop a composite ranking score that encompasses a broader range of risks, incorporating the size of the site, population data, urban extent, slope or elevation behind the site, and possibly other factors like poverty or government capacity.
Future Drying Trends Mexico and Central America and Potential Migration

CIESIN, UNU, and CARE

Description

A collaborative effort between the Center for International Earth Science Information Network (CIESIN) of the Earth Institute at Columbia University, United Nations University (UNU), and CARE, sought to communicate potential migration from areas that may be affected adversely by climate change, based on maps by CIESIN and a study by UNU and partners (de Sherbinin et al. 2011, Warner et al. 2009). A major expected climate impact is changes in precipitation that may result in water insecurity in certain regions. One region that could be particularly negatively impacted by reduced runoff, which integrates rainfall and evapotranspiration along with soil moisture recharge, is Mexico and Central America.

Results Achieved

We mapped the likely changes over Mexico and Central America from an ensemble of model runs for runoff change up to 2080 (Nohara et al. 2006), and examined the relationship between likely runoff change and current runoff and rainfed agriculture. We combined this mapping analysis with field work in Tlaxcala and Chiapas states in Mexico, in which researchers from the European Commission’s Environmental Change and Forced Migration Scenarios (EACH-FOR, www.each-for.eu) research project interviewed experts, migrants, and non-migrants about patterns of migration in relation to environmental stress. The EACH-FOR Mexico case study was conducted by Stefan Alscher of Bielefeld University.

Of particular concern is the likelihood that the region will see persistent declines in precipitation over the course of this century. Figure 1 shows that runoff in the region will likely decline by at least 5 percent and possibly more than 70 percent, with declines getting progressively worse in the semiarid and arid north. Given the region’s mountainous topography, extensive irrigation is only practicable in the coastal and northern plains that are dominated by middle and large landowners. Most smallholder farmers, particularly in the center and south, will remain heavily dependent on rain-fed agriculture.

However, even large-scale irrigated areas, such as those in Sonora and Sinaloa states, the breadbasket of Mexico, will be affected as average reservoir levels decline. Already, summer droughts during El Niño and La Niña events can lead to serious deficits in reservoir levels. In the case of Guatemala, longer and more intense midsummer drought periods have been linked to long-term declines in rainfall since the 1970s (Marn et al. 1999). This drought determines the level of success or failure of rain-fed agriculture.

Processes of slow-onset land degradation including deforestation, soil erosion, and desertification already affect large parts of the Mexico and Central America. In the fragile arid and semi-arid ecosystems of northern and north-western Mexico more than 60 percent of the land is considered to be in a total or accelerated state of erosion, and mountainous lands with high slopes throughout the region have suffered deforestation and soil erosion.

Studies were conducted in the hurricane-prone Chiapas state of Southern Mexico, and in Tlaxcala state, a highly desertified state in Central Mexico. Both areas are considered very vulnerable to the effects of climate change, particularly in combination with deforestation, erosion, and underlying poverty and social vulnerability.
Migration is a common response in Mexico to changing environmental conditions, the 1980s agricultural crisis and economic liberalization (Alscher and Faist 2009). The recurrence of natural disaster such as drought and cyclones combined with the presence of relatives who emigrated due to disasters in the past increases farmers’ probabilities of emigrating (Saldaña-Zorrilla 2008). Some studies have shown links between rainfall, crop yields and desertification and migration in Mexico, noting the impacts on agricultural livelihoods (Feng et al. 2010, Medellin 1978). In dryland areas such as Tlaxcala, which depends on rain-fed agriculture, the majority of interviewees complained of shifting rainfall periods, which increases uncertainty and causes a decline in crop yields and incomes. The area of Tlaxcala is projected to have a 10–20 percent decline in runoff in association with climate change. This indirect link between climatic changes and migration was noted frequently in fieldwork, mostly related to unreliable harvests linked to changing rainfall patterns. Return migration, and seasonal migration as a livelihood diversification strategy have been documented in this area.

The relevance temporary migration and remittances to cope with unreliable income from agriculture has often been highlighted in the environment-migration literature but not always sufficiently considered in adaptation and mitigation policies. Internal and international migration patterns are well established in Mexico and Central America, and it is difficult to project what effects drying trends associated with climate change may have. It is clear, however, that environmental factors like desertification and extreme weather already contribute to the regions’ complex pattern of human mobility. The opportunity for some people to migrate seasonally, send remittances, and return home is an example of migration as an adaptation strategy to deteriorating environmental conditions.

**Challenges and Lessons Learned**

There are many challenges to studying migration because of a paucity data. Field research is often the only way to begin to understand the motivations of migrants. This study was able to explore underlying relationships in a qualitative fashion, but it is far from predictive in terms of identifying likely patterns or volumes of migration from rural areas owing to increasing drought frequency or drying trends. Diversification of livelihood strategies and government investment in disaster risk management has been shown to decrease the likelihood of migration, regardless of poverty status (Eakin et al. 2005, Saldaña-Zorrilla 2008). There are other adaptation options as well. Recognizing that most future migration, like that of the past, is likely to flow toward the U.S. and Canada, policymakers there might consider issuing temporary work visas following climate disasters. The money sent back home by migrants can help local economies to better endure the devastation and rebound more quickly.

**References**


Managing Climate Risk within a Haitian Watershed

Center for International Earth Sciences Information Network (CIESIN)
Earth Institute | Columbia University

Description

The Haiti Regeneration Initiative (HRI) aims to bring about lasting positive change to Haiti’s environment and the livelihood of its population over the next 20 years and beyond. The Earth Institute (EI) and Center for International Earth Sciences Information Network (CIESIN) at Columbia University have joined the partnership to provide a rigorous technical and research-based programs to help catalyze the ambitious, innovative solutions to the country’s large-scale, chronic problems of environmental degradation and poverty, in order to kick-start a virtuous circle of recovery and growth. The HRI vision is simple but bold: to reduce poverty and increase resiliency to natural hazards through the restoration of ecosystems and livelihoods. A critical component of this overall strategy is to enhance the decision-support tools and data inputs that are critically needed in designing climate adaptation and disaster risk reduction programs at watershed scales. The long-term goal is to develop and implement a long term integrated water resources management (IWRM) program within the sub-watersheds of the Cote Sud region [Insert map Haiti_CIESIN_Figure1]. The goal of IWRM is the rational and sustainable use of the variable levels of water resources and the management of flood and drought risks in the Southern region of Haiti. Early activities are focusing on assessment of issues, creating a system data collection as basis for evaluating needs and opportunities, climate event and flood risk reduction infrastructure.

A review of past projects makes it clear that sustainable development in Haiti must tackle a minimum core of interconnected issues simultaneously: disaster risk reduction, agricultural productivity, energy options, health care, education and poverty. [Insert Haiti_CIESIN_Figure2] Crop yields need to grow dramatically to raise incomes thus reducing pressure to cultivate marginal lands. Barren hillsides need to be reforested to reduce soil erosion and runoff. Best practices in watershed and disaster management need to be implemented to reduce flooding and landslide risks. Sustainable energy pathways need to be pursued to reduce deforestation pressures associated with charcoal production. Equal access to basic education and health care needs to be reinforced as part of the overall approach.

Such solutions need to be tightly integrated, implemented with a spatial based ecological mindset, and designed in tightly coordinated with clear implementation programs to attain firm, lasting participation and leadership from local communities and institutions.

Results achieved

A team of researchers from the HRI partnership, including researchers from Columbia University, experts from the United Nations Environment Program, researchers from the American University of the Caribbean, Les Cayes, and Catholic Relief Service practitioners initiated field data collection in April 2010. The initial data collection has integrated research questions from several disciplines and produced analyses in thematic areas of climate vulnerability and livelihoods across varying geographic scales.

Another team focused on inter-departmental cooperation between key spatial research centers to update the data sets and creates the tools required for hazard mapping used for the prioritization and sequencing of disaster risk reduction infrastructure investments. The outputs from this work are part of a long-term process of project design and applied – research. Below are a summary of the main studies launched:

Climate monitoring system: The collection of continuous and reliable data is crucial for climate modeling and risk planning. Currently, the HRI has installed four rain gauges in strategic points across the watershed, including one
climate monitoring station in Port-à-Piment village. The idea is to make the data from all four collection points available for both the watershed and the international communities interested in climate conditions in the southwestern region, and the information gives rise to climate prediction models as part of local early warning systems. Hydrological data will also be collected along the river to build up prediction models on water flow dynamics.

The station in Port-à-Piment collects and reports hourly data on wind speed and direction, relative humidity, ground and air temperature, solar radiation, precipitation, and soil moisture. It is operated with solar panels and sends all the data via satellite to a server in real time figures [www.haitiregeneration.org].

**Land use and land degradation survey:** The Land Degradation Surveillance Framework (LDSF) is a comprehensive field survey of terrain, vegetation, and soil conditions. It is designed to provide a spatially explicit layout for landscape characteristics and soil data. Soil samples were collected in April/May 2010 and are currently being analyzed. Field observations included data on percent and type of vegetation cover, infiltration rates, and visible erosion and slope, among others. Using remote sensing tools, all the information gathered will be combined with other parameters to produce digital soil maps. Those maps will provide valuable information on soil health across the entire watershed, serving as a tool for prioritization of soil rehabilitation and agricultural interventions.

Further, a preliminary land use and land cover map has been produced using remote sensing tools. These tools will help with long-term planning for ecosystem restoration of the watershed and natural systems for reducing disaster risks.

**Communication, risk perception, environmental awareness, and behavior:** The 2010 research included rapid interviews with key informants as well as focus groups to understand social dynamics behind disaster preparedness and the structure of community organizations. The initiative’s objective is to improve risk communication and risk perception to support better decision-making in the watershed. A household survey inquiring about behavioral choices related to risk perception and effective communication will be conducted at the same time of the socioeconomic survey. The results from this study will inform the overall communication strategy of the initiative.

**Challenges**

Defining the scope and optimal outputs of the research for communities remains challenging. The integration of spatial data and monitoring systems into local decision-making processes remains a crucial step in the design process of high impact research tools.

Lack of baseline data and historical data on rainfall limits the modeling of long-term flood risk and respective flood risk models. Baseline information on water resources is very limited, particularly with respect to river flow rates and water quality.

The instability and lack of continuity within the political system and policies creates challenges to building sustainable programs and integrate data into long-term monitoring programs. The increasing frequency of hurricanes and natural disasters disrupts the longer-term recovery process and creates significant needs for humanitarian responses instead of long-term adaptation and disaster risk reduction.

**Lessons learned**

Cooperation and collaboration with key partners was --and continues to be-- crucial during this process. Strategic partnerships with organizations and institutions provided us with first-hand and up-to-dated information at both, the regional and the local scale. Establishing these relationships and gaining knowledge of the area requires time and investment from both researchers and partners.
Many agencies invest in data collection but few remain active and available for decision-makers and researchers. There is a need for the creation of knowledge management and information systems that are maintained and updated by national agencies, with the involvement of local communities and NGO’s and paired with standards of the international community. In order to assess climate change events and prepare for extreme events, which are increasing in frequency, better long-term data is required.

Projects that are managed and part of local decision making processes have greater success over time according to Lessons Learned studies produced by the United Nations Environment Programme. Finding ways to pair data analysis and data-driven decision-making tools with local needs and community knowledge is critical for long-term adaptation.