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CONDESAN
Consortium for the Sustainable Development of the Andean Ecoregion

Land and water management is one of the main thematic research areas at the Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN). Several efforts have focused on improving understanding of hydrological dynamics in the Andean highlands, which are the source of water for most of the population in the region. Based on an adaptive management approach, we are developing and assessing the implementation of sustainable land and water management practices to conserve and restore the environmental services of water regulation and provision. The assessment generates evidence on the outcomes of these practices and can help to inform decision-making processes towards achieving water security.

Tropical mountains matter for water provision

The Tropical Andes are a hotspot of biodiversity, hosting a wide variety of unique fauna and flora (Myers et al 2000). They provide important environmental services such as biodiversity conservation, carbon storage, and water supply. The Andean region is home to approximately 85 million people. Another 20 million people depend on mountain resources and ecosystem services stemming from the Andes (Devenish and Gianella 2012). Andean ecosystems provide reliable, high-quality drinking water to the inter-Andean valley. Large cities such as Quito, Ecuador, and Bogotá, Colombia, overwhelmingly rely (about 85% and 95%, respectively) on surface water from the local páramo, a tropical alpine ecosystem, for their water supply and ubiquitous hydropower projects (Buytaert et al 2011). Lima, Peru, the most populated city in the region, depends heavily on the Andes for its water.

Tropical mountain ecosystems are classified as highly vulnerable to the impacts of climate change (Parry et al 2007). Climate change projections suggest that upland areas will experience significantly greater warming effects than coastal plains (Bradley et al 2006) and greater precipitation variability, resulting in longer and/or stronger dry seasons. Climate change is likely to alter the processes that sustain tropical mountain ecosystems, with major implications for water supplies in the event that local water storage and regulation decrease. Many regions will face—or are already facing—significantly reduced or less reliable streamflow (Buytaert et al 2009).

Addressing knowledge gaps for governance of water resources

As in many regions of the world, an acute lack of data on the Andean region limits understanding of hydrological processes and the ways in which humans interact with local water cycles. Inadequate generation, access, and use of relevant information are major obstacles to advancement of more efficient management of water resources. As part of its work within the Regional Network for the Hydrological Monitoring of Andean Ecosystems (iMHEA), the Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN) has been quantitatively assessing the provision and hydrological benefits of green infrastructure. By "green" infrastructure, we mean well-conserved, well-managed ecosystems that are enhanced so as to provide hydrological benefits. For example, CONDESAN has assessed the effects on water cycles of various widely known, but poorly evaluated practices, including livestock grazing, land sparing, traditional watershed interventions, and water harvesting.

The resulting assessment data have been used by CONDESAN partners: (1) to undertake hydro-economic studies and replace assumptions on watershed interventions with evidence, improving decisions about implementation of gray and/or green infrastructure; and (2) to determine, in combination with cost curve studies, the best green interventions to improve water supplies. These analyses are indispensable to evaluate the cost-effectiveness of green investments. Going forward, they should be extended and reinforced to provide stakeholders with information and enhance their capacity to access financial instruments, such as public and private investment and incentives for conservation, among others.

A key factor to any such assessment is improving understanding of the context of different water users in the watershed. This includes understanding people's types of uses, demands, local economy, systems of knowledge, and governance related to water resources (Figure 1). Further, it means striving to understand the social dimension of water management, in addition to characterizing water availability and grasping the general situation of the environment and land use. As a first step, CONDESAN employed a methodology called Rapid Hydrological Assessment, which provides useful preliminary information to help prioritize

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FIGURE 1 The *bofedales* are wetlands of the *puna* in the Central Andes; they help with groundwater recharge, sediment accretion, and pollution removal. *Bofedales* can also be established and managed by families to generate more vegetation, which can be used as fodder for herds of alpacas. Pictured here: *bofedales* established by local inhabitants in Chalhuanca, Arequipa Region, Peru. (Photo by Bruno Locatelli)



conservation actions. The methodology has been incorporated into the procedures of Peru's National Superintendence of Services and Sanitation (SUNASS) to define public investment projects in watersheds. In the past, 1 obstacle to promotion of sustainable water management practices has been lack of capacity to include such proposals when formulating strategies of public investment. To address this shortcoming in Peru, for example, CONDESAN worked with SUNASS and the Ministry of Environment in Peru to create guidelines for formulation of public investment projects that aim at conserving and enhancing biological diversity and ecosystem services. However, work continues on the instruments and indicators necessary to evaluate the effectiveness of sustainable practices and implementation of green infrastructure.

CONDESAN's current and future work towards water security in the Andes

CONDESAN is currently implementing two key projects on water resource management across different sectors, scales, and entry points. In Peru, together with other members of the Invierte Verde Consortium, namely, Forest Trends (lead organization), the Peruvian Society of Environmental Law (SPDA), EcoDecisión, and the Imperial College of London, CONDESAN is implementing a project called Natural Infrastructure for Water Security (NIWS), funded by the US Agency for International Development (USAID) and the government of Canada. The NIWS project addresses institutional, technical, and capacity constraints to effective implementation of green infrastructure in sectors including sanitation, agriculture, industry, and hydropower. The overall project aim is to reduce water-related risks, with activities occurring at the national, subnational, and local levels. As part of the Invierte Verde Consortium, CONDESAN seeks to improve evidence-based decision-making on water resource management and the design of green infrastructure projects through information management platforms. At the local level, collaborative work with the iMHEA is being extended and strengthened in Peru in order to identify the hydrological impacts of different natural infrastructure projects promoted and implemented in learning sites. The results will inform the design, public and private financing, and implementation of further projects aimed at increasing water security.

CONDESAN's second key project on water resource management is Adaptation to the Impacts of Climate Change on Water Resources in the Andes (AICCA), which began in

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March 2018 and goes for 4 years. It is a regional initiative that unites the countries of Bolivia, Colombia, Ecuador, and Peru as national partners. CONDESAN is implementing and executing the project at the regional level with financing from the Special Fund for Climate Change (SFCC) of the Global Environment Facility (GEF). The objective of the project is to generate relevant knowledge that incorporates insights regarding variability and climate change into planning instruments for watershed management. This will help to define priority areas for pilot investments in the sectors of biodiversity conservation, agriculture, hydroelectric power, sanitation, and drinking water for the 4 countries. The adaptation measures implemented will be monitored to validate their robustness and relevance to achieve adaptation. The results and lessons learned from this process will influence the formulation of policies at the local and national levels.

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