Páramos: A Mountainous Water Storage System and Its Vulnerability to Climate Change

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Páramo Rumipamba volcano, Ecuador. Photo by Miriam Rios


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INTRODUCTION

GENERAL FACTS

Tropical alpine ecosystems are located in highlands, between the upper forest limits and the permanent snow line, typically between 3200 and 5000 m elevation. *Páramos* is used to refer to these ecosystems in areas of Colombia, Ecuador and Peru (Smith & Young, 1987; Buytaert et al., 2006).

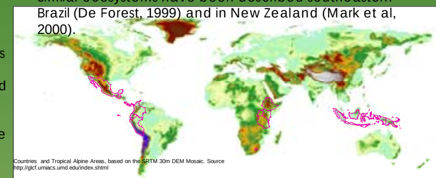
Variable topography, diverse vegetation and fauna, the presence of bog and marshes, lakes and creeks, and seasonal changes in climate give páramos unique physical characteristics and beauty. Among the most important characteristics of these ecosystems are the presence of highly adapted vegetation to the climate and the water regulatory properties, especially in South America.

Among mountainous ecosystems of the world. páramos are especially important as a sophisticated water storage system (Medina, 1999). Páramos are considered as ecosystems with high water production and an elevated regulation capacity. Rivers coming from páramos have a high a sustained base flow through the year (Buytaert et al, 2006; Hofstede et al, 2003).

GEOGRAPHICAL LOCATION

Tropical alpine environments exist in eastern Africa, stretching from Ethiopia and Uganda to Kenya, Tanzania and Lesotho (Wesche, 2003). In eastern Asia, they exist in New Guinea, Indonesia and Malaysia; in Central America they have been reported in Mexico, Guatemala, Costa Rica and Panamá; In South America, Colombia, Ecuador and Peru have tropical alpine environments. Giant rosettes are the most characteristic aspect of this environments (with the exception of the Mexican páramos) that differentiate them from temperate alpine and polar areas (Smith, 1987).

Similar ecosystems have been described southeastern Brazil (De Forest, 1999) and in New Zealand (Mark et al, 2000).


Countries and Tropical Alpine Areas, based on the SRTM 30m DEM Mosaic. Source http://glcf.umiacs.umd.edu/index.shtml

IMPORTANCE

Ecological diversity, organic carbon storage in the soils and water are among the most valuable assets of páramos ecosystems. For instance, part of Nile River headwaters comes from Páramos areas in Ethiopia. Amazonas river headwaters are partly located in páramos areas as well

Economically, páramos and similar ecosystems provide environmental benefit to more than 100,000,000 people (Hosftede, 2003). Aqueducts for cities like Quito, Ecuador (2,000,000 inhabitants) and Bogotá, Colombia (8,000,000) convey most of the drinking water from páramos areas (85% and 95% respectively). Water is also used extensively for agriculture.

Due to the topography of these regions, hydropower projects are very common. The Lesotho area in Africa derives most of its income by selling water to South Africa (Nthako et al 1997).


Páramo of Cotopaxi volcano, Ecuador. Photo by Esa Gross


Photo by: Miriam Rios, C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PHYSICAL CHARACTERISTICS

CLIMATE

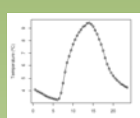
Solar radiation is constant throughout the year in the páramos. There is, however, a great seasonal and spatial variation in rainfall and cloud cover. Fog is very common. Although there is a low annual variation in mean daily temperature, daily temperature variations make these areas subject to being characterized as, "summer every day, winter every night" (Buyaert, 2006, Smith et al, 1987, Wesche, 2003). Precipitation varies from 500 to 6000 mm depending on the geographic location, related to the position relative to regional circulation patterns like ENSO; position of the ITCZ, and variations in topography Seasonal drought is common in these kind of ecosystems (Luteyn1999; Rangel, 2000, Pabon et al., 2001) and the vegetation has adapted to the unique climatic, seasonal, and soil conditions.

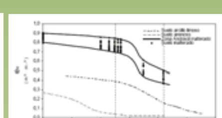
SOILS

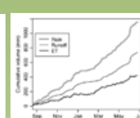
Studies about soils in páramos have been done mainly in Ecuador and Colombia. There is lack of literature about soils in other tropical alpine ecosystems. Páramos soils have excellent properties for water retention due to elevated concentrations of organic carbon (>40%) and the porous structure. Water retention capacity can reach 90% (Rondon et al., 2000, Gomez, 2001; Buyaert, 2006).

VEGETATION

Most of the plants of tropical alpine environments share common physical characteristics. By far giant rosettes are the most representative plants of these ecosystems., Tussock grasses and cushion plants are also part of the dominant life forms. It is generally believed that the forms are morphological and physiological adaptations to buffer the extreme daily variations in temperature and to increase water storage (Smith,1994;Leuschner,2000).


Daily temperature oscilations Páramo de Chanlud, Ecuador (Buytaert,2006)


Water retention curve for several types of soils in Ecuador. (Iñiguez,2003 in Buytaert,2006)


Cumulative water balance of a typical ecuadorian páramo Chanlud, Ecuador (Buytaert,2004 in Buytaert,2006)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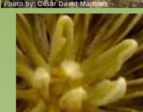
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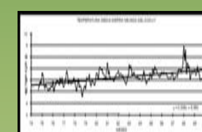
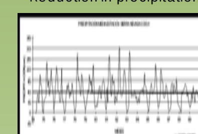
VULNERABILITY TO CLIMATE CHANGE

PROJECTED CLIMATE CHANGE

-Increasing temperature


Data from El Cocuy paramo in Colombia Courtesy of J.D Pabón

-Reduction in precipitation


Data from El Cocuy paramo in Colombia Courtesy of J.D Pabón

IMPACTS

-Changes in soil characteristics: less water storage capacity, subsequently a reduction in water production and regulation.

- Reduction in the areal extent of the páramos areas: release of organic carbon, reduction in water production and regulation.

-Increase occurrence of wildfires: changes in vegetation type, changes in components of water cycle: transpiration

- Receding glaciers: Less amount of water infiltrating to the system, inputs will occur over shorter time scales, causing faster pass-through

CONSEQUENCES

- Reducing páramos water production: impact in water supplies systems for big cities with enormous economical impacts

- Increase of activities such as human cultivation, intensification of livestock grazing, pines plantation and tourism, alteration of the hydrological behavior of the páramo, affecting directly the water supply function.

INFORMATION STILL NEEDED

-Effects of receding glaciers on the hydrology of páramos

-Influence of groundwater in the hydrology of páramos.

-Role of vegetation in the hydrology of páramos.

-Evaluate the water storage capacities of soils in tropical alpine ecosystems of Africa, Central America and Eastern Asia.

-More detailed hydrological studies are needed to improve the understanding of the hydrological cycle and water budget in these areas, including the quantification of precipitation due to condensation of fog and interception by vegetation

- Better simulations to evaluate climate change, to include the large spatial variability in topography and seasonal meteorological conditions

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