Using Artificial Intelligence in Process Automation for the Detection of Land Use Change by Removal of Vegetation

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Abstract

Bauxite mines are usually located within in properties of great extension. In such contexts, it is challenging to monitor changes in vegetation, and hence to guarantee that external agents do not perform deforestation. Using satellite images and GIS (Geographic Information System) is an efficient way to monitor large areas, although some expertise is needed to work with these systems, and it demands time to process the satellite images and evaluate them against polygons where removal of vegetation is authorized, as well as against protected areas. To optimize the efforts applied to this monitoring, and make it more preventive and efficient, we have prepared an automated flow in GIS that:

- receives data (satellite images + protected areas + polygons authorized for removal of vegetation + field inspections);
- processes and analyzes data through artificial intelligence;
- organizes the results in online dashboards (monitoring suppression progress in authorized areas + alert dashboards for deforestation in protected or unauthorized areas);
- sends notifications to personnel about probable events to be checked in the field.

This flow can be used for the detection of changes in vegetation in any large areas, it promotes directed inspections on the ground, and it helps preventing unauthorized vegetation removal, whether in bauxite mining areas or in other contexts.

Keywords: Deforestation, Remote sensing, Automation, Deforestation monitoring, Geographic Information System (GIS).

1. Introduction

Large industries and production chains depend on ores as an input for the manufacture of their products. This requires complex mining activities that involve large investments, planning, and the extraction of non-renewable resources. Its impacts are both positive, in terms of economic and social development, and negative, as the extraction of finite resources has an environmental cost [1].

Brazil is one of the countries with the greatest potential in mineral resources on the planet, with about 55 types of minerals already explored [2]. In Brazil's Northern region, especially the state of Pará, mining occurs at a considerable scale thanks to the investments made by large mining companies.

Paragominas is a municipality that has a great stock of bauxite, which is being mined by Mineração Paragominas S.A (MPSA), a company of the Norsk Hydro Brazil group. MPSA uses the strip mining method, which basically consists of four steps. First, the vegetation is removed, and a layer of soil (typically called topsoil) is mined separately for rehabilitation purposes. Then, the overburden layer is excavated, stacked, and stocked. At that moment, the bauxite is mined and loaded on trucks to be transported to the beneficiation plant. After the bauxite removal, the overburden layer returns to the pit and is leveled before receiving the topsoil for the rehabilitation processes [3].

Thus, bauxite mining according to the strip mining method requires the removal of vegetation of large areas and, unlike the mining process of some other ores, is carried out in the open. In the process, large strips of land are extracted and subsequently recovered [4, 5]. Because of the extension of the areas, the necessary monitoring programs that guarantee that the land cover changes occur as prescribed by Brazilian legislation are particularly challenging to implement.

In addition, within the area where MPSA is active, there are also areas under environmental protection, where removal of vegetation is not allowed, such as Legal Reserve Areas and Permanent Preserved Areas, as defined by the Brazilian Law N. 12.651/2012 [6]. Like the operational areas, these environmental protected areas are large and hard to monitor.

Remote Sensing, Geoprocessing and Artificial Intelligence tools have been widely used to monitor large areas. These tools can provide periodic and consistent land surface data, identifying removal of vegetation by detecting changes in land use. This type of tool is already considered a key instrument in global monitoring and one of the main tools used to understand changes in land cover [7, 8, 9].

Considering the MPSA context and with the aim of automatizing the monitoring of environmental programs, the main motivation of this “Change Detection” project was to create a smart, unified, collaborative, and automatic system to detect land use changes by removal of vegetation. The system aims to monitor such activities, in order to guarantee that removal of vegetation only occurs in areas where it is allowed, and to monitor protected areas or areas where removal of vegetation is not allowed.

2. Study Area

The project area is the MPSA mine area and the Pipeline and Transmission Line Easement Track. The pipeline is the device used to transport the bauxite pulp to the alumina refinery located in Barcarena. And the Transmission Line is necessary to provide energy for the pipeline to work. Both are within the Hydro Paragominas concession, and they are part of the area that is being monitored, like the mine itself.

The MPSA mining area consists of two bauxite deposits on contiguous plateaus referred to as Miltonia 3 (M3) and Miltonia 5 (M5), situated in the municipality of Paragominas, in the northwestern region of the State of Pará, in Northern Brazil. The geographic coordinates of the mine are 2° 59' 51" S; 47° 21' 13" W, as shown in Figure 1.

The region of Paragominas presents a humid tropical climate with regular precipitation, with dry periods lasting from June to November, and a rainy season with high nebulosity from December to May. The local microclimate depends on the vegetative variations since this is an area in transition between native forest and pasture areas. Agriculture is an activity of great influence in the region. The expansion of agriculture can raise temperatures and reduce the relative humidity of the air [10, 11].

intelligent and able to receive data and classify alerts autonomously. It is connected to the dashboards, field map and inspections form. It is hosted in an interactive, automated, and collaborative platform since it enables data collection in the field and data synchronization in real time.

Using this system allowed for monthly monitoring to detect land use changes in more than 20 000 hectares of MPSA areas, and to carry out targeted inspections of areas with high risks of vegetation removal. In addition to this, it became possible to monitor environmental protection areas, creating a virtual fence around these areas.

The MPSA is committed to protecting environmental protection areas and only perform its operations in authorized areas, and this system is helping to fulfill this commitment in the day-to-day operations.

6. References

1. Ibram Instituto Brasileiro de Mineração, Mineração em números. https://ibram.org.br/mineracao-em-numeros/ (Accessed on 16 June 2023).https://ibram.org.br/mineracao-em-numeros/ (Accessed on 16 June 2023).
2. Simineral Sindicato Das Indústrias Minerais Do Estado Do Pará, Pará Mineral, https://www.simineral.org.br/mineracao (Accessed on 12 July 2023).
3. Brandt Meio Ambiente - Casaverdehidrosam. *Estudo de Impacto Ambiental de Lavra e Beneficiamento de Bauxita pela Mineração Vera Cruz S/A - MRCParagominas*, 2006.
4. João Alves Sampaio, Mônica Calixto de Andrade and Achilles Junqueira Boudort Dutra, Bauxita. In: *Rochas & minerais industriais: usos e especificações*. Rio de Janeiro, Brasil, 2005, 279-304.
5. Abal Associação Brasileira do Alumínio, Bauxite in Brazil: Responsible Mining and Competitiveness, http://abal.org.br/downloads/publicacoes/bauxita-no-Brasil-mineracao-responsavel-e-competitividade-eng.pdf (Accessed on 10 July 2023).
6. Brasil, *Federal Law N. 12.651/2012 Establishes the new Brazilian forest code*, 2012.
7. Asa Gholizadeh, Daniel Žižala, Mohammadmehdi Saberioon and Luboš Borůvka, Soil organic carbon and texture retrieving and mapping using proximal, airborne and Sentinel-2 spectral imaging. *Remote Sensing of Environment*, vol. 218, 1 December 2018, 89–103.
8. Evandro Carrijo Taquary, *Deep Learning Para Identificação Precisa de Desmatamentos Através do Uso de Imagens Satelitárias de Alta Resolução*, Master Thesis, Federal University of Goias, Goiânia, Brasil, 2019.
9. Audrey Mercier et al., Evaluation of Sentinel-1 & 2 time series for predicting wheat and rapeseed phenological stages. *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 163, May 2020, 231–256.
10. Juli Lage de Souza Silva et al., Analysis of vegetation recovery in areas impacted by bauxite mining in the Amazon Forest. *Clean Technologies and Environmental Policy*, vol. 23, n. 5, 2021, 1617–1640.
11. Jon Strand et al., Using the Delphi method to value protection of the Amazon rainforest. *Ecological Economics*, v. 131, January 2017, 475–484.
12. Jessica dos Santos Cugula et al., Temporal analysis of mining area recovery in Paragominas by natural regeneration technique through vegetation indices, *Journal of Environmental Analysis and Progress*, 25 November 2021, vol. 06, N. 04, 379-395.
13. Rodolfo L. B. Nóbrega et al., Impacts of land-use and land-cover change on stream hydrochemistry in the Cerrado and Amazon biomes. *Science of The Total Environment*, vol. 635, 1 September 2018, 259–274.
14. Rafaela Flach et al., Conserving the Cerrado and Amazon biomes of Brazil protects the soy economy from damaging warming. *World Development*, vol. 146, October 2021.