

Utilizing Remote Sensing and GIS to Detect Illegal Mining and Environmental Impacts in Bulolo and Wau District, Morobe Province, Papua New Guinea

CONGRESS THEME: *"SURVEYORS ROLE IN RECLAIMING THE LAND, REDEFINING LAWS AND LEGACY ISSUES IN A CHANGING PNG."*



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CARTOGRAPHER
MINERAL TENEMENTS BRANCH
REGULATORY OPERATIONS
DIVISION
MINERAL RESOURCES AUTHORITY
PAPUA NEW GUINEA

A poster for the ASPNG 58th Survey Congress 2026. The poster features a background image of a coastal town at sunset. At the top, it says "THE ASSOCIATION OF SURVEYORS OF PAPUA NEW GUINEA INC." around a red circular logo with a surveying instrument. Below that, it says "ASPNG 58th SURVEY CONGRESS 2026" and "01st - 05th JUNE 2026 WEWAK EAST SEPIK PROVINCE". On the left side, there is a vertical banner with logos for "THEODIST", "DLPP", and "ARAS LIMITED Consultancy Surveyors". At the bottom, it says "SURVEYORS CARTOGRAPHERS/GIS VALUERS PHYSICAL PLANNERS ALLIED PROFESSIONS" and "Uniting for PNG's Future". A surveying instrument is visible in the bottom right corner.

A Landmark Gathering for PNG's Surveying Professionals

REMOTE SENSING AND GIS FOR ILLEGAL MINING DETECTION and MONITORING

Illegal & Unregulated Mining



Papua New Guinea

Environmental Impacts



Deforestation



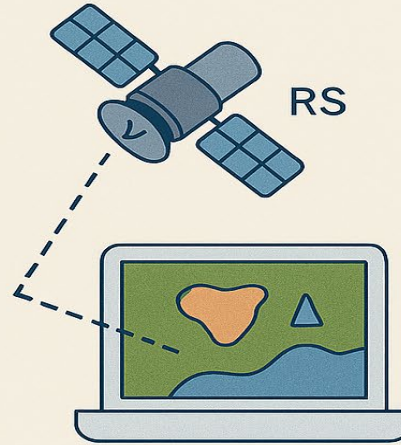
Land Degradation



River Sedimentation



Water Pollution



RS & GIS Monitoring & Detection

Abstract: Illegal and unregulated mining activities present significant environmental and socio-economic challenges in many parts of Papua New Guinea, particularly in the Bulolo and Wau Districts of Morobe Province. These activities contribute to deforestation, land degradation, river sedimentation, and water pollution, posing serious risks to ecosystems and local communities. This study explores the application of Remote Sensing (RS) and Geographic Information Systems (GIS) as effective tools for detecting and monitoring illegal mining activities and their associated environmental impacts.

• PROBLEM

Extraction of minerals without proper government authorization, licenses, or adherence to laws and regulations. It often operates outside official oversight, ignoring environmental, safety, and labour standards, which can lead to environmental damage, unsafe working conditions, and loss of government revenue.

• IMPACT

Illegal mining may provide short-term income for individuals, but it creates long-term socio-economic problems including poverty, inequality, environmental damage, weakened governance, and lost national revenue.

• MONITORING

Monitoring of illegal mining involves using satellite imagery and spatial analysis tools to detect, map, and track mining activities over time. RS helps capture changes like land clearing, water pollution, and excavation), while GIS is used to analyze, visualize, and monitor these changes thus supporting authorities in identifying illegal operations and managing environmental impacts.

Locality & Context

Geographic Location

Located in Morobe Province, Papua New Guinea
Situated in the south-eastern highlands region
Lies within the Bulolo River catchment
Characterized by mountainous terrain, steep valleys, and dense rainforest



Accessibility

Connected to Lae via the Bulolo Highway
Road access can be difficult due to rough terrain and heavy rainfall
Air access available through small airstrips (e.g., Wau Airstrip)
Remote areas accessible only by footpaths or temporary roads



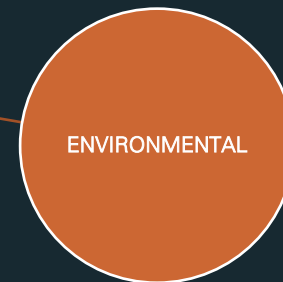
LEGAL

- Mining Act 1992
- Mining Safety Act 1977
- Environment Act 2000
- MRA Act 2005
- Alluvial Mining Policy



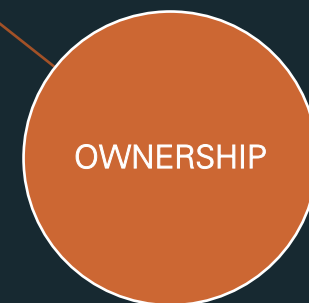
ECONOMIC

- PGK300-600M
- Rural Economy
- Socio-economic issues



ENVIRONMENTAL

- Land disturbances
- Pollution (Water, Noise)



OWNERSHIP

- Land Dispute
- Tribal Conflicts
- Unsettled Grievances
- Compensation
- Ownership and Mining Rights

Geological Setting

Part of the Papua New Guinea
Mobile Belt

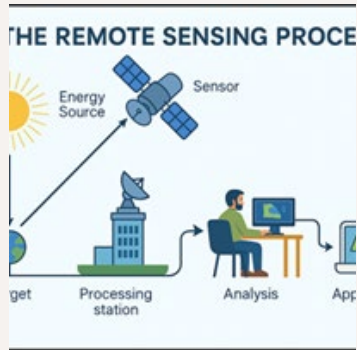
Dominated by Tertiary volcanic
and intrusive rocks (andesite,
basalt, granodiorite)

Structurally complex with faults
and fractures controlling
mineralization

Rich in gold deposits, especially:

- Alluvial (placer) gold in river systems
- Epithermal gold in hard rock

Discover Report Overview



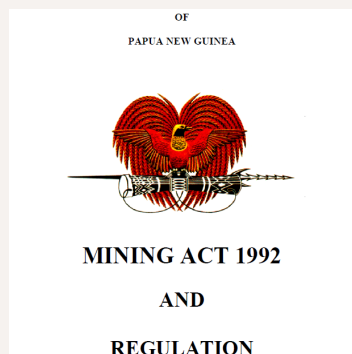
Remote Sensing in Alluvial Mining Sector

Demonstrates the effectiveness of RS and GIS technologies in providing timely, cost-efficient, and scalable solutions for environmental monitoring and enforcement support over large, inaccessible areas.



State Entity Collaboration

Driving transparency, accountability and technology innovation through shared public datasets and fostering knowledge



Regulatory and Environmental Oversight

The report supports regulatory compliance and sustainable mineral development via advanced geospatial analysis.

Case Study: Detecting Illegal Mining in Bulolo

Illegal Mining Detection

Mining activities outside registered tenement boundaries indicate legal non-compliance

Environmental Disturbance

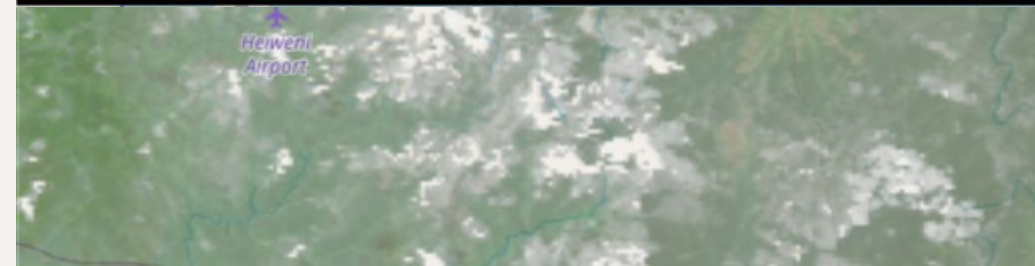
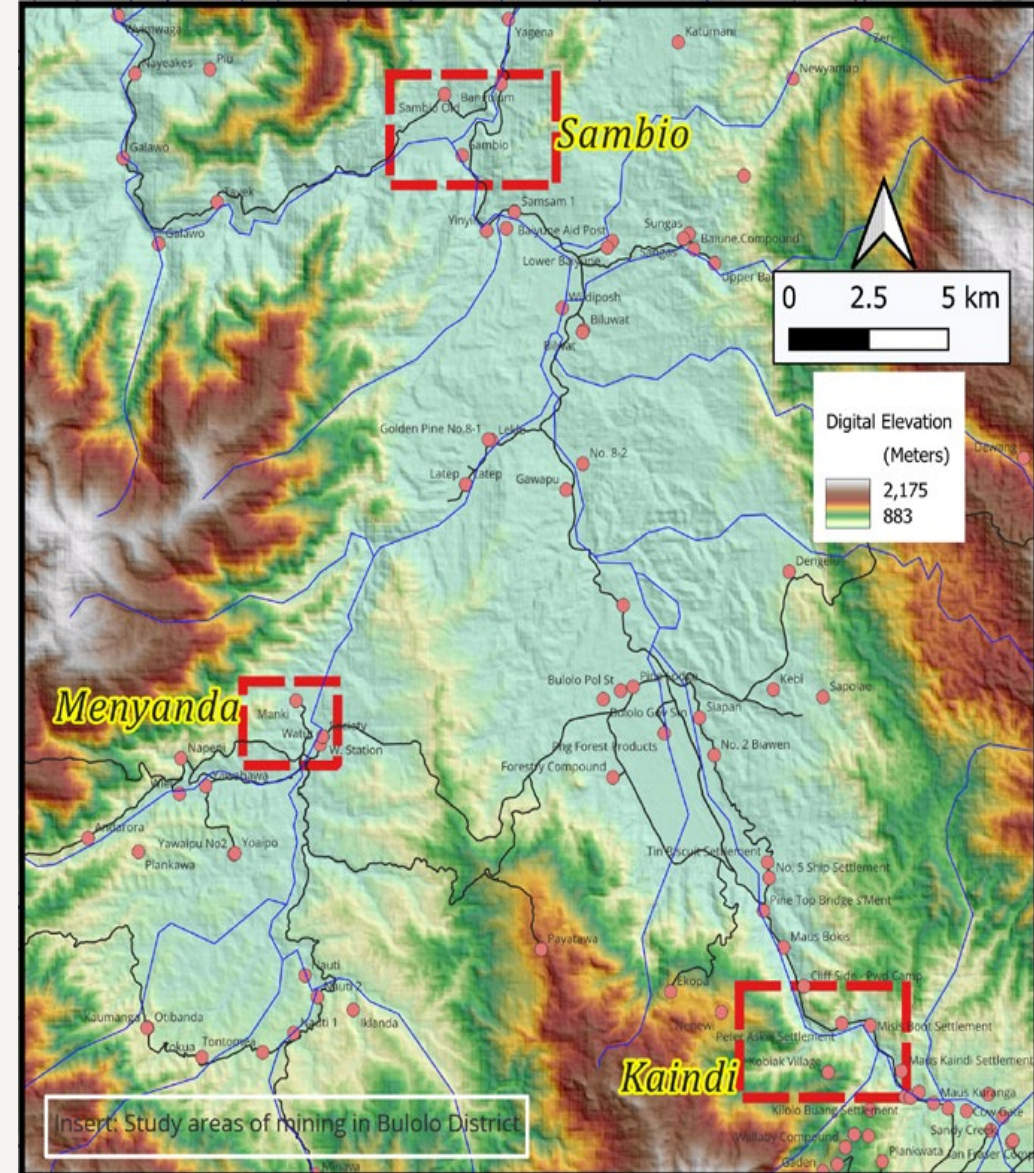
River channel diversion shows environmental risks linked to unregulated mining practices.

Tenement Applications

Clear spatial overlays between active tenements and applications are crucial for regulatory clarity – Data integration, CEPA, DoLPP, and Forestry etc.

Remote Sensing Analysis

Remote sensing enables identification of non-compliance and supports regulatory enforcement efforts effectively.



O1: Mining Outside Registered Tenement

Remote Sensing for Mining Monitoring

Sentinel-2 satellite imagery was used to identify mining activity beyond legal tenement boundaries.

Spatially Accurate Boundary Analysis

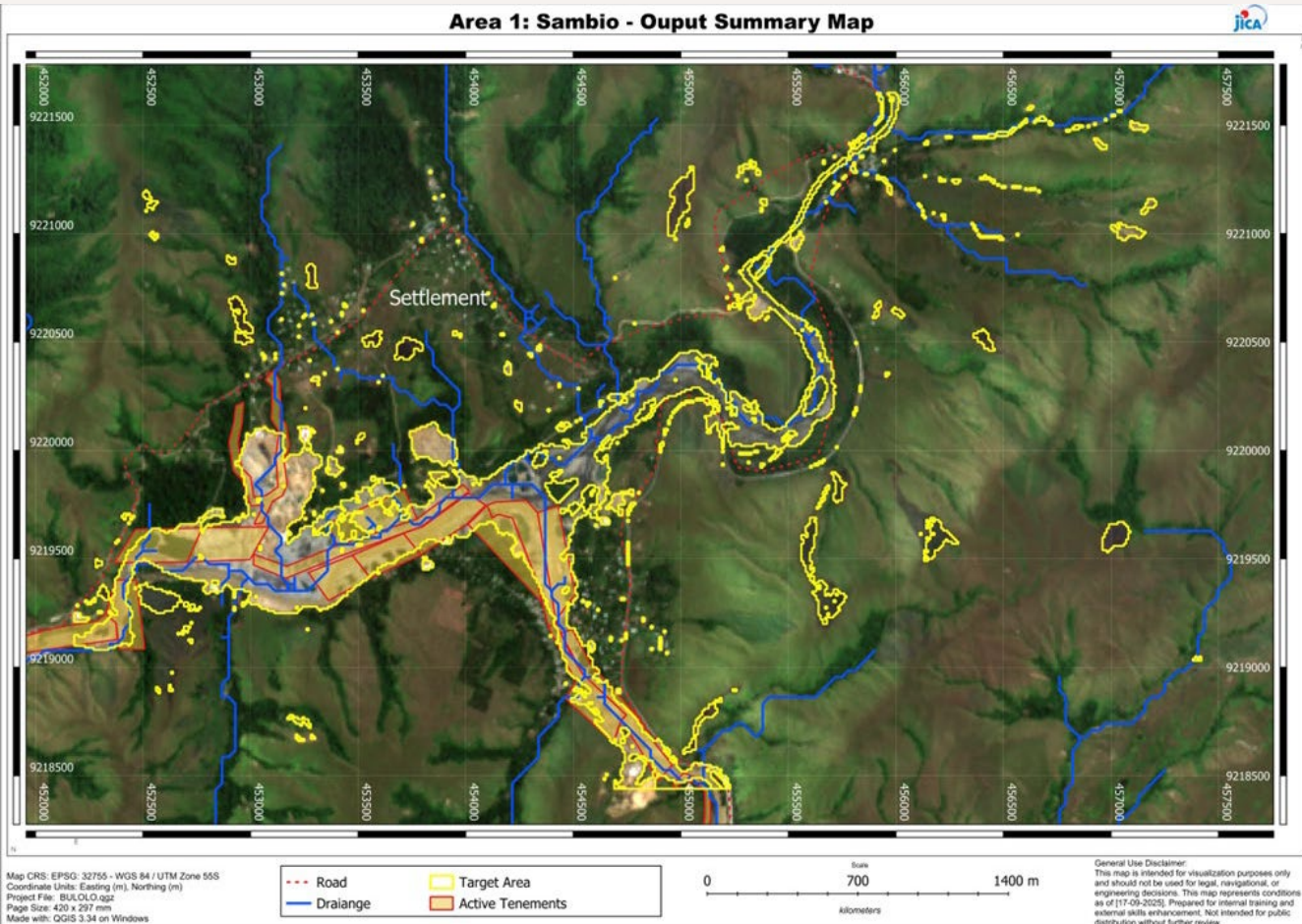
Vectorized datasets overlaid on true-color images provide clear visualization of legal and non-compliant mining areas.

Improved Regulatory Compliance

This method enables early detection of boundary infringements and supports timely enforcement actions by regulators.

Enhanced Resource Allocation

Integrating geospatial tools helps prioritize high-risk areas, improving monitoring efficiency and governance in mining.



O2: Environmental Disturbances to River

River Channel Diversion

Mining activities cause significant alterations to natural river channels, impacting morphology and flow.

Environmental Risks

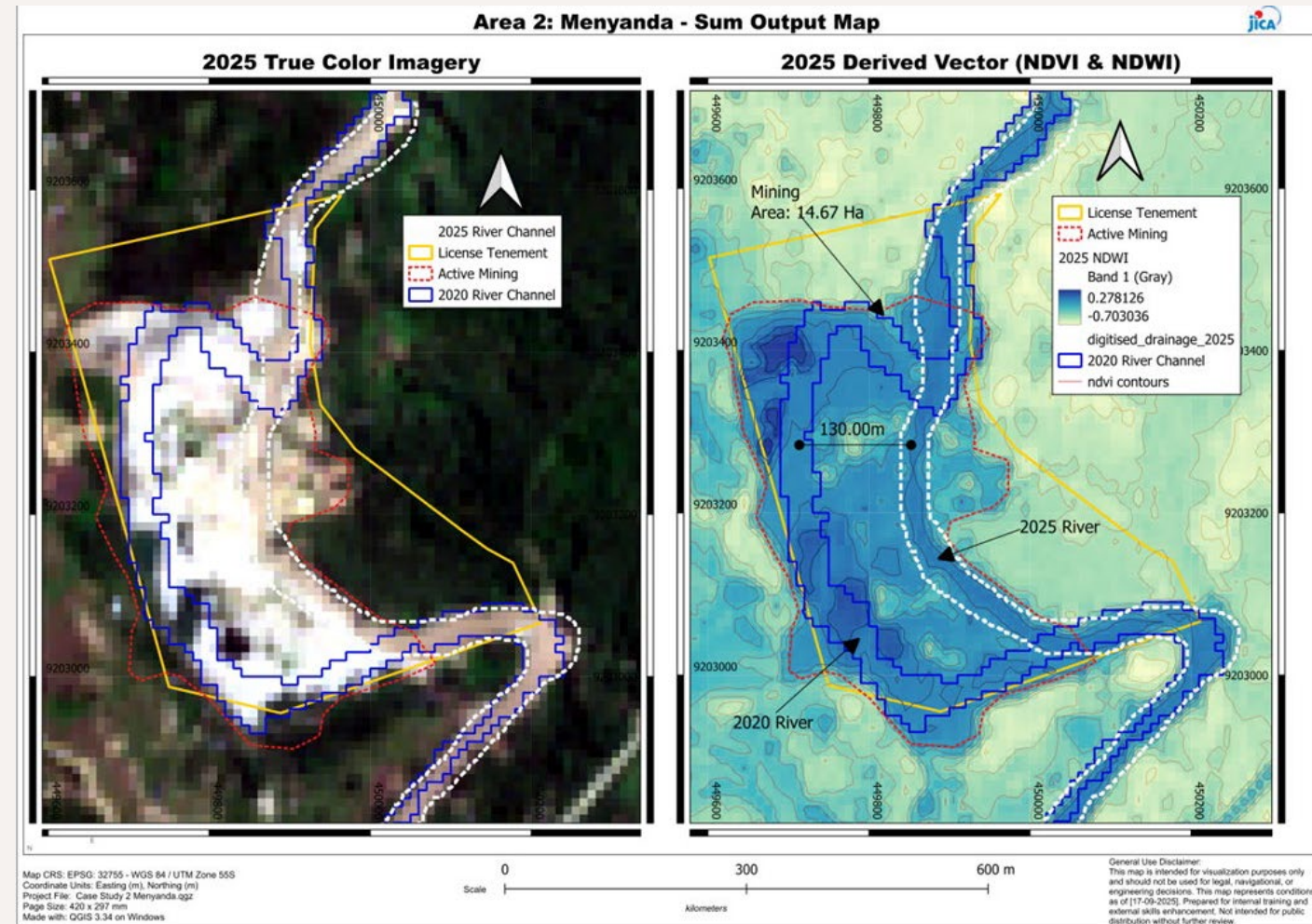
Disturbances from mining threaten downstream ecosystems, water quality, and community livelihoods.

Remote Sensing for Monitoring

Temporal satellite imagery enables detection of recent and ongoing river diversions for enforcement.

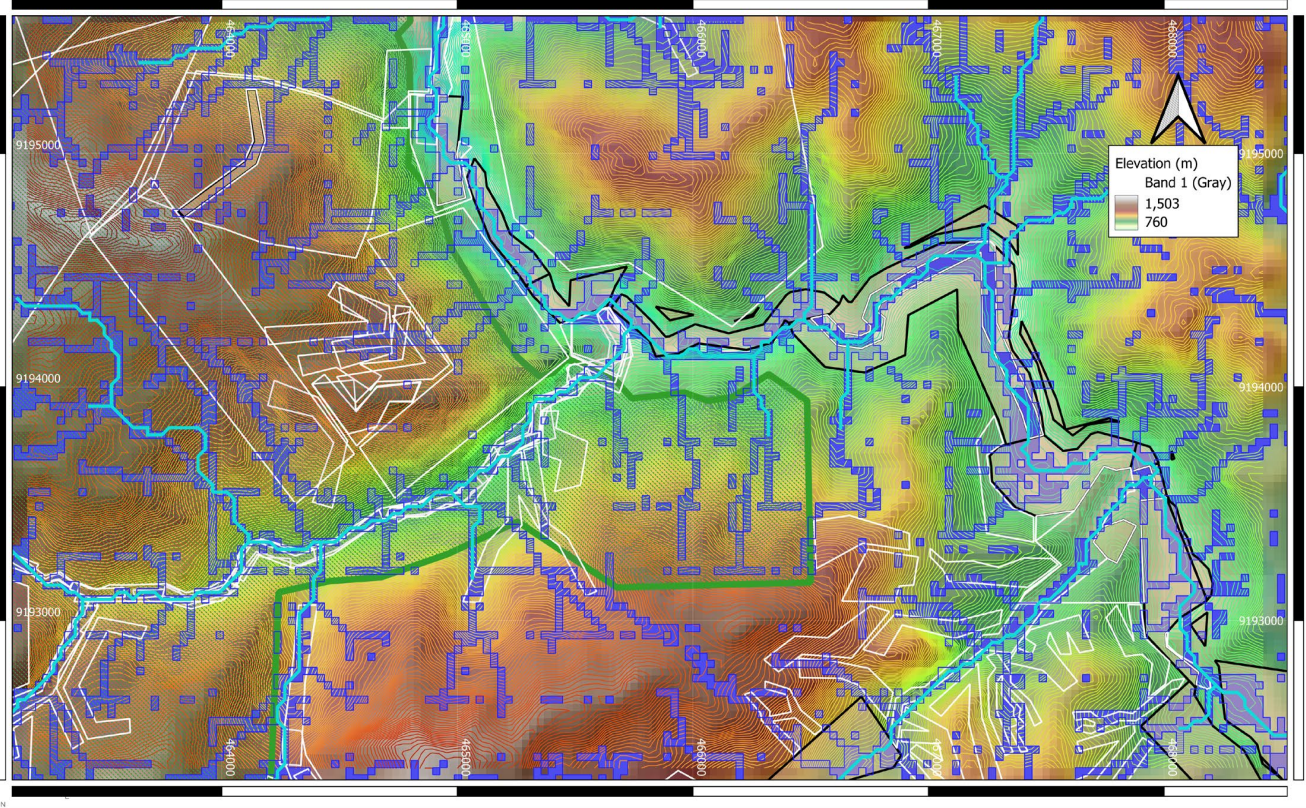
Coordination and Enforcement

Collaboration between mining regulators and environmental agencies is essential for protection.



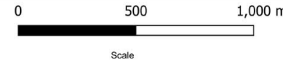
O3: Tenement Applications Overlay

Area 3: Kaindi Output Map - Tenement Overlay



Map CRS: EPSG: 32755 - WGS 84 / UTM Zone 55S
Coordinate Units: Easting (m), Northing (m)
Project File: Case Study 3 Kaindi.gpx
Page Size: 420 x 297 mm
Made with: QGIS 3.34 on Windows

Legend:
SRTM Drainage
topo/drainage (indicative)
AML/ML Application
Active Tenements
CEPA Protected Area



General Use Disclaimer:
This map is intended for visualization purposes only and should not be used for legal, navigational, or engineering decisions. This map represents conditions as of (17-09-2025). Prepared for internal training and external skills enhancement. Not intended for public distribution without further review.

Spatial Overlay Analysis

Using SRTM raster data to visualize active and pending tenement applications highlights spatial relationships and potential overlaps.

Reducing Conflict Risks

Clear spatial overlays help reduce disputes and increase stakeholder confidence in the tenement application process.

Informed Decision Making

Overlaying multiple data sources enables better assessment of terrain, accessibility, and environmental constraints for approvals.

Streamlining Tenement Management

Integrating remote sensing and GIS supports efficient technical assessments and improves mineral rights management quality.

Methodology

1. Data Acquisition (Copernicus Sentinel-2)

- Copernicus Open Access Hub / Dataspace – Level 2A (corrected)
- B4 R, B8 NIR, B3 G

2. Load Data into QGIS

- Opensource GIS

3. Create False Color Composite (FCC)

- False color imagery helps visually distinguish vegetation and water.

4. NDVI (Normalized Difference Vegetation Index) Calculation

- Vegetation Health

5. NDWI Calculation (Water Detection)

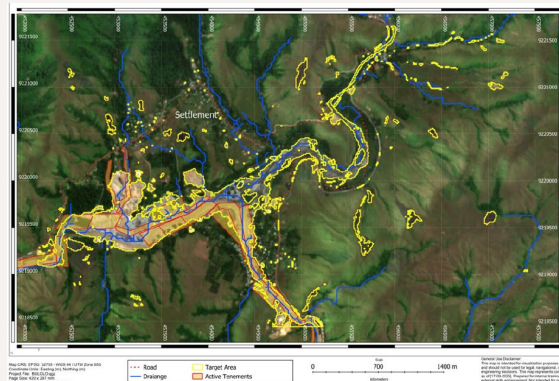
- Water Detection

6. Post-Processing & Classification

- Analysis and color ramps

7. Information Extraction

- Summary map output

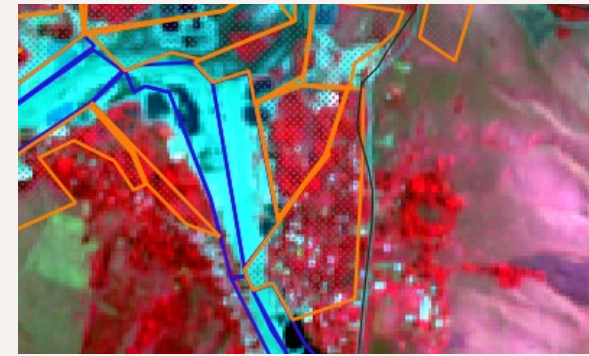


False color
Based on bands B8, B4, B3

+ Add to </> ^

False color composite

A false color composite uses at least one non-visible wavelength to image Earth. The false color composite using near infrared, red and green bands is very popular (a band is a region of the electromagnetic spectrum; a satellite sensor can image Earth in different bands). The false colour composite is most commonly used to assess plant density and health, since plants reflect near infrared and green light, while they absorb red. Cities and exposed ground are grey or tan, and water appears blue or black.



NDVI
Based on a combination of bands (B8 - B4)/(...)

+ Add to </> ^

Normalized Difference Vegetation Index (NDVI) $NDVI = (NIR - Red) / (NIR + Red)$

The normalized difference vegetation index is a simple, but effective index for quantifying green vegetation. It is a measure of the state of vegetation health based on how plants reflect light at certain wavelengths. The value range of the NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).

NDVI Value	Meaning
< 0	Water / clouds
0 – 0.2	Bare soil
0.2 – 0.5	Sparse vegetation
> 0.5	Dense vegetation

NDWI
Based on a combination of bands (B3 - B8)/(...)

+ Add to </> ^

NDWI Value	Meaning
> 0	Water
~0	Moist soil
< 0	Vegetation / dry land

Normalized Difference Water Index (NDWI)

The normalized difference water index is most appropriate for water body mapping. Values of water bodies are larger than 0.5. Vegetation has smaller values. Built-up features have positive values between zero and 0.2.

More info [here](#).

$NDWI = (Green - NIR) / (Green + NIR)$

Action Plan: Integrating Remote Sensing into MRA Processes



Remote Sensing in Regulatory Processes

Integrating remote sensing enhances decision-making, monitoring, and compliance within MRA regulatory frameworks.

Collaboration and Capacity Building

The plan promotes collaboration with state agencies and builds institutional capacity through evolving technologies.

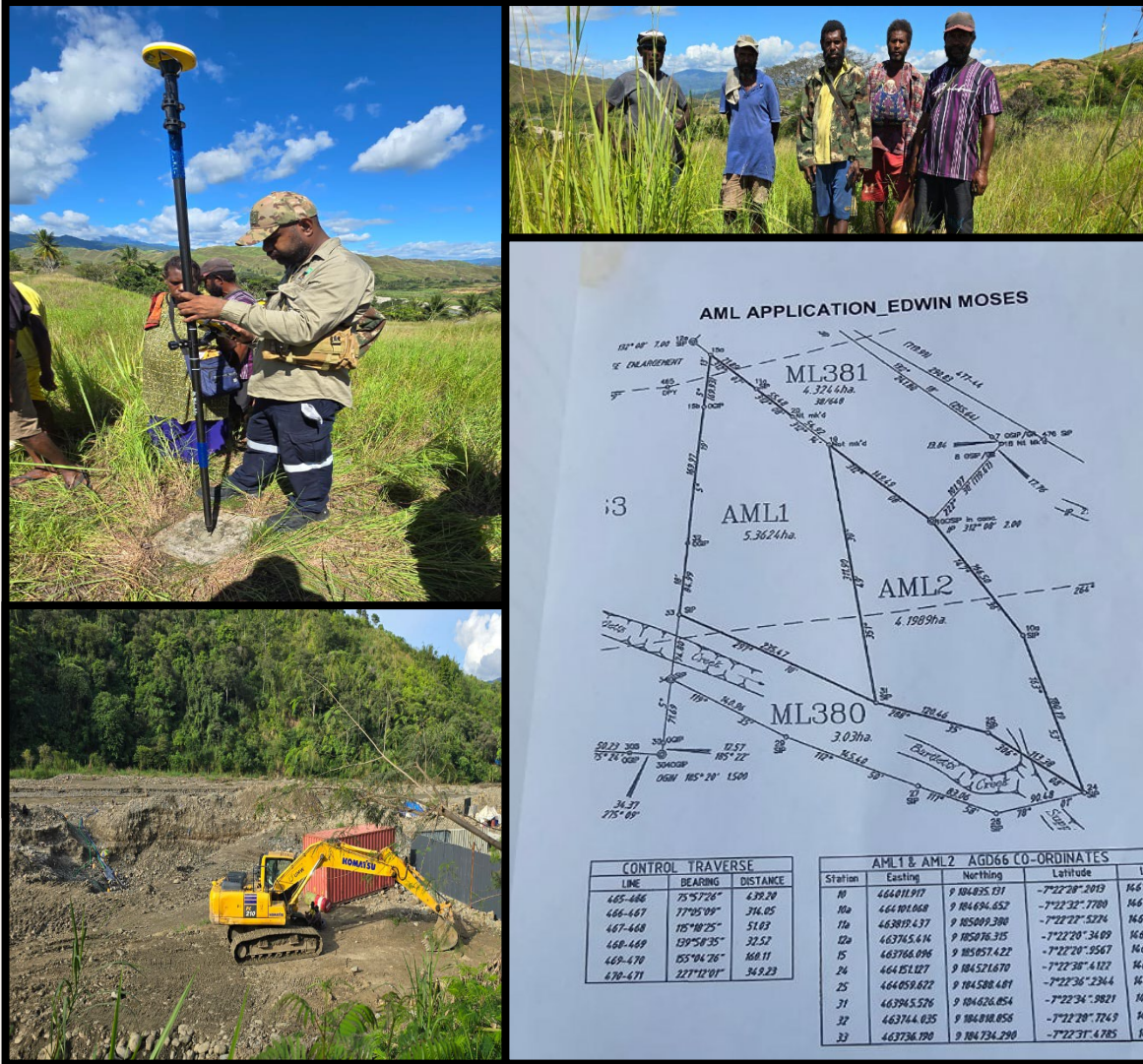
Supporting Geological and Environmental Functions

Remote sensing supports geological services, fisheries applications, and environmental monitoring initiatives effectively.

International Partnerships and Research

Affiliations with international networks and inclusion of laboratory standards strengthen the mineral value chain.

Key Partners and Acknowledgements



Diverse Key Partners

The project involves diverse partners with expertise in satellite systems, geospatial tech, research, and governance.

Importance of International Cooperation

International cooperation strengthens technical capabilities and addresses challenges such as illegal mining and environmental monitoring.

Appreciation and Future Collaboration

Expressing gratitude fosters respect and sets foundation for continued joint initiatives and shared knowledge.

[MRA Mining Cadastre eGov Portal – Trimble Landfolio - Tenement Map](#)

THANK YOU