Data-Driven Detection and Attribution of Illegal Resource Extraction

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Illegal mineral and resource extraction is a rapidly expanding form of environmental crime, exemplified by artisanal gold mining in the Amazon Basin and West Africa, unregulated bauxite mining in Guinea, and large-scale sand extraction across Southeast Asia. These activities drive deforestation, contaminate rivers with mercury and cyanide, accelerate sedimentation, and destroy habitats, while simultaneously funding organized crime, corruption, and human exploitation. Because such operations are remote, transient, and politically shielded, conventional field-based monitoring and enforcement approaches are often ineffective or unsafe. This project defines a new research direction that integrates remote sensing, environmental forensics, and data-science methodologies to detect, attribute, and quantify the environmental and socio-economic dimensions of illegal resource extraction.

The first line of enquiry aims to investigate how multi-sensor satellite imagery (optical, radar, and hyperspectral) and emerging open-access Earth observation datasets can be combined to identify subtle or transient indicators of illicit mining. The project will explore advanced data-fusion pipelines and machine-learning techniques to distinguish mining-related disturbance from natural or agricultural variability. Novelty lies in combining spectral unmixing, radar backscatter dynamics, and temporal anomaly detection into unified workflows that can track activities even under cloud cover or dense vegetation. Technical elements may include self-supervised learning for sparse-label imagery, multi-scale segmentation models, and integration of drone-based data for local calibration.

A second research component can focus on geochemical fingerprinting of mining residues, sediments, and waters to identify diagnostic chemical or isotopic signatures linked to illicit extraction and processing. This work would establish baseline libraries of trace-metal ratios, isotopic markers, and organic residues associated with mercury amalgamation or cyanide leaching. Innovation lies in coupling high-resolution analytical chemistry with geospatial modelling to trace pollutant sources and estimate extraction intensity.

The third strand aims to connect environmental and geochemical indicators with socio-economic and supply-chain analysis, using open-source trade, transport, and logistics data to detect anomalous material flows and link them to potential extraction zones. Technical novelty includes applying graph-theoretic and machine-learning methods to model illicit network structures and relate environmental anomalies to global commodity flows, and apply a data science approach to environmental criminology.

This research framework forms a coherent, interdisciplinary programme at the frontier of geoscience, environmental data analytics, and criminology, aimed at transforming how illegal resource extraction is detected, attributed, and ultimately deterred worldwide. Students can choose to specialise in one or more of these strands, or to propose their own vision (building on regional or national priorities).

We are looking for pro-active and scientifically curious applicants with an excellent background in the appropriate subject, e.g. geospatial analysis, data science, quantitative social science, Earth or environmental science, physics, mathematics, or engineering, and with the willingness to learn computational or other relevant survey methods as needed. Interaction with industry, law

enforcement, NGO and incorporation of field studies may also be possible within the scope of the research.

Applicants with a strong academic record and who can demonstrate aptitude for an independent and creative approach to scientific research (or other activities relevant to their background) are more likely to be successful. Students will be strongly encouraged to make projects their own and will be supported through that growth process so do not hesitate to also propose your vision for a project when contacting us.