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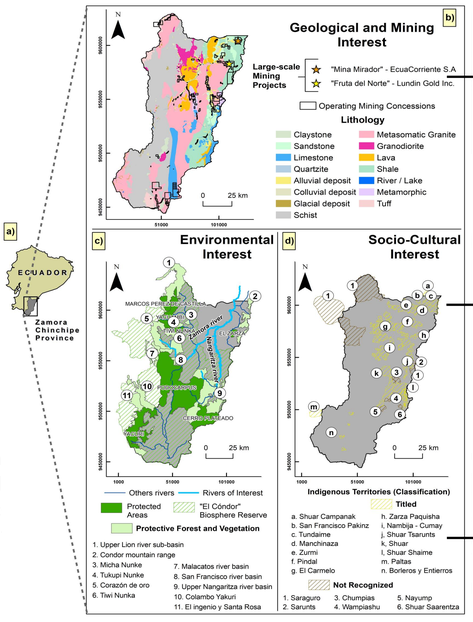
# Mining in the Southern Ecuadorian Amazon: Hotspots analysis and Regulatory efficiency

## PROBLEM

Mining activities in the Southern Ecuadorian Amazon have intensified in recent decades due to increasing demand for mineral resources and the expansion of industrial and artisanal mining. Although the Mining Law of 2009 was established to regulate the sector, illegal mining and weak enforcement continue to drive deforestation, ecosystem degradation, river contamination, and conflicts with indigenous communities. These impacts are particularly evident in Zamora Chinchipe, where mining activities increasingly overlap with protected areas and indigenous territories.

## GENERAL OBJECTIVE

To explore the development of mining activities in Zamora Chinchipe, using land use land cover data and spatial analysis techniques, to evaluate the effectiveness of the Mining Law of 2009 in controlling mining expansion over the last 15 years in the Southern Ecuadorian Amazon.





## METHODOLOGY

### 1 Data acquisition and preparation

- "Mining" class extraction of Land Use Land Cover data from 2008 and 2023
- Mining concessions
- Lithology
- Rivers
- Conservation Units (CUs)
- Indigenous Territories (ITs)

### 2 Mining Hotspot indentification

**Kernel Density Estimation**

- Conversion "Mining" pixels into point data
- ***Epanechnikov Kernel***

$$\hat{f}(x) = \frac{1}{n.h} = \sum_{z=1}^{n} k\left(\frac{x - x_z}{h}\right)$$

- *n = number of samples*
- *h = smoothing parameter*
- *K = kernel function*

| KDE Parameters | |
|---|---|
| Cell size | 500 m |
| Search radius | 2500 m |

### 3 Spatial assessment of Mining intensity

**Mining Law 2009 Regulatory efficiency**

- Evaluation of regulation effectiveness in controlling mining hotspots growth before (2008) and after (2023) Mining Law

**Legacy of Mining Hotspots**

- Identification of Hotspots associated with:
  - V Large-scale Mining projects
  - V Artisanal and Small-scale Mining
  - V Illegal Mining activities

**Environmental & Social Assessment**

- Identification of areas under the highest Hotspots:
  - V Rivers
  - V Conservation Units
  - V Indigenous Territories

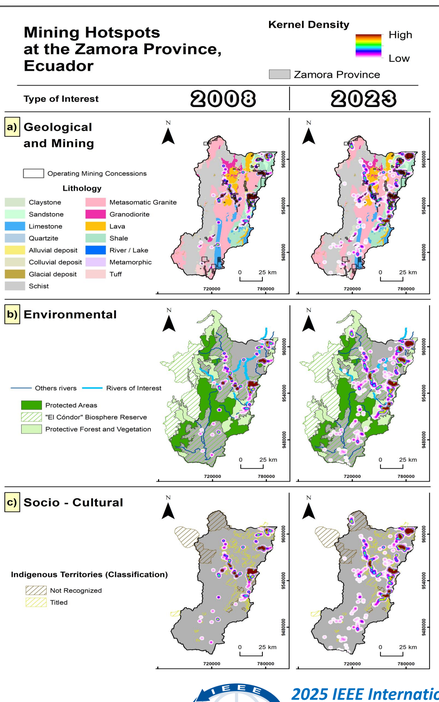
## RESULTS

### 2008

Hotspots were concentrated in the northeast, over claystone, sandstone, and metasomatic granite lithologies associated with the Mirador Cu deposit and the Fruta del Norte Au–Ag project

Highest mining intensity was concentrated along the Zamora and Nangaritza rivers, mainly associated with artisanal and small-scale alluvial mining and legal mining concessions

8 Indigenous Territories of the Shuar and Kichwa nationalities were affected by mining hotspots, mainly associated with the Mirador and Fruta del Norte projects, ASM along the Zamora River, and medium-scale mining on the Nangaritza River




### 2023

Northwestern hotspots were associated with alluvial gold and non-metallic mineral extraction over metasomatic granites and tuffs. Southern hotspots were located on limestone lithologies outside operating mining concessions, indicating the expansion of illegal alluvial mining

Mining activity intensified along the Zamora and Nangaritza rivers, increasing environmental pressure on Podocarpus National Park and El Cóndor Biosphere Reserve through river contamination, channel alteration, and deforestation

Mining hotspots expanded into the Saraguro, Tapala, Sahuinuma, and Zumba Indigenous Territories, reflecting the growth of illegal mining and the limited effectiveness of the Mining Law/2009

## CONCLUSIONS

Kernel Density Estimation revealed a clear expansion of mining hotspots between 2008 and 2023, particularly in the central and southern sectors of Zamora Chinchipe. The increase in hotspot intensity was mainly associated with illegal alluvial gold mining, generating greater pressure on the Zamora and Nangaritza rivers and surrounding protected areas.

Although the Mining Law of 2009 promoted the development of large-scale mining, the persistence and expansion of illegal mining within Indigenous Territories indicate limitations in its implementation and enforcement.

## RECONOCIMIENTOS

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13 CLIMATE ACTION
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