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Research Article

Identification of High Andean Wetlands using SRTM & LANDSAT Images at the Head of the Chaschuil River Basin, Catamarca, Argentina

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Abstract

This work shows a study carried out in the upper area of the Chaschuil Valley in the South Ramsar Subsidy of the province of Catamarca for the identification of wetlands through the analysis of SRTM and LANDSAT images. Factors influencing the use of wetlands, such as size, fertile plains, water dynamics and associated vegetation, were considered. The image processing of the Landsat 8 satellite (PATH-ROW = 232-079) was carried out, as well as the sampling data of the January 2019 campaign. Base maps were generated and analysis of geographic information system (GIS) to classify water bodies. The results allowed us to better understand the relationship between the geomorphology of the basin and its water dynamics and allow us to advance in the study of wetlands of importance to the ecosystem of the region.

Keywords: Wetlands, SRTM Images; Water; GIS

Abbreviations

GIS: Geographic Information System.
SRTM: Shuttle Radar Topography mission.
DEM: Digital Elevation Models.
NDVI: Normalized Difference Vegetation Index.

Introduction

The Ramsar Convention (2010) defined wetlands as "extensions of marshes, swamps and peat lands, or surfaces covered by waters, whether they are natural or artificial, permanent or temporary, stagnant or current, sweet, brackish or salty, including extensions of sea water whose depth at low tide does not exceed six meters".

Wetlands are among the most threatened landscapes in the world, endangering a wide variety of flora and fauna that depend on them for their survival. With the current growth trend of the world population, the increasing pressure on water resources, and the threats posed by climate change; the classification and identification of wetland landscapes, and the evaluation of their environmental status; it will contribute to taking into account the geo-ecological services they provide to society in territorial planning processes (Martínez et al., 2014).

Wetlands are some of the most important biodiversity areas in the world and constitute the fundamental habitat of numerous species; Furthermore, they are particularly important providers of water-related ecosystem services, because they regulate the quantity and purify surface waters, favor the recharge of groundwater, and in some cases help regulate floods and mitigate the impact of storms. (Brena et al., 2016).

After identifying a wetland, its delimitation is essential for protection and monitoring. This information, in addition to its scientific value, can help managers to arbitrate conservation measures, and to detect inappropriate interventions or uses.

When the water layer is not permanent and suffers marked fluctuations, the delimitation is technically problematic and often socially conflictive (Castañeda and Isern, 2009). Both characteristics are distinctive in inland wetlands in arid areas, such as the lagoons and plains located in the Chaschuil Valley.

The High Andean Wetlands (HAA-also known locally as bofedales) belong to a type of ecosystem characterized by having perennial vegetation within the semi-arid landscape of the high Andes. Groundwater originating from the rains and melting of glaciers and the melting of snow is the main source of water for these HAA. HAAs also play an important role in the provision and regulation of water in the basin (Garcia and Otto, 2015).

The objective of this work is to identify high lagoons and fertile plains in the South Ramsar Subsite of the province of Catamarca, using SRTM models of 30 meters of resolution and Landsat 8 images of the upper basin of the Chaschuil river as an advance in the study of wetlands and the ecosystems of the region.

Study area

The area is located in the northwest of the Tinogasta department, west of the Catamarca Province, 350 km from the capital of Catamarca. It is a longitudinal valley that extends to the west of Fiambalá, head of the homonymous district, and which can be accessed from Tinogasta by National Route No. 60 until reaching the San Francisco pass, which connects Catamarca with the Republic of Chile (Fig. 1).

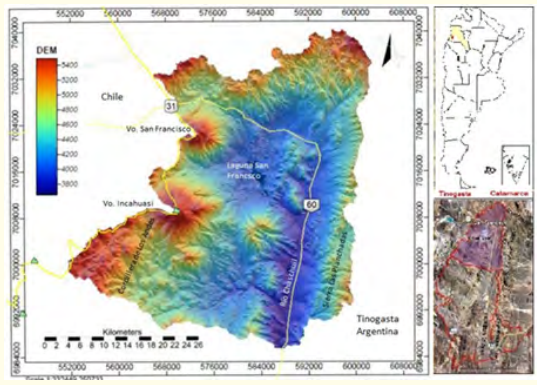

Figure 1: Study area. Upper basin of the Chaschuil river.

The relief of the study area, corresponds to a transition zone between the Puna Austral and Cordillera Frontal geological provinces, it differs from the Puna by the geological characteristics of the rock units that compose it (folded and fractured Paleozoic sediments), but the appearance In general, it is similar to that of Puna: gently undulating plains interrupted abruptly by mountain ranges and volcanic cones, culminating in salt flats, lagoons or plains, in the lower areas. Within the area volcanic apparatuses dominate, exceeding 6000 meters in height, while surrounding it are the most prominent orographic features (mountain ranges and mountain ranges) that

enclose the upper basin of the Chaschuil River. The landscape made up of groups of mountain ranges and hills that enclose valleys and pockets, and that due to their amplitude imprint particular characteristics with little vegetation on the landscape. In the fertile plains or wetland area, the "brama" Bouteloa simplex appears, an annual grass that grows together with Muhlenbergia atacamensis. Trifolium amabile "Puna clover" with Dichondra argentea, Astragalus bustillosii and Astragalus micranthillus, the "culina" (Ipomea minuta) that has edible roots, the "Puna chicory" Hypochoerismeyeniana (Fig. 2) (Paoli 2002).

Figure 2: Images of wetlands in the Chaschuil Valley - heights between 3,000 and 3,700meters above sea level, January 2019 field campaign.

In Catamarca is one of the most important tourist attractions of the snow-capped peaks of the Andes, known as "Seismiles" or "Ruta de losSeismiles" and a chain of high lagoons that constitute the highest air passage area of the Andes Mountains.It is an area of great beauty, where you can appreciate these peaks that were the scene of long pilgrimages and ceremonies by the original Andean cultures who recognized the Seismiles as the abode of gods and supernatural beings. Over the years, led by Monte Pissis, Ojos del Salado and Incahuasi, these summits became important challenges for mountaineers around the world.

Materials and Methods

Four 30-meter resolution SRTM Digital Elevation Models (DEMs) that cover the study area were downloaded from Earth Explore. In SAGA GIS, a mosaic and cut of the area of interest was made from a shape file of the upper basin limit of the Chaschuil river. The SRTM30 needs to be pre-processed before using it in the analysis, so the first step was to reproject the MDE to the flat coordinate system, then the second step was to fill in the blanks by applying a Gaussian filter to remove noise from high frequency which makes the DEM look a bit granular. Finally, in this software the analysis of slopes, roughness, slope orientation and the base level of the drainage network was performed. Subsequently, the analysis of terrain, Geomorphons, cluster, Landforms was performed.

In the generated maps, a color classification was applied to those that gave the best results, which better highlighted the wetlands and depressions that were to be identified, leaving to analyse: Geomorphon, Cluster, LS-Factor and Topographic Wetness Index. The selected maps were Topographic Wetness Index and Geomorphon as the most representative for the proposed objective.

For the analysis of the Landsat 8 image of summer of the year 2019 (PATH-ROW = 232-079), obtained on the USGS download platform, the QGIS software and its GRASS GIS complement were used. In this software, the images were cut out and the NDVI was calculated. Once the Index was obtained, it was classified into Pseudocolor single-band to highlight the water and vegetation of the other covers.

Optical and radar data provide different types of information (Solorza et al, 2016), so the use of both was necessary since they allow us to overcome limitations that each of the types of data have separately.

Results and Discussion

This basin, located in the western region and at more than 3,500 meters above sea level, receives permanent waters from the Las Peladas, Las Lozas and El Cazadero rivers. Along the axis of the valley there are natural upwelling areas (plains), motivated by morphological narrowing. These appear where the mountain ranges approach and the impermeable rocks close the subsoil waters, underground and transversely.

In the upper basin of the Chaschuil River, 5 fertile plains (low, flat, fertile terrain) of different dimensions were identified, based on the application of the NDVI Index in a summer Landsat image and taking into account the research carried out previously in the study area (Fig.3). They are the result of water dynamics, which responds both to the prevailing climate and to the structures that prioritize its route. They are of great environmental importance within the area and are in delicate balance with the geoforms of glacial-periglacial origin that surround the valley.

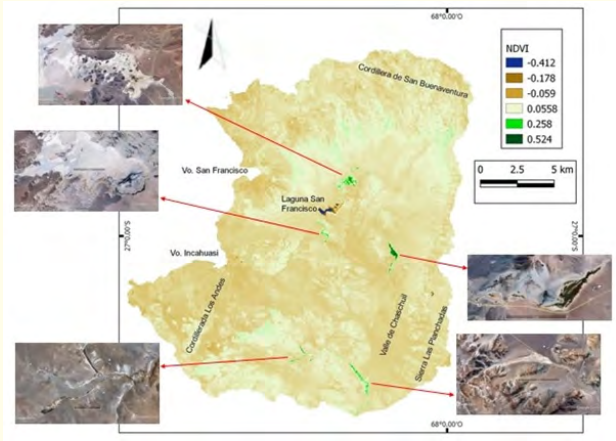

Figure 3: NDVI of the Lands at 8 the basin and Google Earth Pro images of the five identified valleys.

In the identification of wetlands, the NDVI was used as an auxiliary image to discriminate water from the land and other types of cover (bare soils, other vegetation) in order to identify wetland ecosystems.

Regarding the use of SRTM models with a 30-meter resolution, interesting maps were obtained that helped to delimit the depressions that house the plains and, in turn, allowed differentiating those depressions that accumulate water in the upper parts of volcanoes, runoff zones and accumulation-infiltration zones, where the characteristics for wetland formation are promoted.

As can be seen in Figure 4, the Topographic Wetness Index helps to visualize the drainage network, even the one that flows within the depressions of the Chaschuil Valley, this allows us to understand the water dynamics that occur in the depressions that host wetlands. By highlighting the depressions, their size, ratio, runoff, altitude, etc. In a sector where drought prevails, this index makes it possible to predict the behavior in summer, the accumulation of ice and snow, and the water storage capacity for the balance of the fertile plains ecosystem.

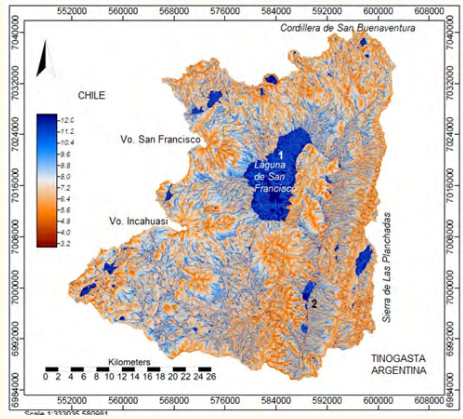

Figure 4: Topographic moisture index map, allows to visualize the drainage system, even the one that flows within the depressions of the valley.

On the other hand, the Geomorphon map (Fig. 5) discriminates between the previously observed depressions and allows identifying those sectors that present characteristics for the occurrence of meadows, where the depressions containing wetlands are represented in green. This classification coincides with the results obtained by applying the NDVI index in the Landsat 8 image. The importance of this map also lies in that it allows to differentiate the valley depressions from those found in the volcanoes at higher altitudes, when compared with the Topographic Wetness Index. The latter accumulate snow and ice that, as temperatures rise, run off as the main contribution to the adjacent low areas classified with the Geomorphon and with the NDVI.

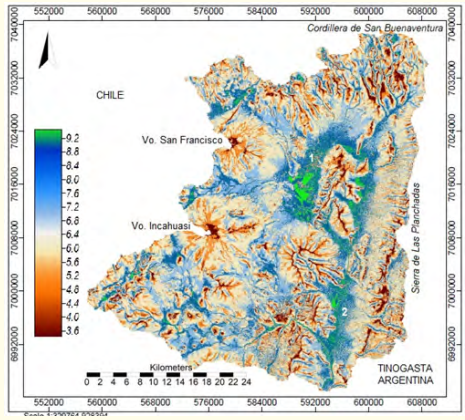

Figure 5: Geomorphome map, where depressions with wetlands are represented in green, 1. Lagoon the San Francisco, 2. Chaschuil Valley.

Conclusion

The extreme conditions and the scarce presence of fertile plains with permanent water make this one of the most inhospitable areas in the Argentine Northwest. In the territory that the study area occupies, only the presence of temporary inhabitants is registered in the Gendarmería and National and Provincial Roads camps, installed at the latitude of the places: Las Cuevas and San Francisco salt flats, a few kilometers from El Paso International.

The Landsat and SRTM images used were appropriate, due to their spatial resolution and spectral characteristics, which makes them suitable for this type of study.

The Normalized Difference Vegetation Index (NDVI) calculated for the image was of great help as a first step in identifying the bodies of water, specifically the water mirror of the target wetlands of this work and the vegetation that characterizes them.

The maps generated from the mosaic made with the SRTM models allowed us to better understand the relationship between the geomorphology of the basin and its water dynamics. It was possible to identify bodies of water or depressions that accumulate snow and melt water on the top of volcanoes and their discrimination of those depressions at the bottom of the valley that generate the conditions for the formation of high-altitude plains, both permanent and temporary.

The best results are observed in: NDVI, Geomorphons, Topographic Wetness Index, Cluster and LS-Factor, which in turn reaffirm the results.

The fertile plains and wetlands are very vulnerable to the decrease in the contribution of water, they are the first to dry when the river bed decreases, in this way they can serve as an alert if their characteristics change. Their importance lies in the fact that they constitute fertile land, which in a controlled way can be used for cultivation and grazing at certain times of the year.

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