Remote sensing techniques for small-scale mining detection
by
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Small-scale and artisanal mining

Major types:
- underground mining of veins
- alluvial mining of particles that concentrate in water pathways
  - Excavation in water channels
  - Excavation on river banks

Small-scale mining can use large machinery.

Photo by Elsy Ibrahim/Luisa Lema
El Bagre/ Zaragoza – Colombia, Nov. 2018
The challenges

Small-scale mining provides livelihood to many households

Unfortunately

- has a **large footprint** with low monitoring or regulation
- has **environmental impacts** (e.g. land degradation, wetland destruction, heavy metal accumulation and biomagnification)
- has **health impacts** (e.g. the inhalation and ingestion of mercury, safety of working conditions)
- has **social impacts** (e.g. is in the heart of major armed conflicts)

In the department of Antioquia, Colombia
A small-scale alluvial mining activity is considered formal/legal when:
- the operator obtains a mining title
- the operator provides an approved a program of works (Programa de Trabajos y Obras – PTO)
- activities are required to be less than 150 hectares (Decreto 1666)
- there are required strict measures of land recovery

More than 70% of the gold production in Colombia is extracted from informal activities.
The landscape setting of alluvial Mining

Formal and informal small-scale mining use similar equipment and carry out similar processes

Gratitude to Emijom mining.

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Introduction to remote sensing

Remote sensing is the technique of gathering data and knowledge about the Earth's surface without physical contact:
- detecting and recording reflected or emitted energy
- analyzing and processing the data
Introduction to VIS-NIR-SWIR passive remote sensing

The electromagnetic spectrum

Energy source

Source: https://sci.esa.int/s/WyP9nXw

Sensors in VNIR-SWIR

Source: sentinels.copernicus.eu
What we “see” and “image”

The reflectance spectrum

$E_I$: incident energy
$E_R$: reflected energy
$E_A$: absorbed energy
$E_T$: transmitted energy

Photo by Elsy Ibrahim/Luisa Lema
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Detecting mining sites on river banks

• Methodology:
  • Classification

Classification is the process of categorizing or grouping data into categories based on their spectral characteristics.
Detecting mining sites on river banks

- Methodology:
  - Classification
  - Post-classification analysis
  - Temporal analysis
  - Validation by local experts
Added value of remote sensing for small-scale mining

- Large spatial coverage with detail reaching 10m resolution
Added value of remote sensing for small-scale mining

• Continuous monitoring, we can analyze temporal patterns

For a study area in the department of Antioquia, Colombia
Added value of remote sensing for small-scale mining

- High revisit time reaching 5 days, so we can analyze sequences

For a study area in the department of Antioquia, Colombia from 2016 to 2019

- There is more mining activity in the dry season than in the wet season
- Areas with persistent mining were 28% of the total mined area
- Recovered land corresponded only to 7% of the total excavated areas
- For land to recover, more than four years were required
How can this be made useful?

- **Early warning**: can we detect trends of spread towards sensitive areas?

- **Intervention**: can this support prioritization of activities?

- **Pollution hotspots**: can we point out areas that have been consistently excavated and their impacts on watersheds (e.g. mercury accumulation)?

- **Remediation**: can we help prioritizing areas for remediation programs?
Conclusions

- Satellite data provides timely information with high spatial coverage - and many of the datasets are free!
- Temporal analysis can allow an understanding of impacts and of mining activities.
- VNIR-SWIR sensors sources are highly affected by cloud cover. Fusion of datasets can be useful.

Photo by Elsy Ibrahim/Luisa Lema
El Bagre/Zaragoza – Colombia, Nov. 2018
References

• Eye in the sky – using satellites to better manage natural resources: https://www.unep.org/news-and-stories/story/eye-sky-using-satellites-better-manage-natural-resources

• Storymap in English on MapX
• Storymap in Spanish on MapX


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