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19

Linking global change research to improved policies and management for rivers: Lessons from the Andean Amazon Rivers Analysis and Monitoring project

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Science framework

Forces of global change on the eastern slope of the Andes pose formidable challenges to sustainable development. Poverty is widespread in the Amazon portions of Colombia, Ecuador, Peru, and Bolivia, and growing population pressures are driving a process of rapid land-use change that is largely uncoordinated and uncontrolled (Mena et al. 2006). Moreover, this conversion of forests to mixed agriculture and pasture is expanding across one of the most biodiverse regions of the planet (Mittermeier et al. 1997), and there are well-justified fears of significant biodiversity losses. Predictions of potential climate change are not reliable in this region, but based on experience with intense climate variability linked to El Niño, Andean governments worry that climate changes will only exacerbate their current development problems (CONAM 2002). Rivers are fundamental in shaping and maintaining Andean Amazon ecosystems, and they are vital to the region's hopes for sustainable development and improved livelihoods of its inhabitants.

Rivers are integral to the health, welfare, and prosperity of human inhabitants and natural ecosystems of the Andean Amazon region, and impacts brought by environmental change threaten the services these rivers provide. Rivers are sources of fish and semi-aquatic animals to the diets of Amazon indigenous people and colonists, accounting for more than 50% of animal protein consumed in many areas (Galárraga et al. 2001, McClain et al. 2001, Ayllon 2002). River valley bottoms offer the only high-quality arable lands in the highlands, and at lower elevations river banks offer the only high fertility soil, supporting protein-rich crops that cannot be grown on upland soils (Cossio 2002, McClain and Cossio 2003). Rivers and streams are the main sources of drinking water, but they are also a common receptacle for wastes (Galárraga et al. 2001, Puentes 2004, Blanco 2005). Consequently, inhabitants of the region suffer from a wide array of waterborne illnesses, and diarrhea is a common ailment among children (McClain et al. 2001). In addition to the impacts of towns and cities, other threats linked to agriculture, cattle-raising, forestry, and petroleum extraction also have measurable impacts on the condition and quality of rivers in the region (McClain 2002, Celi 2005). Rivers are vitally important to commerce; they serve as the primary avenue for transporting products to and from many portions of the region. Finally, rivers are an important part of people's daily

recreation, as many families, and especially children, seek relief from the heat in the river's cool waters. For indigenous people, rivers also hold important spiritual significance.

The Andean Amazon Rivers Analysis and Monitoring (AARAM) project was financed by the Collaborative Research Network (CRN) program of the Inter American Institute for Global Change Research (IAI) to examine the relationships between climate, terrain features, land use, human demographics and river systems in the Andean Amazon Region. The primary goal of AARAM was to provide scientific guidance to policy and management actions involving rivers and water resources, and the key science findings are summarized below. Work focused on characterizing the current spatial and temporal patterns in water quantity and quality and investigating functional relationships between quantity, quality, natural features and human actions. The principal investigators of AARAM were all limnologists and hydrologists, and expertise in the human dimensions of resource management was sought through the involvement of local collaborators.

Key findings

- Land use conversion is progressing rapidly across the Andean Amazon region in proportion with growing population densities and expansion of roads.
- Land cover configuration in colonist and indigenous controlled areas is more correlated with biophysical variables limiting land uses than to cultural variables.
- Concentrations and fluxes of sediments and solutes from Andean catchments are correlated with both discharge and land use. Concentrations of sediments and nutrients increase with increasing discharge over daily timescales, while longer-term average concentrations increase with the proportion of agriculture and pasture upstream.
- While sediment concentrations become very high during large runoff events, solute nutrient and organic matter concentrations remain low when compared to more intensively used landscapes.
- The responsiveness of sediment and solute concentrations to daily runoff suggest, however, that Andean Amazon river systems are especially vulnerable to biogeochemical changes in response to land-use change and more intensive future land use may produce strong changes in riverine biogeochemistry.
- People of the region rely on rivers for many services. They are the primary source of water for all human uses and also a common receptacle for wastes. Fish are an important component of the local diet and riverside soils produce the most nutritious crops.
- Andean Rivers appear to be able to assimilate domestic wastes from riverside towns quite effectively, but the cumulative effects of these discharges significantly disturb river bed habitats, even when contamination is difficult to detect in the water column.
- Management of water and riparian ecosystems is inconsistent across the region, as laws are loosely adhered to and enforcement is ineffectual. Household-level compliance with management prescriptions was highest among indigenous people because of stronger community structure respect for community authorities.

Relevance: The political and legal situation

Despite the obvious value of rivers to the welfare and development-potential of communities in the Andean Amazon, legal protection and careful management of rivers are not high priorities for national and local authorities. Rivers may in fact be the least protected and most vulnerable resources in the Andean Amazon. The explanation for this situation is multifaceted and differs somewhat from one part of the region to another, but certain common factors stand out.

From a national perspective, low population densities, relative poverty, and remoteness result in the Amazon being commonly left out of the national dialog on issues of public policy, legal reform, and community-level investments for development. Another key consideration at the national level is the distribution and commercial value of resources in these countries. For example, petroleum and timber are regarded as resources of national importance in the Amazon. Thus the Amazon is the focus of considerable national attention by the ministries and agencies managing these resources, and national policies and regulatory agencies are in place – although regulatory agencies are not always effective at enforcement. Fisheries are regarded primarily as a resource of the coasts, and virtually all policies and investments are focused on the coast. Inland fisheries receive much less attention and even then only big-river fisheries in the vicinity of major Amazon cities (Leticia, Iquitos, Pucallpa). Smaller artisan fisheries are generally unregulated. The legal and regulatory systems for water resource management are biased toward the semi-arid and arid portions of Andean countries. Water management is thus viewed almost exclusively as water supply for irrigation, and laws and policies strongly reflect this view. We believe this to be a fundamental obstacle to effective river management in the Andean Amazon (McClain and Llerena 1997). As currently practiced, water is managed primarily for its uses outside of the river channel, while the most pressing issues of river and water management in the Amazon are linked to in-stream uses. Consequently, the countries of the Andean Amazon generally lack legal frameworks and institutional capacities to effectively manage water in its river channels for the benefit of in-stream uses.

That said, for much of the rural Andean Amazon, questions of national policies are largely irrelevant to the day to day realities of natural resource management. While some forms of resource use (e.g., petroleum extraction) are strongly influenced by national policies, extraction and use of local resources (including water, wood, land, and wildlife) by local people operate somewhat independently of national policies. Instead, local economies, authorities, institutions, and cultural practices exert the greatest controls over resource management and extraction. At the local level, effective resource management is closely linked to education and land tenure, reasoning that land owners and indigenous groups with tenure over their lands are confident that they will reap the rewards of good management and are therefore willing to make the effort and investment to manage more wisely. Rivers and their resources, on the other hand, are property of the State and therefore shared resources. Consequently, river resources are subject to the irresponsible use and management that plague common resources. Effective management of common resources generally falls to government. But the national government presence is minimal

in Amazon communities and regional and local governments have very limited capabilities.

Outreach, networking and capacity building: Our approach and lessons learned

From our planning stages, we worked to link AARAM activities to decision making and water resources management in Colombia, Ecuador, Peru, and Bolivia, but our approach evolved and changed over the course of the project. In the proposal stage we signed letters of agreement with the government agencies responsible for monitoring water resources in each country (Table 19.1). Our goal was to ensure that AARAM activities built upon, and our data fed directly into, the national monitoring systems. We reasoned that the most effective way to build strong bridges between AARAM and those agencies was to bring agency staff into AARAM as graduate students. This technique proved effective, and over the course of the project we trained one hydrologist from the National Meteorology and Hydrology Department of Peru - SENAMHI-Peru (who has since been promoted to head of hydrology) and two hydrologists from the National Institute for Meteorology and Hydrology of Ecuador - INAMHI-Ecuador (one of whom is now head of research in the institution).

Table 1: AARAM Government partners at the initiation of the project

Country	**Agency**
Colombia	Inst. de Hidrología, Meteorología y Estudios Ambientales (IDEAM)
Ecuador	Instituto Nacional de Meteorología e Hidrología (INAMHI)
Peru	Servicio Nacional de Hidrología y Meteorología (SENAMHI)
Bolivia	Servicio Nacional de Hidrología y Meteorología (SENAMHI)

Our experiences were, however, quite inconsistent between the agencies, and the key to long-term engagement was subcontracting the agency to conduct monitoring at existing stations within their networks. We found interest among each of the agencies to add gauging stations to their networks, but the construction and staffing of these stations was more expensive than our budget would allow. Only INAMHI remained engaged in the project over the entire 5 years, largely because we subcontracted them to sample three of their existing stations and worked closely with them to model daily precipitation runoff processes in the upper río Quijos basin (Galárraga and Torres 2001, Galárraga et al. 2004, Galarraga et al. 2005). IDEAM (Colombia) participated directly in the project for the first three years as we subcontracted hydrologists to participate in field campaigns sampling lowland rivers where no permanent stations were installed. SENAMHI-Bolivia dropped out of the project early because Bolivia had not yet ratified the IAI agreement and funds could not be expended there. SENAMHI-Peru was engaged only through the involvement of their staff member studying within AARAM. This staff member did however develop a very useful model for predicting flows in the Pachitea river basin (Ordoñez 2001), and it is our understanding that this model has now been adapted to other basins in Peru.

In the first year of AARAM we also made concerted efforts to inform and engage government agencies at the national level. We presented AARAM in meetings and seminars at a number of national agencies, including the Ministry of Environment of Colombia (in the presence of the vice-minister), Instituto para el Ecodesarrollo de la Región Amazónica Ecuatoriana, (ECORAE-Ecuador), Fundación para la Ciencia y la Tecnología (FUNDACYT-Ecuador), Consejo Nacional de Ciencia y Tecnología (CONCYTEC-Peru), Instituto Nacional de Recursos Naturales (INRENA-Peru), and others. These meetings and seminars served to spread the word about AARAM and the IAI, but they did not result in any long term collaborations. They also made clear to us that these agencies, and their modest resources, were committed to their own agendas and activities. There was interest on their parts to have AARAM conduct studies in support of their planned and ongoing activities, but they did not see a clear way to apply planned AARAM results to their needs. This proved to be a revelation about the divide between investigator-driven research priorities and the practical interests of policy makers. Approaching national government partners at this stage of AARAM, even if still an early stage, was too late.

During the second and third years of the project, as national level partnerships failed to develop and as we began to understand better the dynamics of river resource management in the rural portions of the region, our emphasis shifted to the local level. Our primary strategy was to build partnerships with local governments and non-governmental organizations (NGOs) in the immediate vicinity of our field activities (Figure 19.1). Our strongest partnership with local authorities developed in the town of Oxapampa, Peru, where we established a semi-permanent presence with co-funding from the Andrew W. Mellon Foundation. The local Oxapampa government took a real interest in our work and as a consequence began a community program designed to reduce the dumping of trash in the river, which was previously the preferred technique of waste disposal. Informative signs and trash cans were placed along the river near the town center. We also began an environmental education program in the local elementary schools, and this developed into an annual “Día del Río” (day of the river) event in which local school kids hosted a mini fair in the town square, presenting drawings, models, and posters of their studies on river processes and good management practices. In two cases, individual students in AARAM took the initiative to partner closely with the small communities in which they worked. In both cases they produced educational materials and held community workshops presenting project results and discussing their implications.

Figure 19.1. Project P.I. meeting with mayor of Puerto Bermudez, Peru, to discuss project activities.

Our most productive local partnerships were forged with development NGOs, whose staff proved to be excellent complements to our technical teams. NGOs often make long term commitments to working with individual communities, and they therefore enjoy a level of community trust that a 3-5 year research program could not hope to achieve. They understand community needs and are able to see linkages between technical studies and community development that our team members would not. The ideal NGO partner is linked to larger international actors and activities, such that they understand better the context of the research themes emphasized by the IAI. For example, our most effective NGO partners were ProNaturaleza (Peru), which is closely associated with The Nature Conservancy, the Instituto del Bien Común (Peru), which has close ties to the Woods Hole Research Center, and EcoCiencia (Ecuador), which has acted as the local implementer of several international initiatives. Here too the strategy of building bridges through students was effective. Two staff members of EcoCiencia completed graduate degrees with AARAM.

Future challenges

The important lessons that emerged from the AARAM project will continue to challenge efforts to forge effective partnerships with policy makers and local stakeholders in the lesser developed countries of the Americas. A first challenge is to adapt the science to the immediate and existing interests of government agencies. We learned that research activities that do not address immediate national interests, regardless of merit, are unlikely to stimulate collaboration. The second challenge is to understand the scale at which decisions about resource management if one wishes to maximize the impact of science guidance. As we learned, for field-based research programs it may be more effective to shift focus to policy makers and stakeholders at the local scale. In this case, it is wise to develop partnerships with local NGOs who can better link research products to the needs and development programs of communities.

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