SEI Stockholm Environment Institute

Hydro-ecological monitoring of high-elevation wetlands in the Katari watershed, Bolivia

SEI fact sheet
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Bofedales wetlands in the Katari watershed

Bofedales are a type of high-elevation wetlands with a unique floristic composition that are typically situated in the Andes Mountains above 3,800 metres. Their unique characteristics are derived from almost permanent inundation by the outflow of shallow groundwater and seasonal surface water from rain and glacial melt. Bofedales play a critical role in the Andean plateau communities in Bolivia and Peru, as they control the water balance and regulate soil and nutrient cycles of mountain watersheds. In particular, the bofedales in the watersheds northwest of the La Paz-El Alto metropolitan area, which drain into the famous Lake Titicaca (Figure 1), support a sustained water supply to local communities as well as the urban water supply system for its 2.3 million inhabitants.

Over recent decades, the health of the bofedales in Bolivia generally, and in the La Paz-El Alto region specifically, has been deteriorating due to overgrazing, urbanization, construction of dams, and uncontrolled groundwater extractions that support mining activity. Evidence indicates that climate change is also damaging these wetlands, though these exact impacts are still poorly understood (SEI, 2020).

This factsheet summarizes the project carried out by Stockholm Environment Institute (SEI) as a first step towards better monitoring and understanding the impacts of climate and human activity on the Bolivian bofedales. Supported by the Inter-American Development Bank (IDB), SEI worked closely with national and local governments, including the Bolivian Ministry of Environment and many scientific counterparts.

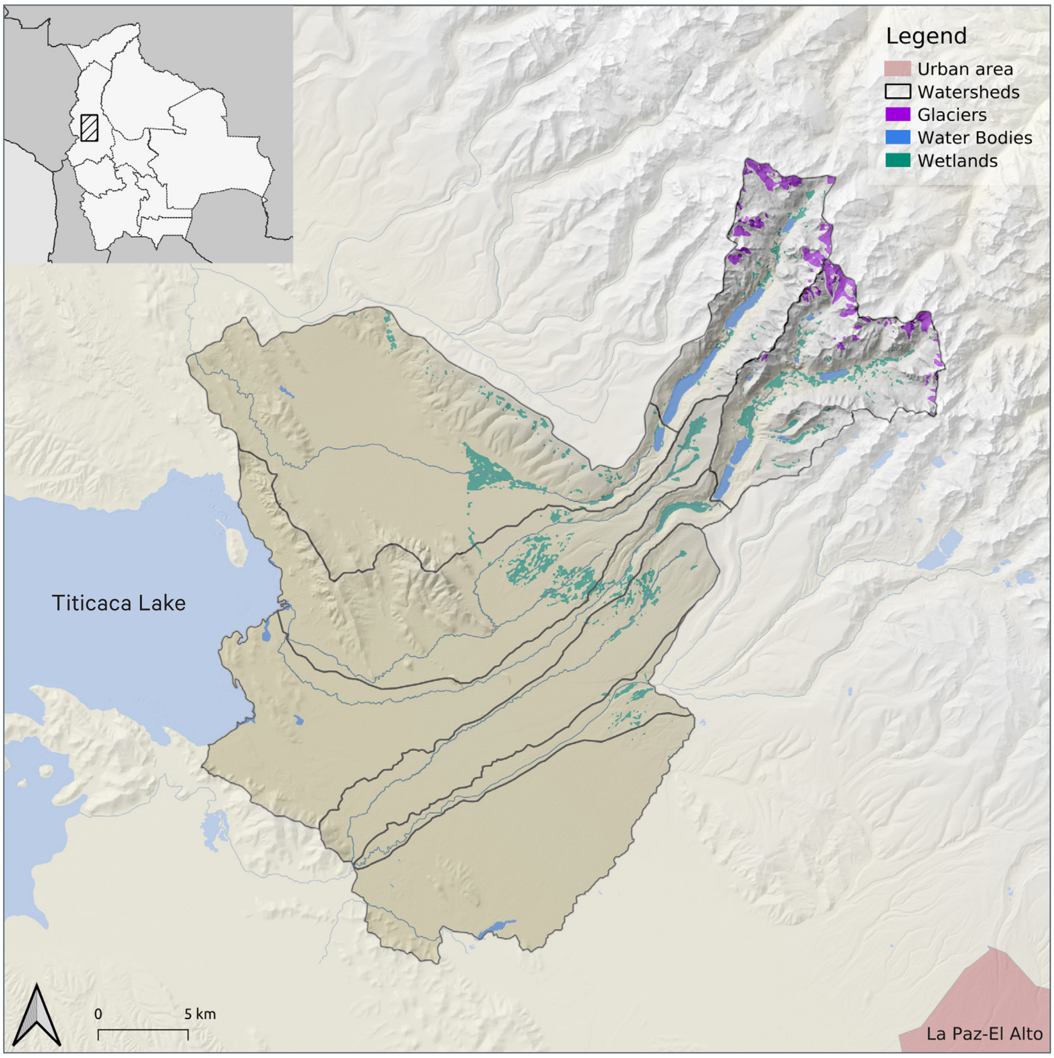
Spatial data to monitor bofedales wetlands and model their water demands

A first step in protecting the bofedales' ecosystem benefits is to study the hydrological regime that supports them and understand underlying connections between the hydrological and ecological systems. To conceptualize the water balance in the watersheds northwest of La Paz and build a decision support system geared towards integrated watershed management, we developed a WEAP (Water Evaluation and Planning) model. WEAP illustrates hydrological processes in a basin and evaluates water demands – including environmental requirements – and potential supply conflicts between users (WEAP, 2021).

Given the lack of long-term observational hydrological records and environmental data, SEI also carried out a remote sensing study. We constructed a dataset of 222 satellite

IMAGE (HEADER): Condoriri Peak and lake in Cordillera Real, Andes, Bolivia

Figure 1. Bofedales, glaciers, water bodies and main watersheds in the study area.

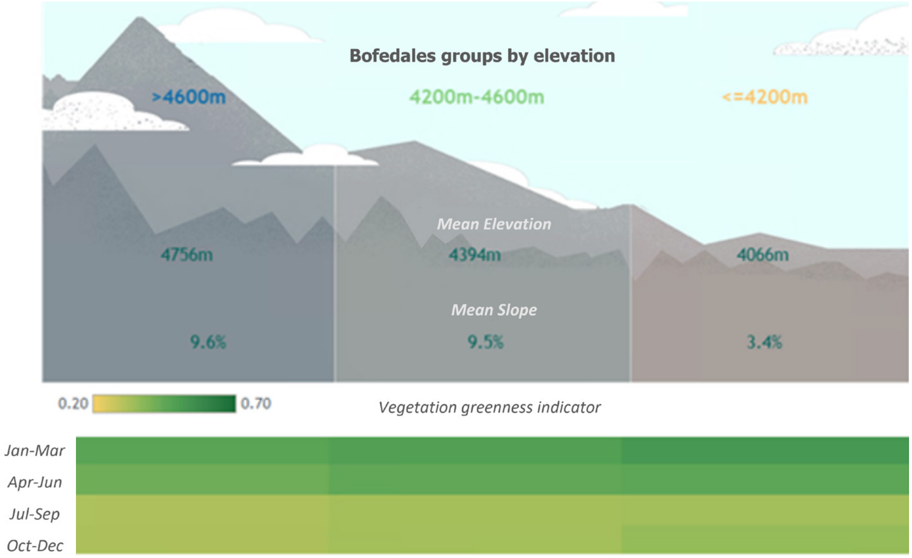


images spanning a 36-year period (1984–2020). From each image, we calculated widely used indicators that describe vegetation greenness, the presence of open water and snow cover. The seasonal, annual and long-term variations of spectral indicators can tell us about changes in these land cover characteristics. The greenness indicator informs us about how productive (i.e., healthy) the wetlands are while variations in snow cover and water body extent reveal climate and hydrological changes.

How climate change may be impacting high-elevation wetlands

The multi-temporal remote sensing analysis of indicators highlights hydrological characteristics of the high Andean wetlands and possible consequences of climate change on bofedales and the water cycle. Using a combination of terrain analysis, remote sensing data and local researchers' input, we established an initial classification of wetland types based on elevation ranges and hydrological conditions. The seasonal variations of vegetation and open water signals suggest a distinct difference in vegetation and water patterns between the highest-elevation wetlands (above 4600 m) and the lower wetlands (below 4200 m) (Figure 2). The latter appear to be greener and more productive, which can be justified by the higher temperatures at lower elevations, as well as more constant groundwater outflows.

Figure 2. Illustration of bofedales vegetation greenness signal at different elevations. The closer the indicator is to 1, the greener the vegetation.



The snow indicators reveal a dramatic impact of climate change with loss of glacier area. There are also strong indications of changing snow and rainfall dynamics. While the glaciers of the Cordillera Real – the mountain range that feeds the wetlands – are clearly retreating, the impacts of climate change on bofedales might be positive for the time being, given the vegetation's generally greening trend. This could be related to the greater supply of snow melt and rainwater, as well as higher temperatures. It is likely, however, that climate change will negatively affect the area in the longer term, once aquifer recharge begins to decline due to glacier retreat and altered precipitation patterns, and when the adaptive capacity of the wetland vegetation has reached its limits.

Towards a deeper understanding of bofedales' eco-hydrology

Dependent on funding, SEI aims to deepen the analysis of the complex hydrological processes that sustain bofedales wetlands by validating the spatial data and modelling observations with field data. Measurements of the groundwater's discharge, evapotranspiration, and groundwater residence times could improve the classification of the wetlands according to their hydrological behavior. In addition, contributions from local actors could support a more complete mapping of the wetland species. SEI then expects to refine the representation of wetlands in the conceptual WEAP model and develop model scenarios of climate change, population growth and possible infrastructure developments in the basin.

References

SEI, 2020. https://www.sei.org/projects-and-tools/projects/hydro-ecological-monitoring-and-modelling-of-high-altitude-wetlands-in-the-katari-watershed-bolivia/

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