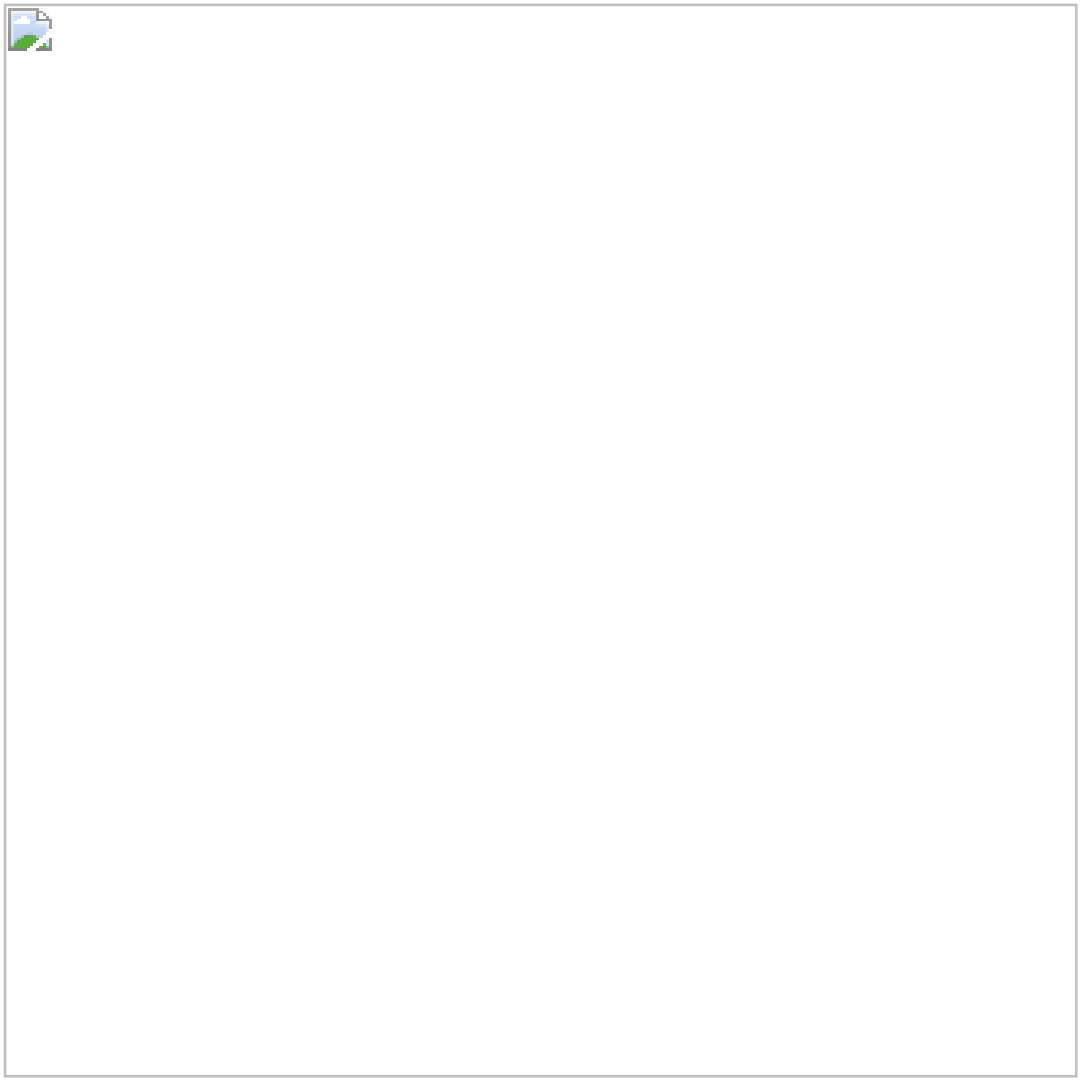

# Adapting to Uncertain Futures

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# Adapting to Uncertain Futures

## A Report on New Glacier Recession and Livelihood Vulnerability Research in the Peruvian Andes

### Glacier recession and hydrologic change in the tropics

Throughout the tropics, glaciers are receding at a rapid pace and during the latter half of the 20th century a number of tropical glaciers vanished completely due to melting. As harbingers of a warming planet, the recession rates of tropical glaciers will likely continue to increase in the near future according to leading scientific research that indicates global greenhouse emissions are growing faster than even the worst-case scenarios considered by the Intergovernmental Panel on Climate Change (Raupach et al 2007) and that abrupt and irreversible impacts from climate change may occur over shorter time scales than previously predicted (IPCC 2007).

As the recession rates of tropical glaciers have increased, discharges from glacier-fed streams have also been increasing. However, once glacial replenishments disappear, streams and rivers throughout the tropics will have smaller dry season flows and will exhibit increasing hydrologic variability (Mark and Seltzer 2003). Since glacier-fed discharges currently provide a continual supply of meltwater that serves as a buffer during the tropical dry season and drought years, accelerating glacial recession and its impacts on the hydrologic regime are predicted to lead to significantly diminished water supplies during these periods with potentially grave consequences for the people of the region (Bradley et al 2006).

### Human vulnerability to glacier recession in Peru

With a large portion of the world's population dependent on hydrologic resources linked to tropical glaciers, the decline of these natural "water towers" has important repercussions for the social and ecological systems that depend on these vital reservoirs of freshwater. In Peru's Cordillera Blanca (the highest and most extensively glaciated range in the tropics) glacial meltwater makes up a critical percentage of the discharge of a wide array of water courses, ranging from first-order, highland streams to the Rio Santa, one of the largest and economically most important rivers on Peru's Pacific slope (Mark et al 2005). Climate change-induced warming is occurring rapidly in this region and glaciers have lost between 11 and 30% of their mass in the past 40 years (Raup et al 2007). While there have been significant and temporary increases in glacial meltwater discharge flows, predictions for the coming decades suggest that these flows will decrease and be more variable across seasons in even the most glaciated catchments of the range (Juen et al 2007).

Current population levels and patterns of water use in the Central Andes suggest that many human communities are highly vulnerable to decreasing quantities of water. As issues of future water supply lie at the nexus of the biophysical, ecological, and social systems of the region, interdisciplinary research assessing the multiple dimensions of vulnerability across a variety of scales is important for local residents and policy-makers as well as for scholars of global change. Specifically, ongoing monitoring and future modeling of climate-induced changes to glacier-fed water supplies must be integrated with assessments of the specific ways in which human livelihoods and social and economic systems are vulnerable to water scarcity in order to inform strategies for adaptation to and mitigation of increasingly uncertain and conflicted futures.

### Current research efforts

In an effort to address these pressing concerns, an analysis of glacier recession and its impacts on hydrologic regimes and human livelihoods is currently underway in the Cordillera Blanca. Bridging disciplinary divides, this project, which is currently supported by grants from the National Science Foundation, NASA, and National Geographic, links a diverse group of researchers from a range of international academic research institutions including The University of California at Santa Cruz, The Ohio State University, and McGill University. The research is also being conducted in collaboration with Peruvian researchers and government institutions as well as international nongovernmental organizations. Capitalizing on the team's range of technical expertise, linkages with civil society and political institutions, and long-term experience working in the region, the project is in the process of (1) quantifying recent and future changes in glacial volume; (2) evaluating the regional impact of glacial melt on seasonal and inter-annual water availability and quality; (3) assessing human vulnerability to increasing hydrologic variability due to glacier recession; (4) evaluating how changing access to water resources is contributing to livelihood adaptation and potential conflicts over resources; and (5) disseminating critical findings and recommendations for adaptive strategies to help mitigate the impacts of climate change and glacier recession on water resources and livelihoods.

Since mid-2006, project participants have been engaged in research to address these objectives in several case-study watersheds with different percents of glacierization, variable hydrologic characteristics, and diverse livelihood pursuits in order to understand and measure hydrologic processes, calibrate hydrochemical mixing models, and evaluate the ways in which household livelihoods are produced and depend on access to water resources. Currently, field teams are measuring glacial volume changes over the past 45 years utilizing state-of-the-art oblique digital photographic technology in combination with remote sensing and aerial photogrammetry, assessing hydrologic shifts through multi-scale sampling and analyses of hydrochemical and endmember-mixing models, and evaluating historical and current evaporation and precipitation rates. In addition, research is being conducted across a variety of scales in several communities in the case-study watersheds to assess human vulnerability to shifting climatic conditions and hydrologic resources, to evaluate potential household livelihood adaptation strategies, and to identify key vectors of medium and long-term social and economic change. Field teams are engaged in extensive interviews with national, regional and local key informants and are conducting intensive surveys, with households being sampled utilizing stratified systematic unaligned techniques. All of the research findings and modeling efforts are being compiled and integrated into geospatial information databases that include digital elevation models, geological maps and high resolution satellite imagery.

## Project outcomes

The expected outcomes of the collaborative research project, which will continue through at least 2010, are (1) the generation of cutting-edge empirical data and theoretical insights into the current rate and magnitude of climate change-induced glacier recession, shifting hydrologic processes, and human livelihood vulnerability and adaptation; (2) the refinement of rigorous and transferable interdisciplinary research methods and information dissemination strategies that have the potential to address the complexities posed by the uncertainty and variability of global change processes; (3) the formation of enduring partnerships that illustrate the critical value of linking leading academic research with the on-the-ground capacities of local civil society and governance organizations; and (4) the generation of an array of effective site-specific educational outreach programs, capacity-building strategies, policy recommendations, and field projects that will assist local people and institutions in their efforts to adapt to and mitigate the rapidly worsening impacts of climate change, glacier recession, and water scarcity on human societies.

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