Journal of Information Systems Engineering and Management
2025, 10(35S)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Historical Study of Land and Forest Degradation using GIS Technologies in Jaguay Negro – Lancones

Cecilia Lizeth Risco Ipanaqué1, Yerson Paul Semillan Rosales1, Gustavo Adolfo Mendoza Rodríguez1, Luis Ramón Trelles Pozo1, Jepner Neyra Jimenez1, Marlon Martin Mogollón Taboada1, Franklin Guerrero Campos1
ORCID: 0000-0002-7738-5717, criscoi@unf.edu.pe
ORCID: 0000-0001-6492-6003, semillan.19@gmail.com
ORCID: 0000-0002-6280-1757, gmendoza@unf.edu.pe
ORCID: 0000-0002-5523-2031, ltrelles@unf.edu.pe
ORCID: 0000-0003-2689-9504, jneyraj@unf.edu.pe
ORCID: 0000-0003-2689-9504, mmgollon@unf.edu.pe
ORCID: 0000-0002-9284-9014, fguerrero@unf.edu.pe
Universidad Nacional de Frontera (UNF)[1]

ARTICLE INFO

Received: 18 Dec 2024

Revised: 10 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

The research entitled "HISTORICAL STUDY OF LAND AND FOREST DEGRADATION USING GIS TECHNOLOGIES IN JAGUAY NEGRO – LANCONES" assessed historical changes in forest cover and land degradation in this region. It used historical data, satellite imagery, and aerial photographs taken with drones, along with Geographic Information Systems (GIS), to analyze historical and current patterns of land use and vegetation cover. This methodology generated thematic maps and detailed spatial analyses. The results revealed a progressive decrease in vegetation between 2020 and 2024, with a notable increase in bare soils and sparse vegetation due to deforestation, water stress and unsustainable resource management. Critical areas with limited natural regeneration and greater loss of vegetation were identified. The study underscores the urgency of implementing reforestation, sustainable soil management and conservation strategies in priority areas. It also confirms the relevance of GIS and remote sensing as key tools for monitoring and managing resources in vulnerable rural contexts. In addition, this process strengthened forestry engineering students' skills in geospatial technologies, critical analysis of environmental data, and interpretation of results, preparing them to face complex challenges in the environmental field.

Keywords: Historical , land and forest, GIS.

INTRODUCTION

Soil degradation and loss of forest cover are two of the main environmental problems affecting terrestrial ecosystems globally. These problems are closely related to human activities, such as intensive agriculture, deforestation, and urban expansion, which have profoundly altered natural ecological processes (Lal, 2020). According to the Food and Agriculture Organization of the United Nations (FAO, 2021), approximately 33% of the world's soils are degraded due to unsustainable practices, which compromises the ability of ecosystems to sustain future generations.

In the Latin American context, deforestation has been one of the predominant factors in environmental degradation. According to Armenteras et al. (2019), Latin America lost about 2.6 million hectares of forest per year between 2010 and 2020, with rural communities being the most vulnerable to the impacts of these changes. In this sense, the monitoring and analysis of these phenomena through technological tools, such as Geographic Information Systems (GIS), has become a fundamental strategy for understanding the spatial and temporal dynamics of soil degradation and forest cover (Chen et al., 2022).

Geographic Information Systems (GIS) allow geospatial data to be collected, stored, analyzed, and visualized, making them a key tool for natural resource management and planning. According to Longley et al. (2015), GIS not only facilitates the analysis of spatial patterns, but also allows for modeling future scenarios based on environmental and socioeconomic variables. Its application in studies of land degradation and forest cover loss has proven to be effective in identifying critical areas, assessing historical changes, and proposing sustainable solutions (Mitasova & Hofierka, 2020).

The community of Jaguay Negro, located in the district of Lancones, Piura region, represents a relevant case study due to its high dependence on natural resources and its vulnerability to environmental degradation processes. During the years 2020 and 2021, this area has undergone significant transformations in its landscape, derived from the interaction between climatic factors and anthropogenic activities.

Therefore, this research aims to historically assess soil degradation and forest cover in Jaguay Negro through the use of GIS. This approach allows for the integration of spatial and temporal data to analyze trends and propose sustainable management strategies that can be implemented for the benefit of the community and the environment.

The lack of studies that analyze the historical evolution of soil degradation and loss of forest cover in the community of Jaguay Negro - Lancones represents a significant obstacle to the identification of critical areas that require intervention. The absence of information limits decision-making to propose and implement effective conservation and restoration strategies, aggravating the negative impacts on local ecosystems. Soil degradation, a product of different factors such as climate change, deforestation and unsustainable agricultural practices, not only reduces soil fertility and productive capacity, directly affecting biodiversity.

The advancement of technologies, such as Geographic Information Systems (GIS) and Unmanned Aerial Vehicles (UNVs), offers new alternatives for obtaining key information that allows a detailed and quantifiable analysis of past and present changes. These tools, when combined, have the potential to transform the study of complex problems such as degradation and deforestation. However, to date, the lack of integrated studies linking these technologies with historical data remains a significant challenge. This lack limits the ability to address these issues effectively, leaving a significant gap in environmental analysis.

The general objective of this study is to evaluate the historical changes in forest cover and soil degradation in the community of Jaguay Negro, located in Lancones. To achieve this goal, four specific objectives were proposed. First, it seeks to identify the historical forest cover of the locality by analyzing old records, historical maps, and other relevant data. This will allow us to reconstruct a clear picture of the state of the environment in past times. Second, it aims to capture and process recent images using drones, in order to obtain accurate information on the current situation of forest cover and the state of the soil. This technology, being highly detailed and accessible, is a key tool for generating up-to-date and reliable data. The third objective focuses on the use of Geographic Information Systems to compare historical and current data, allowing the analysis of changes in forest cover and levels of land degradation over time. This comparative analysis is essential for identifying patterns of change and areas of concern. Finally, the fourth objective seeks to assess the areas most affected by deforestation or soil degradation, in order to propose specific mitigation or conservation measures. These proposals will be based on the analysis of the areas that have suffered the most significant impacts, allowing actions and resources to be prioritized in the areas of greatest need.

Taken together, this integrative approach aims not only to understand the changes that have occurred in the environment, but also to lay the groundwork for the development of effective conservation and restoration strategies that benefit both the ecosystem and local communities.

Land degradation and loss of forest cover are global issues that require urgent attention due to their impacts on food security, climate change and ecosystem sustainability (FAO, 2020). In the specific case of the Jaguay Negro – Lancones community, these processes have severely affected local natural resources, reducing the capacity of ecosystems to provide vital goods and services such as water, biodiversity, and local climate stability (Houghton, 2019). However, despite the relevance of this topic, historical studies on land degradation and forest cover in this area are limited, making it difficult to plan adequate strategies to mitigate these problems.

The use of Geographic Information Systems in this study will provide detailed and quantifiable information on the evolution of these processes over time. Through the analysis of satellite imagery and the use of vegetation indices, such as the NDVI (Normalized Difference Vegetation Index), it will be possible to assess changes in forest cover, while other indices, such as the NBR (Normalized Burned Area Index), will make it possible to identify areas degraded by erosion and deforestation (Zhu et al., 2016). The justification for this research lies in its potential to provide scientific data that serve as a basis for the formulation of public policies aimed at soil conservation and forest restoration in the region. In addition, the results obtained can be used to promote more sustainable agricultural and forestry practices that help reduce negative impacts on the environment.

THEORETICAL FRAMEWORK THE FRAMEWORK

BACKGROUND

Castillo and Muñoz (2019), aimed to carry out a multitemporal analysis of deforestation in the buffer zone of the Tambopata National Reserve in the period 2013-2022, using Landsat 8, 7 and Sentinel-2A satellite images.

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2025, 10(35S)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
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The deforestation rate of anthropogenic activities was quantified by performing a supervised classification using the spectral angle mapping method of the "Semi-Automatic Classification Plugin – SCP" of the QGIS software. The results indicate that from 2013 to 2022 there was a loss of forest cover of 14,456.92 ha, where "mining" and "agriculture" were the two anthropic activities that contributed the most to deforestation. It is concluded that it is necessary to take measures in this regard in the face of the advance of deforestation generated by anthropic activities. These results will help the actors involved in the management of the buffer zone of the protected area to monitor and mitigate the advance of deforestation in those areas of high anthropic pressure.

Ibáñez and Damman (2014) conducted research in order to determine changes in land cover and use and landscape in the Apurimac Region. According to the study, during the years 1986, 1994, 2002 and 2009, they concluded that the analysis of soil cover shows trends of change, mainly in the lower and middle part of the sub-basin in the period considered, linked to agricultural activity. In the case of the upper part, the drastic reduction of the snow-capped area is evident. These processes of change would be linked to four factors or drivers of change: the degradation of vegetation cover, the reduction of water sources, mining activity and extreme weather events. At the level of the territorial scenarios for 2016, calculated with the Markov model, it can be seen that the trends in the period 2002 and 2009 will be maintained, considering that the conditions of the model also maintain their trends (p. 1).

Pinedo (2012), with the thesis: "Monitoring deforestation in the period 2005-2009, in the province of Maynas, Loreto region, Peru", argues that: He showed the deforestation data obtained from the digitization and interpretation of satellite images and geographic information systems. In its results, it shows four categories for the periods 2005 and 2009: natural vegetation (which covers a larger area of the study area), deforested areas, islands and bodies of water. The areas deforested in 2005 covered an area of around 348 826 ha, which is 2.87 %, of the study area and with 430 938 ha, which represents 3.54% in 2009, deforestation processes were recorded, which means a decrease of 0.695% in 2009, since 79 828 ha have been used as secondary forest. pastures, crops, etc. (p. 5).

At the regional level, López and Salazar (2018) carried out a study on the loss of forest cover in the Chira River basin, located in the Piura region, Peru, during the period 2005-2015. This work focused on the analysis of changes in land use, specifically in forest cover, through the use of satellite imagery and the application of Geographic Information Systems (GIS). The main objective of the research was to identify the areas most affected by deforestation and to analyze the factors that contributed to the loss of vegetation in this area. Using satellite image processing techniques from Landsat sensors, the authors generated thematic maps that visualized changes in forest cover over time. The study revealed that the Chira River basin experienced a significant reduction in its forest cover during that period, with a decline of approximately 10%. The research identified that the areas of greatest deforestation coincided with areas of agricultural expansion, particularly in regions close to urban centers and export cultivation areas. In addition, it was observed that human activities, such as intensive agriculture and the expansion of the agricultural frontier, were the main drivers of this loss.

THEORETICAL FOUNDATIONS.

According to Lambin et al. (2003), environmental degradation is the result of complex interactions between natural factors and human activities, which generate cumulative impacts on ecosystems. In addition, studies on deforestation, such as those conducted by Geist and Lambin (2002), show that the main underlying causes include agricultural expansion, logging and poorly planned development policies, which are particularly evident in rural regions of developing countries.

On the other hand, the use of vegetation indices, such as NDVI, EVI, and SAVI, has proven to be an effective tool for measuring and monitoring changes in forest cover and soil quality, allowing the identification of degradation patterns and critical areas for intervention (Zhu et al., 2016). According to Mitasova et al. (2020), GIS and remote sensing techniques not only contribute to the analysis of the past, but also to the modeling of future scenarios, which is essential for designing sustainable management strategies.

In the case of Jaguay Negro, Geographic Information Systems (GIS) as well as NPVs allow for the integration of historical and current data to assess how local factors, such as deforestation for agricultural expansion and overexploitation of natural resources, have contributed to environmental degradation. The combination of drone data, satellite imagery, and GIS analysis provides an interdisciplinary and robust approach that facilitates evidence-based policymaking. This theoretical framework not only reinforces the importance of the research, but also highlights its relevance for conservation and sustainable development in vulnerable areas such as Jaguay Negro.

DEFINITIONS.

Soil degradation: Soil degradation is defined as the deterioration of its physical, chemical, and biological properties, affecting its ability to support human life and activities. This can be caused by factors such as erosion,

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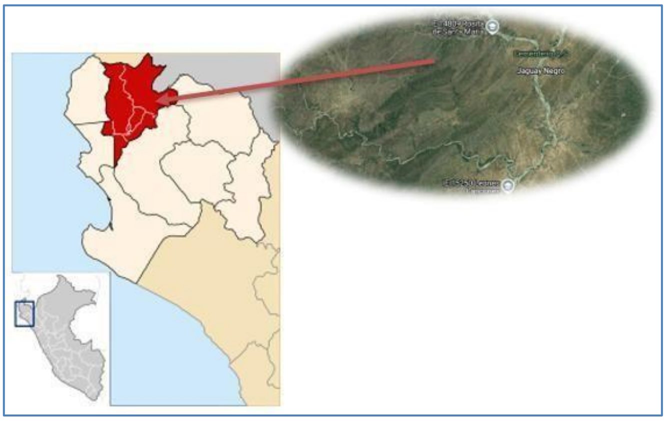
e-ISSN: 2468-4376
https://www.jisem-journal.com/ **Research Article**

compaction, and nutrient depletion (Lal, 2020).
Forest cover: Forest cover refers to the area of land occupied by forests, measured in terms of density and extent. Its monitoring is key to assessing the impacts of deforestation and changes in land use (Armenteras et al., 2019).
Deforestation: Deforestation is the process of converting forested areas into non-forest land due to human activities such as indiscriminate logging, agriculture, and urbanization (FAO, 2021).
Geographic Information Systems (GIS): GIS are technological tools used to analyze and visualize spatial and temporal data, facilitating decision-making on natural resources (Longley et al., 2015).
Normalized Difference Vegetation Index (NDVI): NDVI is a widely used indicator to assess vegetation density and health, calculated from reflectance in different spectral bands (Zhu et al., 2016).
Remote sensing: It is the use of remote sensing (multispectral drones) to collect data on the earth's surface without direct contact by capturing images in visible and infrared bands, which facilitates analysis to detect changes in vegetation cover and perform environmental monitoring (Chen et al., 2022).
Reforestation: Reforestation involves the restoration of degraded land by planting trees, with the aim of recovering ecosystem services (Houghton, 2019).
Critical areas: These are geographical areas that experience a high degree of environmental degradation and require priority interventions for their conservation or restoration. According to FAO (2021), these areas can be identified through the analysis of environmental and socioeconomic indicators.
Landsat 7: is an Earth observation satellite launched on April 15, 1999. It is part of the Landsat program, operated by the United States Geological Survey (USGS). This satellite provides detailed images of the Earth's surface, used in studies of land use, vegetation and the environment. Its main instrument is the "Enhanced Thematic Mapper Plus" (ETM+), which captures images in various spectral bands, including near-infrared, offering a spatial resolution of 30 meters. (gubernamental, 1999)
Landsat 8: It is a satellite launched on February 11, 2013, which is also part of the Landsat program. This satellite carries two main instruments on board: the "Operational Land Imager" (OLI) and the "Thermal Infrared Sensor" (TIRS). Landsat 8 provides high-resolution imagery in various spectral bands, with significant improvements in terms of resolution and accuracy compared to Landsat 7. This satellite is used to monitor changes in land use, vegetation, and other environmental features. ((USGS), 2013)
QGIS (Quantum Geographic Information System): It is an open and open source geographic information system (GIS) that allows you to visualize, edit and analyze spatial data. It is a widely used tool for managing geospatial data, such as maps, satellite imagery, vector data, and raster, and is employed in various disciplines, including engineering, urban planning, ecology, and environmental management. (Team, 2022)

METHODOLOGY

Figure 1*Geographical Location of Jaguay Negro*



The community of Jaguay Negro is located in the district of Lancones, in the province of Sullana, within the department of Piura, in northern Peru. It is located in a strategic region, near the border with Ecuador, which places it in the coastal area of the country. Lancones, which is one of the most important districts in the province, covers an area of 216,718.22 hectares, which represent approximately 6.01% of the total territory of the department of Piura and 40.72% of the province of Sullana. Within this vast area, the community of Jaguay Negro occupies a fraction of the land, extending mainly over agricultural and livestock lands, considering the following coordinates: WGS84-Zone 17 (see figure 2).

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2025, 10(35S)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

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Figure 2 *Geographical Location - WGS*

JAGUAY NEGRO	Geographic Location of the centroid WGS Coordinates 84 - Zone 17		Altitude (M.S.N.M)
	South (S)	West (W)	(M.S.N.M)
	1 . Latitud: 04° 18' 20" S , Longitud: 080° 31' 35" W 2 . Latitud: 04° 18' 38" S , Longitud: 080° 31' 35" W 3 . Latitud: 04° 20' 27" S , Longitud: 080° 31' 40" W 4 . Latitud: 04° 20' 26" S , Longitud: 080° 29' 26" W		181

This hamlet is part of an ecosystem of tropical dry forests, a type of vegetation that adapts to the arid and semi-arid conditions of the region. The community is located in a relatively accessible area, connected by rural roads to the city of Sullana, the nearest urban center, and to other important localities within the district. Jaguay Negro's proximity to the Chira River, which crosses the province of Sullana, influences agricultural activities in the area, although access to water is limited due to the aridity of the climate.

In administrative terms, Jaguay Negro depends politically on the district of Lancones, which is part of the province of Sullana, located in the Piura region. This administrative structure means that management and development policies in the community are framed within the decisions of the local government of Lancones, which is in charge of coordinating projects that affect both Jaguay Negro and other localities in the district.

The study of the research is **Descriptive and Comparative**; since it describes the historical and current conditions of forest and soil cover in the community of Jaguay Negro – Lancones; comparing historical data with current data to identify trends and patterns of change in land degradation and forest cover. Descriptive studies seek to specify the properties, characteristics, and important profiles of phenomena or problems analyzed, while comparative studies examine the differences between variables or specific moments of a phenomenon as mentioned. (Hernández Sampieri, Fernández Collado, & Baptista Lucio, 2014)

The research is of **Mixed approach**, in which it integrates qualitative data: Historical records, as well as quantitative data: Processing and analysis of satellite images and images obtained by drones using Geographic Information Systems (GIS) tools, combining both qualitative and quantitative methods having a greater understanding and allowing to have a depth in the analysis as mentioned; The level of research is (Hernández Sampieri, Fernández Collado, & Baptista Lucio, 2014)**exploratory and explanatory**; explores the historical and current conditions of the study area in order to identify the factors associated with the observed changes; Exploratory studies seek to examine little-studied or new phenomena, while explanatory studies aim to identify the causes of certain events or behaviors and understand how they are related as defined .(Hernández Sampieri, Fernández Collado, & Baptista Lucio, 2014)

To carry out the research, the following design was implemented in phases (see figure 3):

Figure 3 *Research Phases*

Literature review: An exhaustive review was carried out on soil degradation and forest cover. This served to establish the theoretical and methodological basis of the study.

Imaging:

- Work was done in the laboratories to obtain high-resolution satellite images (see figure 4) and were downloaded from the USGS (United States Geological Survey) platform. These multispectral images capture the reflectance of the Earth's surface at different wavelengths, which is key to analyzing vegetation and soil.

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e-ISSN: 2468-4376
https://www.jisem-journal.com/

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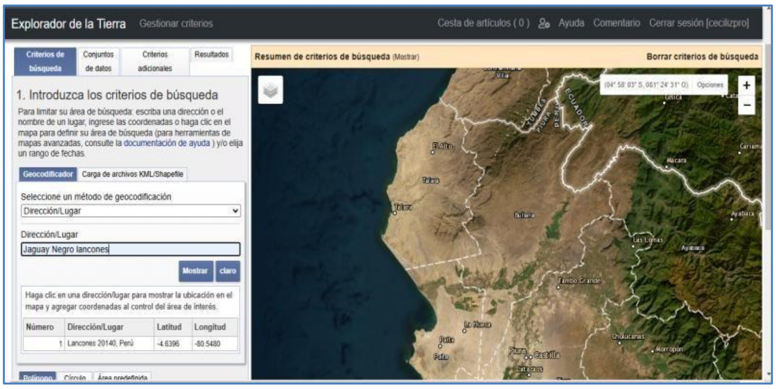
Figure 4 *Using the USGS Platform*

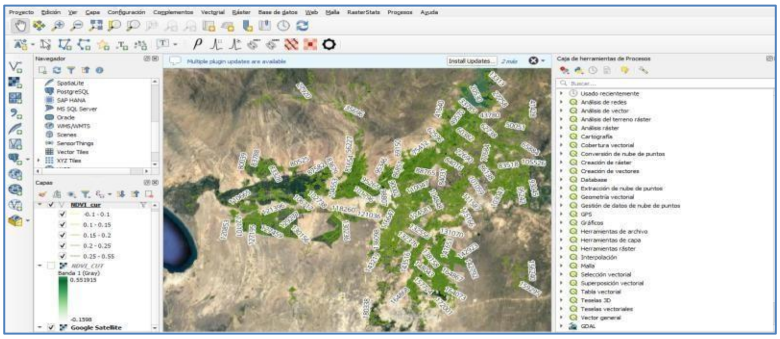


- A visit was made to the community of Jaguay Negro-Lancones (see figure 5) in order to

Figure 5 *Visit to the community of Jaguay Negro*

Processing and Analysis:
The QGIS software (see figure 8) was used, which is a widely recognized open source tool in geoprocessing, where the following operations were performed:
Atmospheric correction: Ensuring the homogeneity and comparability of satellite images over time.

Figure 6 *Working with QGIS*



The calculation of the NDVI was performed in the QGIS software (see figure 9), this index, based on the red and near-infrared bands, allowed quantifying the vegetation cover and its vigorousness, used to evaluate the density and health of the vegetation, calculated from the reflectance in different spectral bands (Zhu et al., 2016).

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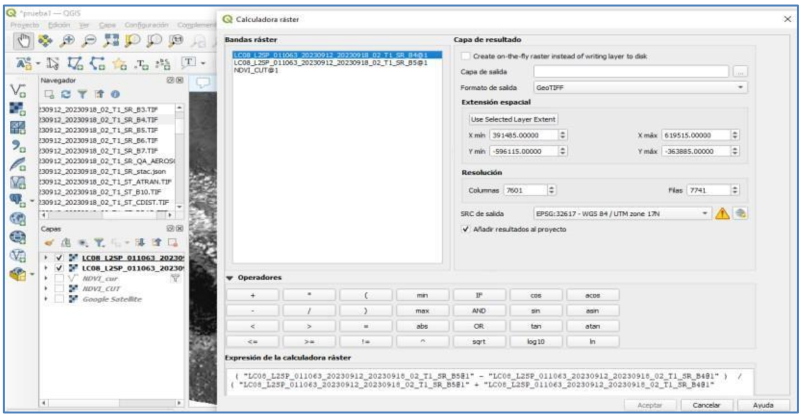
Figure 7 *NDVI calculation*



Temporal Analysis:
To identify trends in vegetation change and detect possible significant alterations due to natural or anthropic events, satellite images corresponding to the years 2017, 2020, 2021 (images obtained from UGSS) and 2024 (images taken by drone) were selected. These images were processed using the open-source software QGIS, widely recognized in the field of geospatial analysis (QGIS Development Team, 2023).
Processing began with the creation of a new project in QGIS, where the corresponding raster layers were added. It was critical to ensure that the geographic projections of the images matched the UTM - WGS84 coordinate system to maintain spatial accuracy in the analysis (Santos et al., 2021). Since the satellite images were composed of several spectral bands, a composite image was generated using bands 5, 6, and 2. This combination is particularly useful for performing analyses such as the Normalized Difference Vegetation Index (NDVI), a widely used metric to assess vegetation vigorousness and density (Rouse et al., 1974).
NDVI was calculated using the QGIS Raster Calculator tool, using the formula:
NDVI = (From Banda 5 - Banda 4) / (Banda 5 + Banda 4)
To analyze a specific area, the images were cropped using a vector layer that delimited the extent of interest. Green symbology was applied to this cut area to facilitate its visualization, contour lines were generated from the NDVI values to analyze vegetation patterns in more detail. The steps followed were as follows:

1. Selecting the Raster > Extraction > Contours option in QGIS.
2. Configure the range of the curves, define the vegetation index and establish an output directory to save the results.
3. Modifying the properties of the curves, applying a specific range of NDVI (e.g., NDVI > 0.195) and using a gradient color scheme to improve visual interpretation.
4. Added descriptive labels to facilitate the readability of the generated map.

This methodological approach allowed to effectively analyze the evolution of vegetation in the study area, detecting areas with greater or lesser vegetation cover, as well as trends associated with environmental degradation.
Once the analyses have been carried out, the histograms of both the contour lines and the cropping of the study image are evaluated, as can be seen in figures 10 to 20.

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e-ISSN: 2468-4376
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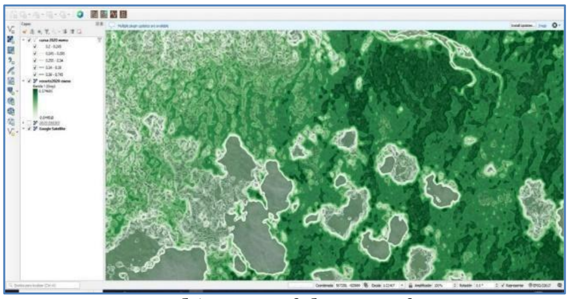
Figure 8 *Image 23/01/2020*

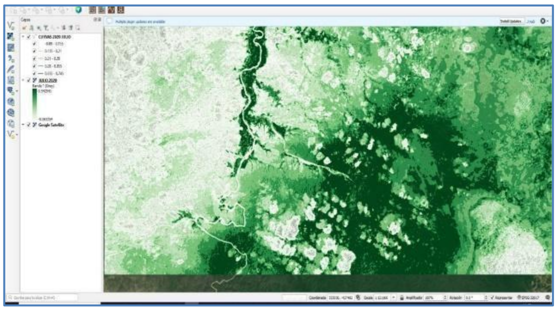


Note: processed image of the year for January 23, 2020

Figure 9 *Image processed in QGIS 23/01/2020*

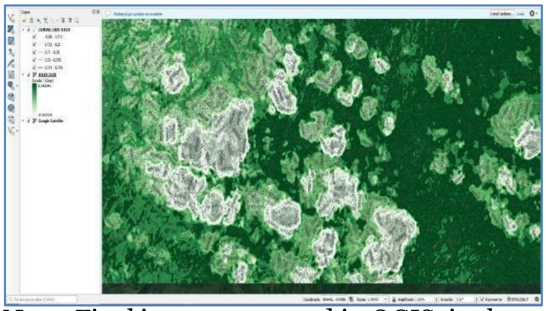
Note: Final image processed in QGIS, in the period of January 2020

Figure 10 *Image 01/07/2020*



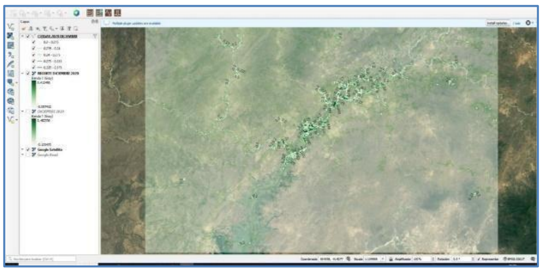
Note: image processed on July 01, 2020.

Figure 11 *Image processed in QGIS 01/07/2020*



Note: Final image processed in QGIS, in the period of July 2020.

Figure 12 *Image 8/12/2020*



Note: processed image of the year for December 8, 2020.

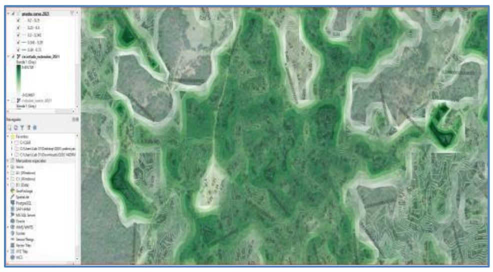
Figure 13 *Image processed in QGIS 08/12/2020*

Note: Final image processed in QGIS, in the period of December 2020.

Figure 14 *Image 19/01/2021*

Note: Processed image of the year for January 9, 2021.

Figure 15 *Image processed on QGIS 19/01/2021*



Note: Final image, from the month of January-2021.

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e-ISSN: 2468-4376
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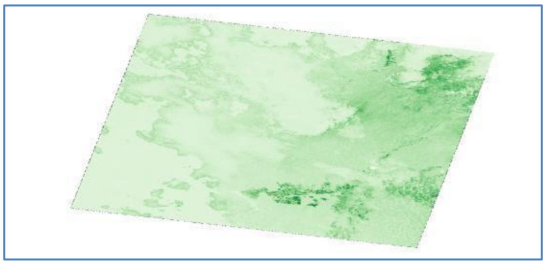
Figure 16 *Image 12/01/2022*



Note: Processed image of the year for November 25, 2022.

Figure 17 *Image processed on QGIS 12/01/2022*

Note: Image from 2022

Figure 18 *Image 29/12/2024*

RESULTS AND DISCUSSION

The results obtained are interpreted according to the following NDVI ranges, providing specific descriptions for each category according to table 1:

Board 1 *NDVI Ranges*

RANGES	INTERPRETATION	DESCRIPTION
NDVI < 0	Non-vegetated areas	Bare soil, water, snow, clouds, urban areas, or other non-vegetated surfaces
0 to 0.2	Sparse vegetation or bare soil	Areas with little or no vegetation cover, such as deserts, beaches, or exposed soil.
0.2 to 0.5	Moderate vegetation	Grasslands, shrublands, early-stage crops, or vegetation with water stress or medium health.
0.5 to 0.7	Dense and healthy vegetation	Young forests, well-irrigated crops or vegetation in good condition.
0.7 to 1.0	Very dense and healthy vegetation	Dense forests, healthy plantations, or areas of very vigorous vegetation.

Source: Based on Rouse et al. (1974) and adapted from remote sensing vegetation index analysis.

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2025, 10(34s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

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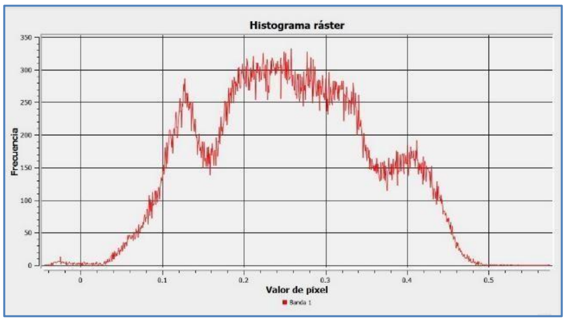
Figure 19
Raster histogram of the clipping layer 20/01/2020.



Note: result of the Image processed in QGIS 23/01/2020

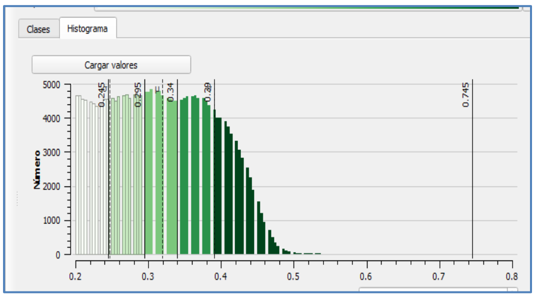
The histogram confirms that the analyzed area mainly presents bare soils or very scarce vegetation, with a lower proportion of moderate vegetation and almost no dense vegetation. This supports the hypothesis that the area has been strongly impacted by human activities such as deforestation, soil degradation or adverse climatic factors.

According to Table 1, the NDVI provides ranges that allow analyzing the vegetation cover and the state of the soil in the area studied, with the results shown below:
Primarily, it is in the **range of 0 to 0.2**, with peaks in the histogram around 0.1-0.2, indicating that a large proportion of the area analyzed could experience very sparse vegetation or be bare. This is likely due to intensive deforestation and soil degradation processes. This range is typical of areas under anthropogenic influence or climatic conditions too severe to allow vegetation to develop.

Range from 0.2 to 0.5:
The pixel rate gradually decreased from 0.2 to 0.5, indicating areas with moderate vegetation, such as grasslands, shrubs, or early-stage growing crops. Although it has a lower representation in the histogram compared to the previous range, it shows sectors where vegetation is in an intermediate state, possibly due to water stress or poor land management (Huete et al., 2002).

Rank > 0.5: Dense and healthy vegetation
In this range, the pixel frequency is minimal or almost zero. This would show that the area studied is practically devoid of dense or healthy vegetation, such as young forests or vigorous plantations. The absence of pixels in this range confirms the conclusion that the area has very limited vegetation cover, probably due to unsustainable land use (Pettorelli et al., 2005).

Figure 20 *Histogram of contour lines Image 23/01/2020*



Overall, the information provided by the histogram shows that most of the landscape has sparse or moderate vegetation. This can be explained by reasons such as water limitations, environmental stress, soil degradation and human-induced pressures. The presence of areas with dense and healthy vegetation is very limited, indicating that well-developed forests do not predominate in the Jagua Negro study area, at coordinates 570331, -421611, during January 2020

From the contour lines, it can be observed that the histogram shows a region where moderate vegetation predominates, with NDVI values between 0.3 and 0.5, followed by a significant amount of scarce vegetation, with values between 0.2 and 0.3. There are very few, if any, areas with dense or very dense vegetation. This could be attributed to areas where natural or cultivated vegetation is under some form of environmental stress, perhaps due to activities such as deforestation or intensive land use.

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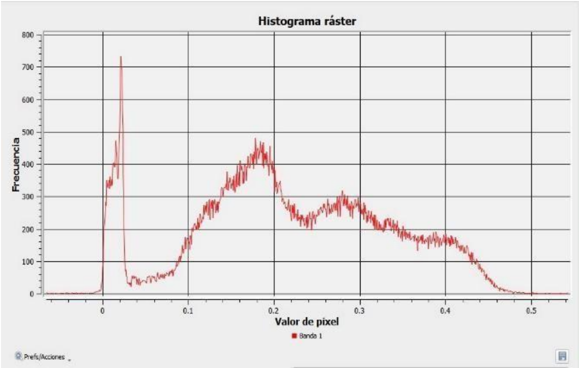
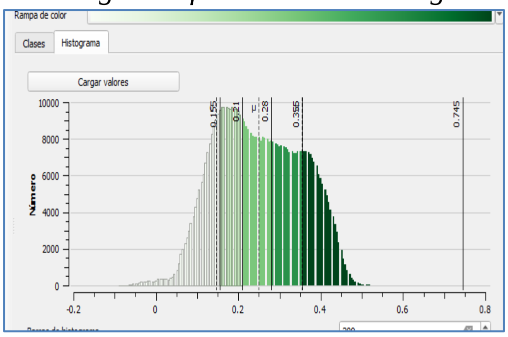
Figure 21 *Raster histogram of the clipping layer Image processed in QGIS 01/07/2020*  Note: Image from July 01, 2020 processed. In summary, the histogram analysis indicates that the investigated area is predominantly non-vegetated and with low vegetation cover; These surfaces could be bare soils and semi-arid regions. Areas with moderate vegetation are very small and can hardly be recognized as areas with dense or very dense vegetation. This pattern could be related to an arid or semi-arid climate and/or to a high level of anthropogenic pressure, such as deforestation, soil degradation or high-intensity agriculture.	. In the histogram of the cutout, it can be clearly observed that a very large peak is close to the value of zero, which represents the predominance of bare soils, bodies of water or other non-vegetated areas. This is the histogram mode, which indicates that most of the studied area lacks any type of vegetation. In the graph, the intervals increase steadily to 0.2, reflecting areas with sparse vegetation, probably on bare soils or semi-arid regions. In the range of 0.2 to 0.3, there is also a marked peak; This could be related to the presence of pastures or crops under stress. There is a steady and progressive decrease in frequency as NDVI approaches the value of 0.5, due to the lower proportion of areas with moderate vegetation.
Figure 22 *Histogram of contour lines Image 01/07/2020*  In conclusion, the histogram shows that the landscape of the area studied in Jagua Negro (coordinates 569446, -425980) in July 2020 is mainly characterized by many points with little vegetation cover and low vegetation. In addition, areas with moderate vegetation are less frequent, and dense or very dense vegetation is virtually absent. This indicates some environmental problems, problems related to water stress, or possibly human activities in the region.	The predominance of the left half of the graph on the X-axis, right from its origin, shows that in most of the sites studied there was less than 20% vegetation cover, leaving the land either bare or with very little vegetation. In this graph, a very small, practically non-existent proportion of dense vegetation is also observed, while scarce to moderate vegetation is noted in values ranging between 0.2 and 0.5.

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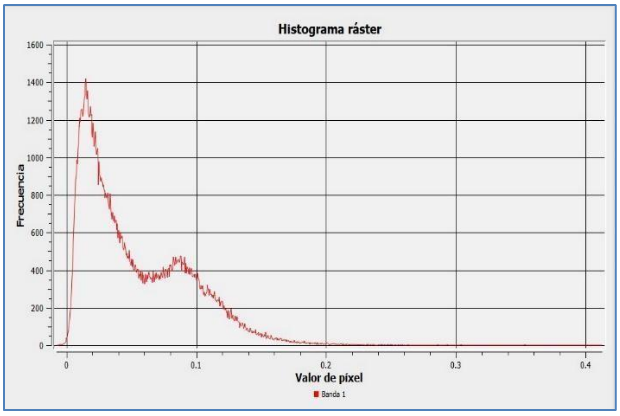
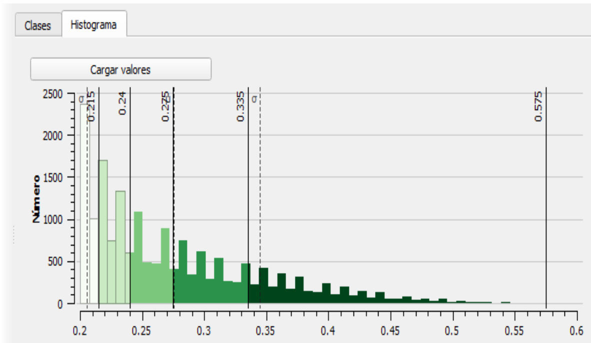
Figure 23 *Raster histogram of the crop layer of the image processed in QGIS 08/12/2020*



In this histogram we observe that most of the data is concentrated in the range 0 to 0.2 with a very pronounced peak near 0, indicating that most areas have little or no vegetation cover, such as bare soil, arid areas, or very limited vegetation with very few areas showing signs of moderate or dense vegetation. This could represent a dry, degraded landscape or in an initial state of plant recovery.

Figure 24 *Histogram of the contour lines of the image processed in QGIS 08/12/2020*



Note: Final image processed in QGIS. We can realize that if we take into account the histogram of the cut, which evaluates the entire area (Figure 8), we observe that there is a high index of little vegetation or no vegetation, such as bare soil, arid areas or very limited vegetation. And when looking at the contour lines, it only takes the curves and in this case, only the part of the river, which shows us that near it there is moderate vegetation, but it does not show us the reality of the total area such as the histogram of the cut.

In this histogram by the contour lines we observe that the range that has the highest increase is from 0 – 0.2 which indicates that the vegetation is scarce or bare soil, then there is a gradual decrease in pixel frequency from 0.2 to 0.5, indicating moderate vegetation, such as grasslands and shrubs.
So we can say that in December 2020 the study area, there is moderate vegetation, since the plantations are located on the banks of the river.

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e-ISSN: 2468-4376
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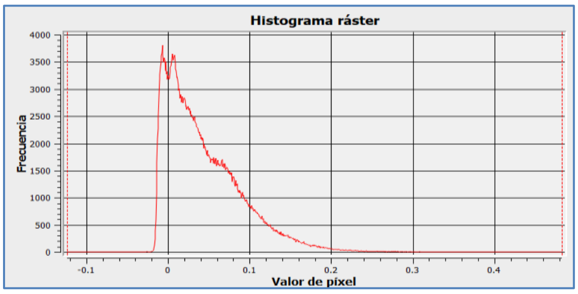
Figure 25 *Raster histogram of the crop layer of the Image processed in QGIS 2021*



Note: Final image processed in QGIS, in the period of January 2021

The region lacks dense forests or extremely vigorous vegetation. General conclusion: The "Jaguay Negro" region, according to this analysis, seems to be dominated by non-vegetated areas (NDVI < 0) and scarce vegetation (NDVI between 0 and 0.2). This is typical of arid or semi-arid environments with exposed soils **and** little vegetation cover. Areas with moderate vegetation (0.2 to 0.5) are present, although in a smaller proportion, while dense or very dense vegetation is practically non-existent.

Analysis of the histogram using the ranges: NDVI < 0 (Non-vegetated areas): The histogram shows a significant peak in this range. Interpretation: There is a considerable proportion of non-vegetated areas, such as water, bare soil or urban areas. This is consistent with arid areas or areas with low vegetation presence. NDVI between 0 and 0.2 (Sparse vegetation or bare ground): There are also a noticeable number of pixels in this range. Interpretation: This indicates the presence of exposed soil or very sparse vegetation. It could represent arid areas, such as deserts, beaches, or water-stressed grassland areas. NDVI between 0.2 and 0.5 (Moderate vegetation): The histogram shows a lower frequency in this range, but there is still a representative number of pixels. Interpretation: Suggests areas with moderate vegetation, such as grasslands, shrubs or crops in non-optimal conditions (water stress or early stages of development). NDVI between 0.5 and 0.7 (Dense and healthy vegetation): The frequency is low in this range, indicating few areas with healthy or well-irrigated vegetation. Interpretation: There is a small proportion of dense vegetation, which could correspond to young forests, well-managed crops or areas where the vegetation is in good health. NDVI between 0.7 and 1.0 (Very dense and healthy vegetation): The histogram has virtually no pixels in this range.

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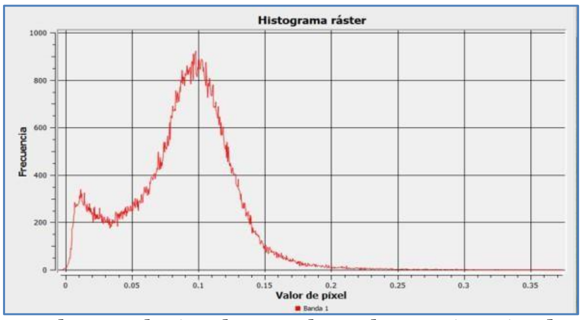
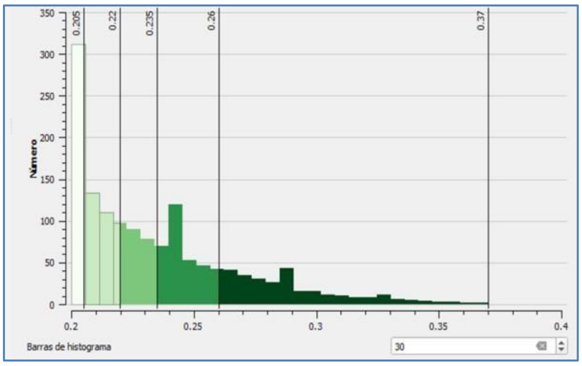
Figure 26 *Raster histogram of the crop layer of the Image processed in QGIS 12/01/2022*



In summary, the analysis shows that the region is dominated by vigorous vegetation, although it also suggests the possibility of areas with scarce vegetation cover or less favorable conditions for vegetation growth.

Figure 27 *Histogram of the contour lines of the image processed in QGIS 12/01/2022*



In this histogram we observe a characteristic distribution, where most of the studied area is covered by vigorous and dense vegetation, NDVI values are considered between 0.235 and 0.26, which could indicate vegetation present but possibly less dense or with less vigor compared to the higher ranges, on the map, these areas are represented by shades of intermediate green.

On the other hand, the lowest NDVI classes, from 0.2 to 0.205, 0.205 to 0.22, and 0.22 to 0.235, account for only 2.941%, 8.823%, and 8.823% of the total area, respectively. The lowest values could correspond to areas of sparse vegetation, bare soil, bodies of water or vegetation under stress conditions. In NDVI, these areas would appear with lighter or completely different shades if more bands had been used in addition to those in NDVI.

Journal of Information Systems Engineering and Management
2025, 10(34s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

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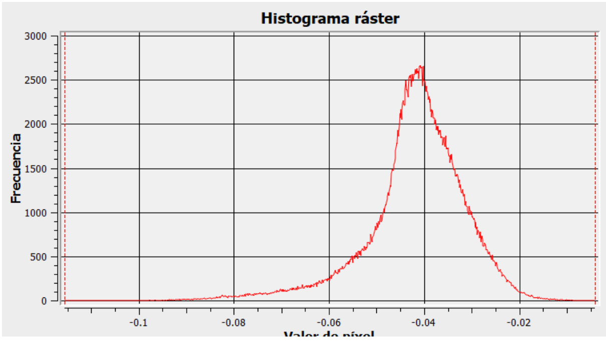
Figure 29 Histogram of the contour lines of the image processed in QGIS 29/12/2024



Negative values: Indicate that the areas are not without vegetation.
Pixels close to -0.04: Probably represent bare soils or bodies of water.
Lowest range (close to -0.1): It could correspond to deep water or surfaces with lower reflectance, such as shadows or urban areas.

The histogram represents the distribution of pixel values and displays the values of the parsed parameter (usually NDVI, albedo, etc.). We can describe it in general terms as follows:
X-axis: In this case, the values vary between approximately -0.1 and 0, which probably indicates an indicator with negative values, associated with non-vegetated areas, water or bare soils (if it is an NDVI, the negative values usually correspond to these areas
Y-axis (Frequency): Shows the number of pixels that each value has. In the graph, it can be seen that many pixels have a value close to -0.04, which is the predominant value in the analyzed region.
The histogram is asymmetrical, with a pronounced peak around -0.04 and a more marked drop towards values close to 0. This suggests that most of the analyzed area has dominant features (e.g., a common surface type), while the ends reflect less frequent surfaces.

CONCLUSIONS

- **The identification of historical forest cover** through old records and maps made it possible to determine that the community of Jaguay Negro has suffered a considerable loss of vegetation density in recent years. During the period analyzed (e2020 - 2021-2022-2024), the landscape showed predominantly scarce or moderate vegetation, influenced by factors such as water limitations, environmental stress, and deforestation. These findings reflect a historical pattern of environmental degradation in the area.
- The use of images captured by drones made it possible to obtain accurate data on the current state of vegetation and soil. The results for December 2020, November 2021, and January 2022 reveal an increase in areas with bare soils and scarce vegetation cover, which represent 42% of the area studied. This shows rapid soil degradation and an increase in arid areas, which hinders the possibilities of natural regeneration of vegetation.
- With the use of Geographic Information Systems (GIS), a detailed comparison of changes in forest cover between historical periods and recent data was made. The histograms showed a progressive deterioration in vegetation vigor, with an increase in areas of low plant density between January 2020 and November 2021. Although a slight recovery was observed in certain areas in January 2021 (34% with moderate density), this change was insufficient to reverse the overall trend of degradation.
- Critical areas with high levels of soil degradation have been identified, evidencing sectors where vegetation is practically non-existent or shows clear signs of significant stress. These findings highlight the urgent need to implement sustainable management and reforestation strategies in the most affected areas, with the aim of mitigating deforestation and the effects of desertification in Jaguay Negro.

REFERENCES

[1] QGIS Development Team. (2023). *QGIS Geographic Information System*. Open Source Geospatial Foundation Project.
[2] Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. *NASA Special Publication*, 351, 309-317.
[3] Santos, P., Lima, F., & Monteiro, H. (2021). Fundamentals of remote sensing: Applications in geospatial

analysis. *Journal of Geospatial Science*, 45(3), 215-229.

[4] Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1974). *Monitoring vegetation systems in the Great Plains with ERTS*. En F. R. Greeley (Ed.), *Third Earth Resources Technology Satellite-1 Symposium, Volume I: Technical Presentations* (pp. 309–317). NASA SP-351.

[5] Alarcón-Aguirre, G., Canahuire-Robles, R. R., Guevara-Duárez, F. M., Rodríguez-Achata, L., Gallegos-Chacón, L. E., & Garate-Quispe, J. (2021). Dynamics of forest loss in the southeastern Peruvian Amazon: A case study in Madre de Dios: Ecosystems, 30(2), 2175. https://doi.org/10.7818/ECOS.2175

[6] Soria-Díaz, H. F., Valeriano-Quispe, V. D., Da-Fonseca, M. V., Chambi-Legoas, R., Zevallos-Pollito, P. A., & Soria-Solano, B. (2024). Multitemporal analysis of deforestation in a buffer zone in the southwestern Amazon. Wood And Forests, 30(3), e3032678. https://doi.org/10.21829/myb.2024.3032678

[7] Gonzales, G. (2018). Multitemporal analysis of deforestation and loss of forest cover in the province of Manu, 2000 – 2016. [Bachelor's thesis, Federico Villarreal National University].

[8] Gutiérrez, R. (2013). Monitoring of deforestation in the department of Ucayali for the period 2005 – 2009. [Bachelor's thesis, National University of the Peruvian Amazon].

[9] Zuloaga-Obregón, J. L., & Gabriel-Campos, E. N. (2023). Land use change and its impact on the vegetation cover of the Tingo María National Park between 2006-2021. Kawsaypacha Journal: Society and Environment, 12, A-009. https://doi.org/10.18800/kawsaypacha.202302.A009.