Tracking the Impact of Mining Activity in the Amazon Rainforest Using Satellite Data

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Project Highlights:

- Large scale, systematic tracking of mining impacts in the Amazon since beginning of the satellite era
- Development of skills in latest satellite imagery analysis including machine learning tools
- Creation of an open-access geospatial database of mining impacts allowing users to view maps, download satellite data, and access analytical tools

Overview:

The Amazon rainforest, a crucial component of the Earth's climate system and a global biodiversity hotspot, has been facing increasing threats due to deforestation and mining activities. Mining in particular, while often less extensive than large-scale agricultural deforestation, has localized but intense effects on ecosystems, often causing significant damage to vegetation and water systems. Gold mining (both legal and illegal) in particular affects not only the immediate area but also has downstream impacts due to river contamination and ecosystem disruption, for example due to tailings dumped in rivers. Monitoring these activities using satellite technology offers a non-invasive, large-scale, and cost-effective solution to track environmental impacts. This project will examine the environmental impacts of mining activities in the Amazon rainforest using high-resolution optical and infrared satellite data to detect and quantify changes in vegetation over time. The study will focus on identifying areas of degradation and deforestation related to mining, providing actionable insights for environmental monitoring and policy development.

This project aims to (1) Detect and quantify vegetation loss in mining-affected areas of the Amazon rainforest using satellite remote sensing techniques, (2) Analyze temporal changes in vegetation health to track the progression of degradation and deforestation due to mining activity, (3) Develop a database of mining-related environmental impacts to inform conservation and reforestation efforts.

By developing a scalable approach using satellite remote sensing, the project will contribute to efforts to protect the Amazon by providing a tool to track and mitigate environmental degradation. The development of a publicly accessible database will ensure that these insights are available to all, enhancing transparency and encouraging evidence-based policymaking.

Figure 1. Illustration of rainforest affected by mining in Suriname, showing the impact of artisanal small scale gold mining including deforestation and forest degradation.

Methodology:

The project will leverage a combination of optical and radar satellite instruments, each providing unique insights into the state of vegetation in mining-impacted regions:

•Landsat (NASA/USGS) data back to the 1970s will allow time-series analysis and historical comparisons of forest cover pre- and post-mining activities from optical/IR bands

• Sentinel-2's (ESA) higher spatial resolution and increased revisit frequency is excellent for more detailed and frequent for analysing optical/IR changes around smaller mining sites including changes to waterways

• Sentinel-1 Synthetic Aperture Radar imagery (ESA) is unaffected by cloud cover and can be used to monitor deforestation and terrain changes

In addition, we will use higher resolution SAR and hyperspectral imagery for a selected number of case study mining sites to analyse trajectories of impact, recovery (where applicable) over short and longer terms. After atmospheric correction, we will use vegetation indices calculated from multispectral data to assess vegetation health over time.

Possible Timeline

Year 1: Development of methodology, selection of case studies and initial interactions with stakeholders in NGOs and industry. The student will have the opportunity to develop change detection algorithms (e.g., Continuous Change Detection and Classification, or CCDC) and employ machine learning-based classifiers, such as random forest or support vector machines, to identify land use, e.g., forest, mining areas, and regenerating forests.

Year 2: Analysis of timeseries of mining impacts in the Amazon basin 1970s-date. Comparison of results from different satellite instruments will provide a validation of our results along with ground truthing from NGO reports on illegal mining activity.

Year 3: Production of comprehensive geospatial database of mining impacts and analysis of trajectories of vegetation degradation and recovery.

Training and skills:

Training will be provided in analysis of satellite imagery (including SAR), machine learning and cloud computing methods.

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

Partners and collaboration (including CASE):

The successful applicant with have regular meetings with Dr Alessandro Novellino at the British Geological Survey online every 6 to 8 weeks and in person quarterly. In addition, the candidate will develop relationships with international NGOs and national geological surveys in South America to develop the maps and analysis tools best suited to end-users. Supervisor has collaborative links with Ecuadorian geological survey and colleagues in humanitarian and environmental NGOs using satellite imagery.

Further reading:

Caballero Espejo J, Messinger M, Román-Dañobeytia F, Ascorra C, Fernandez LE, Silman M. Deforestation and Forest Degradation Due to Gold Mining in the Peruvian Amazon: A 34-Year Perspective. *Remote Sensing*. 2018; 10(12):1903. https://doi.org/10.3390/rs10121903

Fonseca A, Marshall MT, Salama S. Enhanced Detection of Artisanal Small-Scale Mining with Spectral and Textural Segmentation of Landsat Time Series. Remote Sensing. 2024; 16(10):1749. https://doi.org/10.3390/rs16101749

Hethcoat MG, Carreiras JMB, Edwards DP, Bryant RG, Quegan S. Detecting tropical selective logging with C-band SAR data may require a time series approach, *Remote Sensing of Environment*. 2021; 259(112411), https://doi.org/10.1016/j.rse.2021.112411

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply.

For project details please email: s.k.ebmeier@leeds.ac.uk.