Remittances Review
June, 2023
Volume: 8, No: 4, pp. 2143-2151
ISSN: 2059-6588 (Print) | ISSN 2059-6596 (Online)
remittancesreview.com

Received: 11 November 2022 Accepted: 15 March, 2023
DOI: https://doi.org/10.33182/rr.v8i4.149

Change in the vegetation cover of wetlands in Pueblo Libre, Huancavelica, period 2016 - 2018

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Abstract

Wetlands play an important role in mountain ecosystems, providing ecosystem services such as natural water and food for livestock, but due to human activities such as overgrazing and burning of pastures, there is degradation, soil compaction and decrease of vegetation cover, whose recovery takes a long time. The study aims to determine the variation in vegetation cover of the wetlands of the town of Pueblo Libre, Huancavelica, period 2016 - 2018, for which we worked with a sample of 15 wetlands, obtaining their areas with the help of Sentinel satellite images using QGIS software and the commercial program ArcGis. It is highlighted among the results that there are 15 wetlands in Pueblo Libre, with an area of 1 024 421.99 m2 in 2016 and a total area of 901,653.70 m2 in 2018, which are located between 4 315 to 4 862 m a.s.l.; being the highest point 9 with 4 862 m a.s.l. It is concluded that there are 15 wetlands in Pueblo Libre, with an area of 1'024,421.99 m2 in 2016 and a total area of 901,653.70 m2 in 2018. It is concluded that there is a significant percentage variation greater than 10% of vegetation cover of wetlands in terms of area in the town centre of Pueblo Libre between 2016 and 2018 with a confidence level of 0.99%, which generated the loss of 11.98% of wetlands.

Keywords: *High altitude wetlands; wetland; vegetation cover; Sentinel*

Introduction

The wetlands are flora found in the bottoms of the valleys, in the channels and margins of the rivers and streams, or in places with springs on their margins, which are characterized by their constant irrigation at all times (1). In winter, from May to June, the bofedal is pale yellow and the water freezes. They are always composed of different native plants: rushes (Juncus capitatus), grasses (Festucas sp, Calamagrostis sp and Agrostis sp), distributed according to the amount of surface water. Climate change is an important factor affecting the well-known high Andean wetlands or "qochas" since they are considered fragile ecosystems during seasonal changes, that is, in dry and rainy seasons (2), although their function of water retention and food source for cattle

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and sheep should be emphasized.

Changes in vegetation cover directly affect soil erosion, the hydrological cycle and biodiversity loss, as well as nutrient movement in watersheds and habitat loss. Land cover assessment is an essential part of the land use planning process and is considered a complex, dynamic and interdisciplinary work in which the need for change is recognized, goals and recommendations for its implementation are identified, as well as alternative forms of use, management and identification of different land uses (3,4).

Over the years, Andean peoples have become more sensitive and frequent to natural events such as droughts, frosts, floods, and are more vulnerable in the adaptation process, so that the population, crops and livestock are affected by changes in temperature and precipitation (5,6), adding to this the use of the "eyes of water" or puquiales to wash clothes of the population and the continuous daring of solid waste above vegetation cover, altering current biodiversity (7.8); It is worth mentioning that mountain ecosystems are very fragile due to climate change, which requires the development and implementation of conservation plans at the national level. reason why the objective of this study is to determine the variation of vegetation cover of the wetlands in the population center of Pueblo Libre, Huancavelica, period 2016-2018.

The importance of these ecosystems focuses on their environmental services linked to the use of their flora, such as reeds and totora, which are used in the manufacture of handicrafts for sale; and of course in carbon sequestration, becoming important mitigators of climate change (9,10).

MATERIALS AND METHODS

The research was developed in the population center of Pueblo Libre, district, province and department of Huancavelica, at 3 946 m a.s.l., with an average temperature of 19, 8º in the day and -4º at night and at 4336 m a.s.l., the experimental phase considered the data of the period 2016 - 2018, using the Geospatial technique with the ArcGis instruments, Qgis, Geomatic, Erdas, to evaluate the variable: variation of vegetation cover.

The methodology consisted of downloading satellite images from the Sentinel satellite of the European Space Agency (ESA). This image was used for different fields of research. SENTINEL-2 data were acquired in 12 spectral bands in the visible and near-infrared (VNIR) and short-wavelength infrared (SWIR) spectrums. The download was made with the name

"s2a_msil1c_20170506t105031_n0205_r051_t30syj_20170506t105029.safe" (being the code sent by the agency to conduct the study).

For the processing of satellite image, SNAP, QGIS with the Sen2Cor tool was used, with which we can perform the atmospheric corrections of Sentinel 2 images and get from a product level 1C to 2A. Sen2Cor performed atmospheric correction in the SNAP environment by replicating the band file structure and allowing a new pixel resizing at 10, 20 and 60 meters of spatial resolution.

After performing the atmospheric correction, bands were combined with ArcGis for different types of analysis of atmospheric and territorial components, but for this study a natural color combination was carried out to obtain the reflectance of the vegetation: Sentinel 4,3,2 and Land uses / water bodies: Sentinel 8A,11,4. Sentinel images feature Level 1 (S2_MSI_L1C): georeferenced top-of-atmosphere reflectances (TOA). And Level 2 (S2_MSI_L2A): georeferenced ground level reflectances (BOA).

After the combination, the vegetation cover of the wetlands and classification of these areas were carried out; Later it was exported in shape format for the generation of the maps.

The technique used was the geospatial analysis of data that was carried out through the use of QGis v. 3.6.1 software, following the procedure for obtaining the Sentinel images of the European Space Agency, according to years 2016 and 2018, to then be processed with computer instruments such as ERDAS, GEOMATIC, ARCGIS, QGIS AND SNAP WHICH HELPED TO PERFORM THE ATMOSPHERIC CORRECTION, obtaining the reflectance, resizing pixels and finally establishing the vegetation cover of the populated center of Pueblo Libre according to the years 2016 and 2018, the database collection was carried out and the field work was done to validate the data and the cabinet work was carried out for the spatial analysis to obtain the maps in the Arc.Gis V.10.2 Software.

To have reliability in the calculations of the results, the data were processed with the geographic information systems program (ArcGis, Qgis, Geomatic, Erdas), through the PLUGGIN and SNAP tools, using Euclidean and geodetic methods. Euclidean zones of influence measure distance in a two-dimensional Cartesian plane and geodetic zones of influence are those that represent the actual shape of the earth. These are the most common types in its use, likewise the descriptive and inferential statistics were used, with the statistical significance of the proportions difference test, using the following formula:

.

$$\hat{p}_0 = \frac{n_x \hat{p}_x + n_y \hat{p}_y}{n_x + n_y}$$

RESULTS

Figures 1 and 2 show the vegetation cover of the wetlands for the years 2016 and 2018, respectively, obtained in the software Arc.Gis V.10.2; while Tables 1 and 2 show the vegetation cover (m2) of the wetlands of Pueblo Libre for the years 2016 and 2018, respectively. Table 3 shows the variation of vegetation cover of the wetlands in the populated center of Pueblo Libre in the years 2016-2018; while Table 4 shows the height above sea level of these wetlands.

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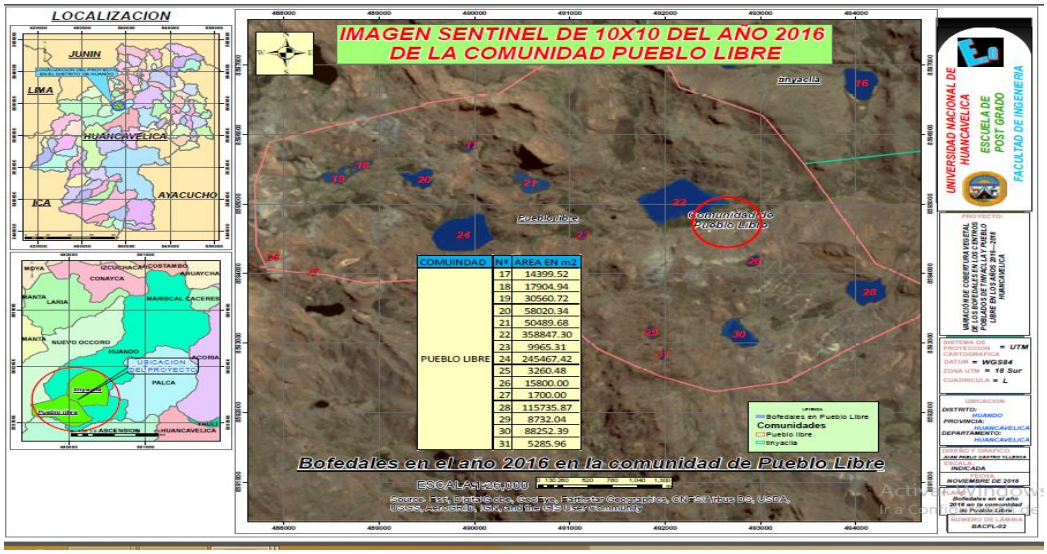

Figure 1. Vegetation cover of the Bofedales in 2016 in Pueblo Libre

Table 1. Vegetation cover of wetlands in square meters in the town center Pueblo Libre in 2016

Community	Bofedal	Area in m²	%
Pueblo Libre	1	14 399.52	1.41
	2	17 904.94	1.75
	3	30 560.72	2.98
	4	58 020.34	5.66
	5	50 489.68	4.93
	6	358 847.30	35.03
	7	9 965.31	0.97
	8	245 467.42	23.96
	9	3 260.48	0.32
	10	15 800.00	1.54
	11	1 700.00	0.17
	12	115 735.87	11.30
	13	8 732.04	0.85
	14	88 252.39	8.61
	15	5 285.96	0.52
Total		1 024 421.99	100

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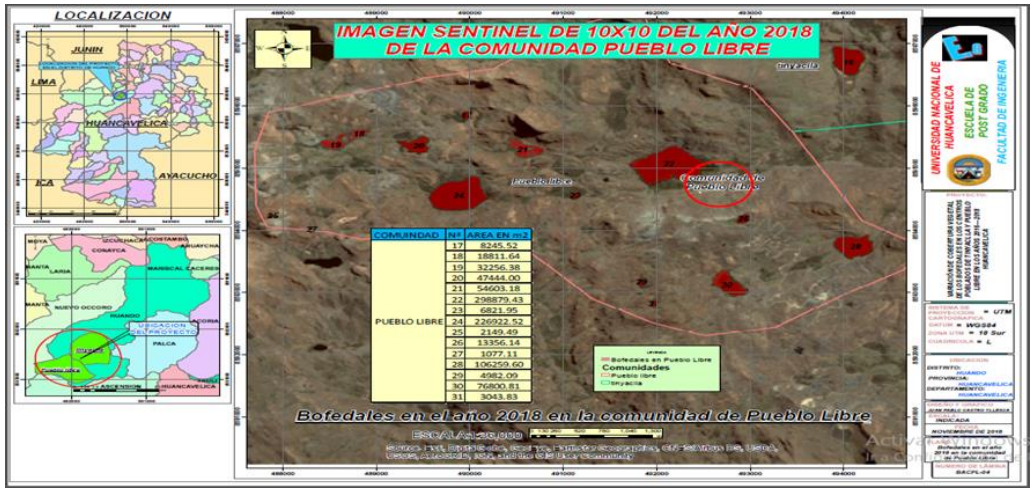

Figure 2. Vegetation cover of the Bofedales in 2018 in Pueblo Libre

Table 2. Vegetation cover of the wetlands in square meters in the Pueblo Libre population center in 2018

Community	Bofedal	Area in m2	%
Pueblo Libre	1	8 245.52	0.91
	2	18 811.64	2.09
	3	32 256.38	3.58
	4	47 444.00	5.26
	5	54 603.18	6.06
	6	298 879.43	33.15
	7	6 821.95	0.76
	8	226 922.52	25.17
	9	2 149.49	0.24
	10	13 356.14	1.48
	11	1 077.11	0.12
	12	106 259.60	11.78
	13	4 982.09	0.55
	14	76 800.81	8.52
	15	3 043.83	0.34
Total		901 653.70	100

Table 3. Variation of vegetation cover of wetlands in the populated center of Pueblo Libre in the years 2016-2018

Year	Area in m2	%
2016	1 024 421.99	100
2018	901 653.703	88
Difference	122 768.287	12

Table 4. Height in meters above sea level of the wetlands of the town center of Pueblo Libre

Bofedales Altitude		
	Bophedal	(m s.n.m.)
Pueblo Libre	1	4600
	2	4635
	3	4690
	4	4639
	5	4565
	6	4389
	7	4439
	8	4507
	9	4862
	10	4615
	11	4792
	12	4412
	13	4647
	14	4480
	15	4641

DISCUSSION

The difference of 122 768,287 m2 equivalent to 12% obtained in the present research work, in relation to the general objective that establishes to determine the variation of vegetation cover of the wetlands in the populated center of Pueblo Libre, Huancavelica, in the years 2016-2018, agree with Olivares (3) who mentions that the loss of vegetation cover in the province of Yauyos was negative, exceeding 10.5% of the total area.

This research corroborates the negative effects of climate change on the water supply of a community (11), coinciding with Rosas y Trucios (12) and Zeballos et al. (13) who proposed to quantify the variability of wetlands within the context of climate change, taking into account that total snow and wetland cover can have a high interannual variability, The algorithm helps to quantify the temporal evolution of the surface of snow-capped mountains and wetlands; it had previously been asserted that there is variation of healthy and vigorous vegetation cover in periods

of time, especially in times of climatological phenomena such as "El Niño" (14). In response to the worrying decrease in vegetation cover, the theory of global warming is taken into account, where it is expressed that this generates meteorological changes that affect the water cycle, therefore, the behavior and conservation of the high Andean wetlands (15).

The results of the specific objectives denote the existence of 15 wetlands in the populated center of Pueblo Libre with total extensions of 1 024 421.99 m2 and 901 653,703 m2, for the years 2016 and 2018, respectively, suffering a loss of coverage of 122 768,287 m2 equivalent to 12%; coinciding with Rosero (16) who asserts that, the vegetation has changed in losses of vegetation cover due to human activities and the irrational use of existing native forests; especially in periods of low precipitation in which there are the greatest spectral changes of the wetlands (17) contrast with Rojas et al. (18) who evidenced in the province of Rodríguez de Mendoza a loss of 918.81 km2 of forest cover in 29 years, specifying a loss of 8.75% during the first period (1987–2001).

Satellite photos show 15 wetlands found at altitudes above 4 300 m a.s.l., according to research that mentions that wetlands are located in high Andean areas with altitudinal range from 3 400 m a.s.l. to more than 4300 m a.s.l. (19, 20); In such a way that, due to its high altitude, the surface reduction of wetlands occurs in greater magnitude due to natural impacts, such as climate variability and water stress (21).

CONCLUSIONS

It is concluded that there is a significant percentage variation of 12%, due to the loss of 122 768,287 m2 of vegetation cover of the wetlands in the population center of Pueblo Libre, in the years 2016-2018.

For the year 2018 the bofedal No. 13 lost a higher percentage of vegetation cover (42.9%); while wetlands 2, 3 and 5 increased their percentage of vegetation cover by 5.06; 5, 55 and 8.15%, respectively, the case of the latter three due to a null anthropic intervention.

For the year 2018 the largest bofedal is the N° 6 with 298 879.43 m^2; while the smallest is No. 11 with 1 077.11 m^2.

CONFLICT OF INTEREST.

The authors declare that there is no conflict of interest for the publication of this scientific article.

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