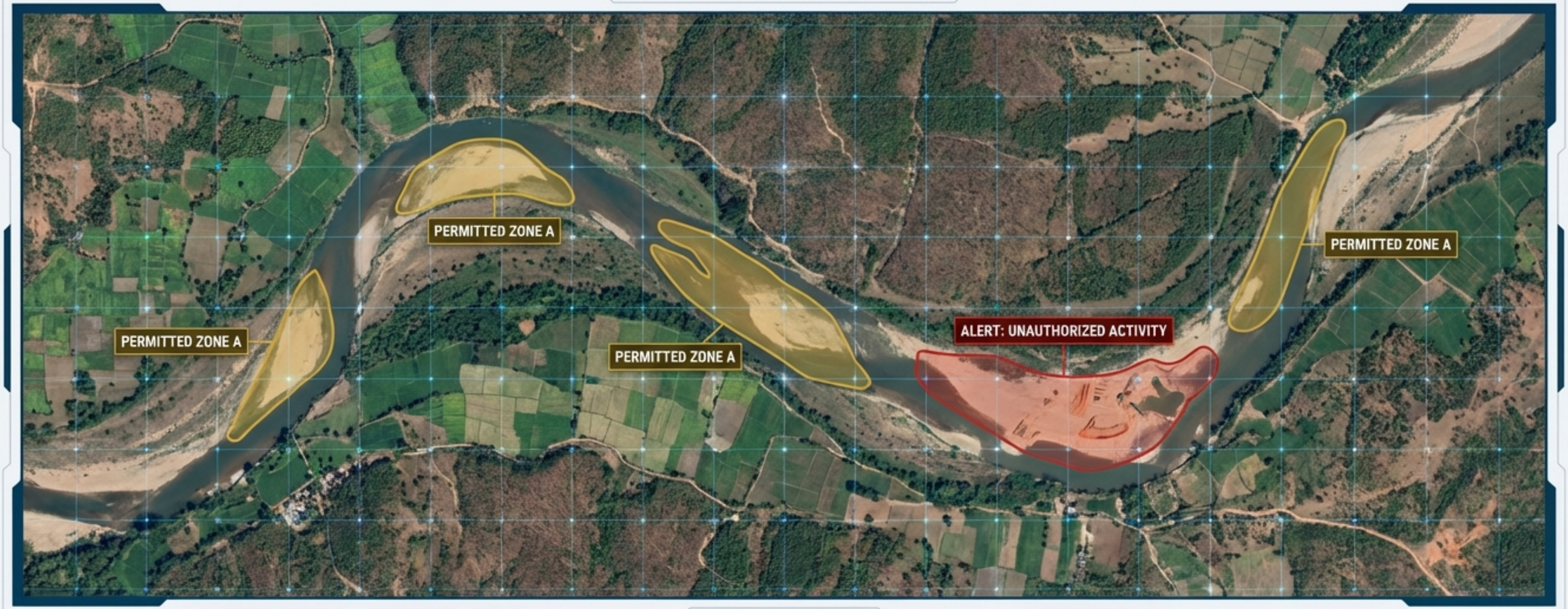


Odisha River Sand Monitoring: The GIS & AI Enforcement Framework

A Multi-Layered Proposal for Sustainable Extraction, Revenue Protection, and Scientific Replenishment across the Mahanadi and Rushikulya Basins.

- Integrating real-time satellite imagery, drone surveillance, and ground sensors for continuous monitoring of riverbed health.
- Deploying AI-driven change detection algorithms to identify illicit mining operations and calculate extracted volumes.
- Implementing a tamper-proof digital permitting system with geofencing to restrict extraction within approved zones.
- Enabling revenue leakage estimates and replenishment forecasts through advanced data analytics for long-term sustainability.
- Empelting in-analise avaneas wllum for sermitioned conditms nising trading and pepsoswicr porentia.
- Projected Revenue Recovery: $X.X Million Annually
- Reduction in Illicit Volume: XX% in Year One
- Failure to Implement: Irreversible Ecological Damage & Significant Revenue Loss.

Prepared for the State Government of Odisha / Director of Minor Mineral Resources

DOCUMENT TYPE: HIGH-DENSITY ST

Executive Summary: Moving from “Gate Monitoring” to “Source Monitoring”

The Strategic Shift

From / To

Current State (i4MS) - Monitors the Road. Focus on transport passes, weighbridges, and check-posts.

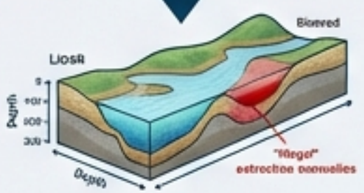
Proposed State (Basin Watchdog) - Monitors the River. Focus on volume geomorphology, and unleased areas.

The Mechanism

The Top-Down Funnel

Alert

Verify



Evidence

The Value Proposition

Why This Matters

- **Revenue:** Closing the loop on **royalty evasion** and **‘hidden’ theft** outside lease boundaries.
- **Environment:** Adherence to MoEFCC **Sustainable Sand Mining Guidelines** (2016/2020).
- **Scope:** All major river basins, segmented into **50-60km operational clusters**.

Regulatory Alignment and Economic Imperative

The Legal Mandate

- **Odisha Minerals Rules 2025**
  Mandates prevention of illegal mining, transportation, and storage.
- **Environmental Clearance (EC)**
  Strict enforcement of mining plans; extraction must stop when licensed volume is reached.

The Economic Case Study

Proof of Value: Cuttack Pilot 2025

Finding: Drone/DGPS mapping revealed massive over-extraction.

₹12 Cr

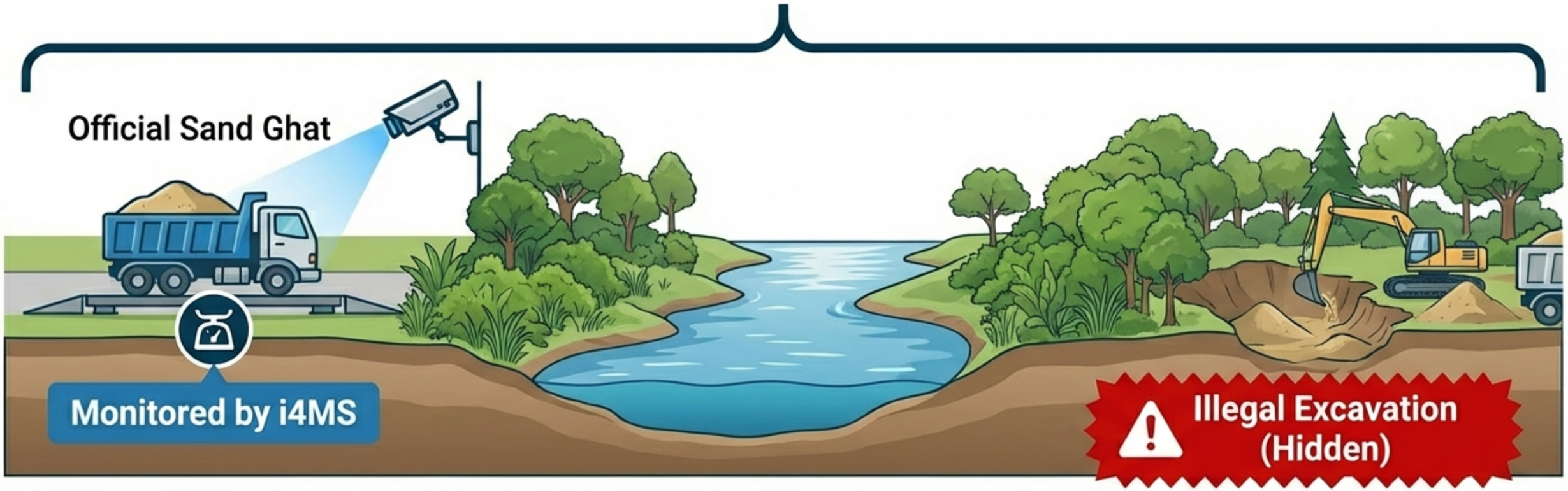
Penalty levied and recovered.

Verification: Vetted against ORSAC archives.

Takeaway: Technology pays for itself through recovered revenue.

The Operational Gap: Why We Need a 'Basin Watchdog'

Proposed 1km Buffer Zone Surveillance



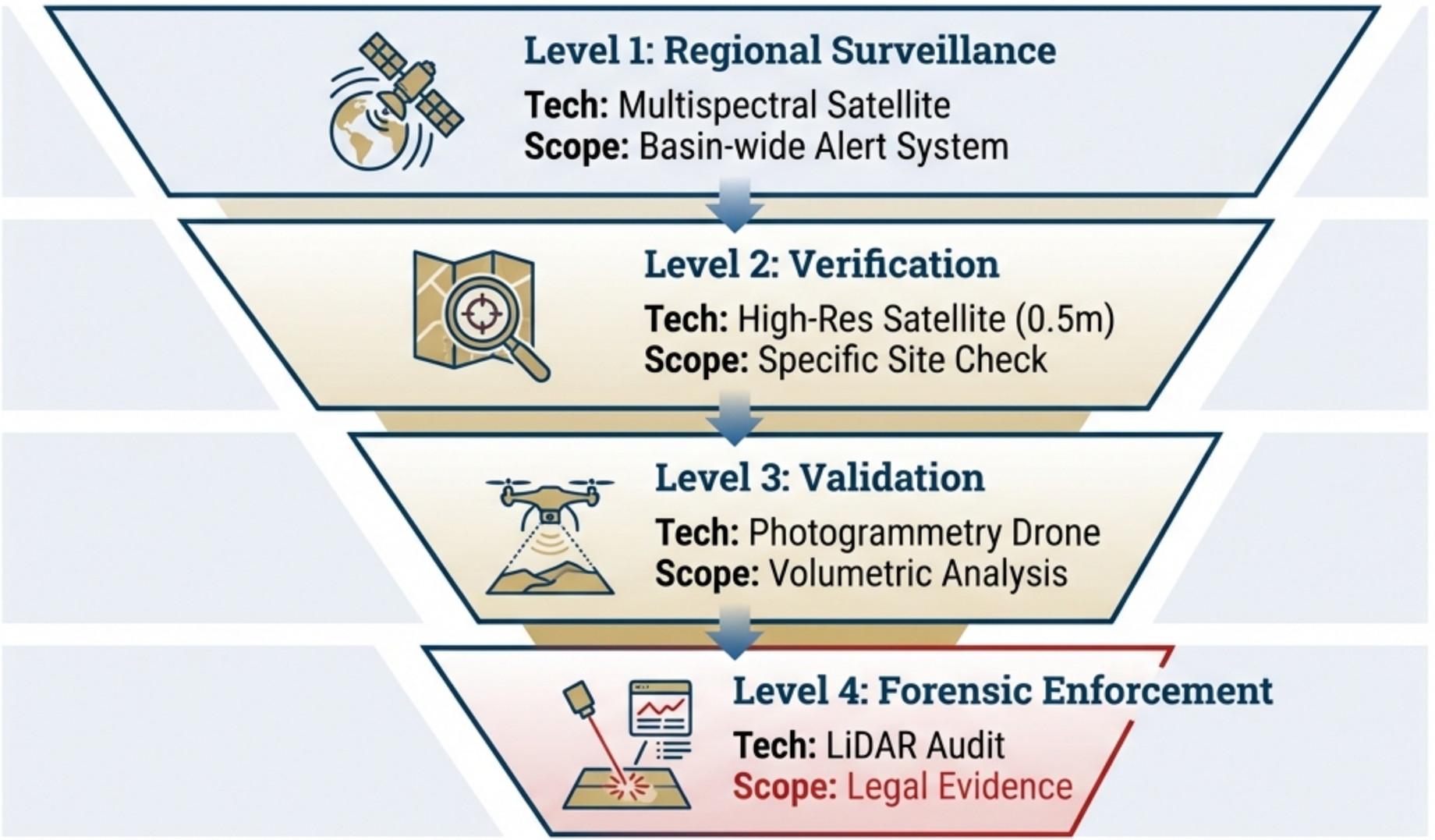
The Problem

Current cameras see the road, not the river.

The Solution

Buffer Zone monitoring extends 1km on either side of the bank to detect unauthorized stockpiles and access roads in unleased areas.

The ‘Funnel’ Methodology: Filtering Data from Space to Ground



Cost Efficiency

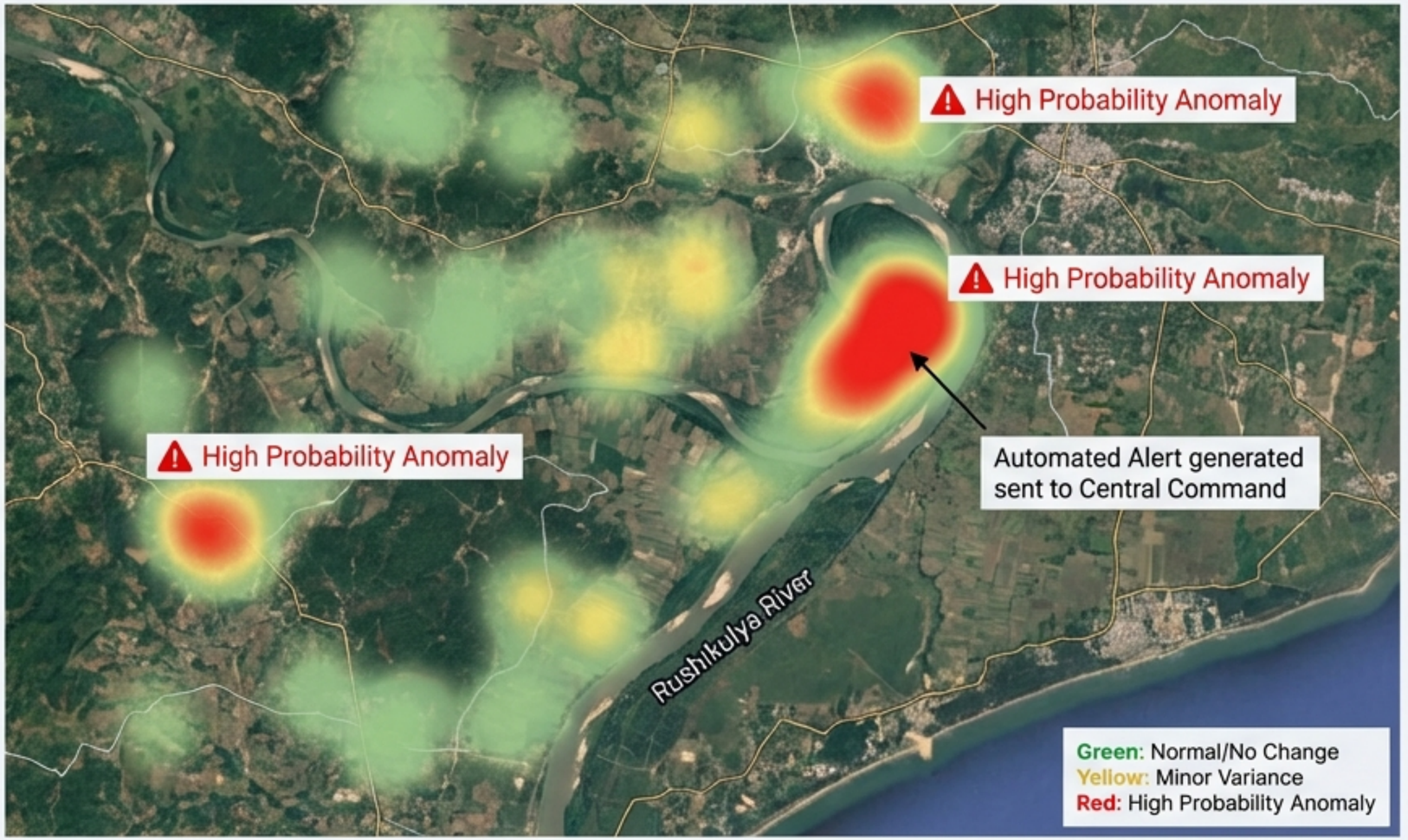
Expensive assets (LiDAR/Teams) are deployed only when satellite data confirms high-probability targets.

Level 1: Regional Surveillance (The Alert Layer)

Technical Specs

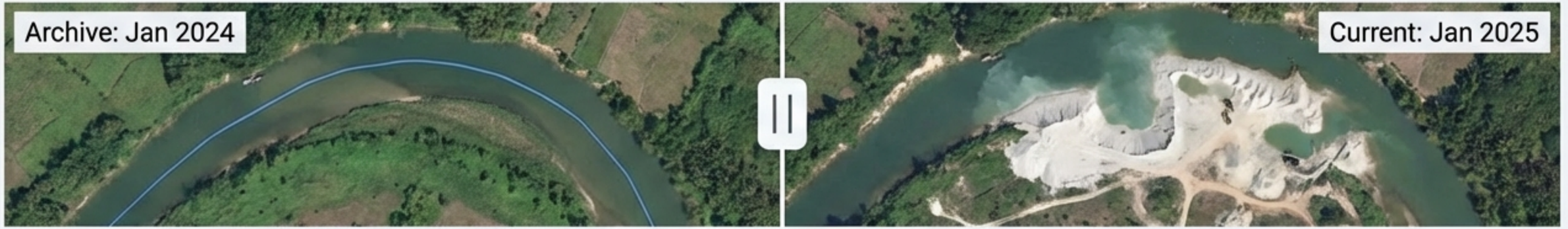
- **Input**
  - Multispectral Satellite Data (Medium/High Resolution)
- **Frequency**
  - Weekly Revisit Cycle
- **Methodology**
  - Vegetation Clearing (New access roads)
  - Water Turbidity (Active dredging indication)
  - Spectral Signature (Fresh sand excavation)

Visualization



Levels 2 & 3: High-Res Verification and Volumetrics

Level 2 - The ‘Slider’ Check



0.5m Resolution Satellite Change Detection.

Level 3 - Drone Photogrammetry

Calculated Volume: 15,000 m³

Permitted Limit: 10,000 m³

→ **Violation: +5,000 m³**

Level 4: Forensic Enforcement via LiDAR

Why LiDAR?

- Penetrates vegetation to measure true depth.

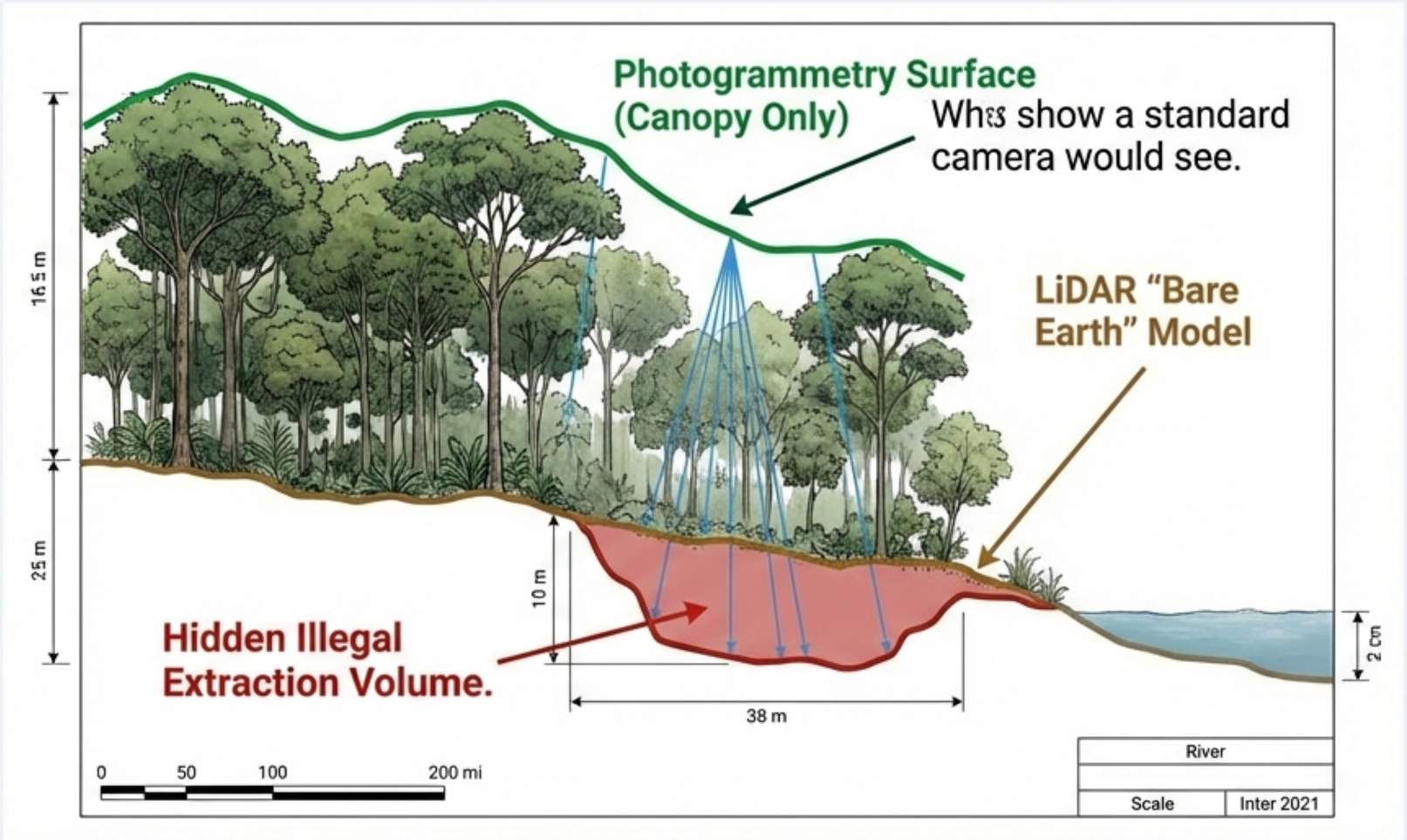
Accuracy

- Centimeter-level precision on Z-axis.

Output

- Tamper-proof Scientific Audit Report for Court Evidence.

Visualization



Scientific Replenishment and Ecological Equilibrium

Objective

Sustainable extraction based on river replenishment rates.

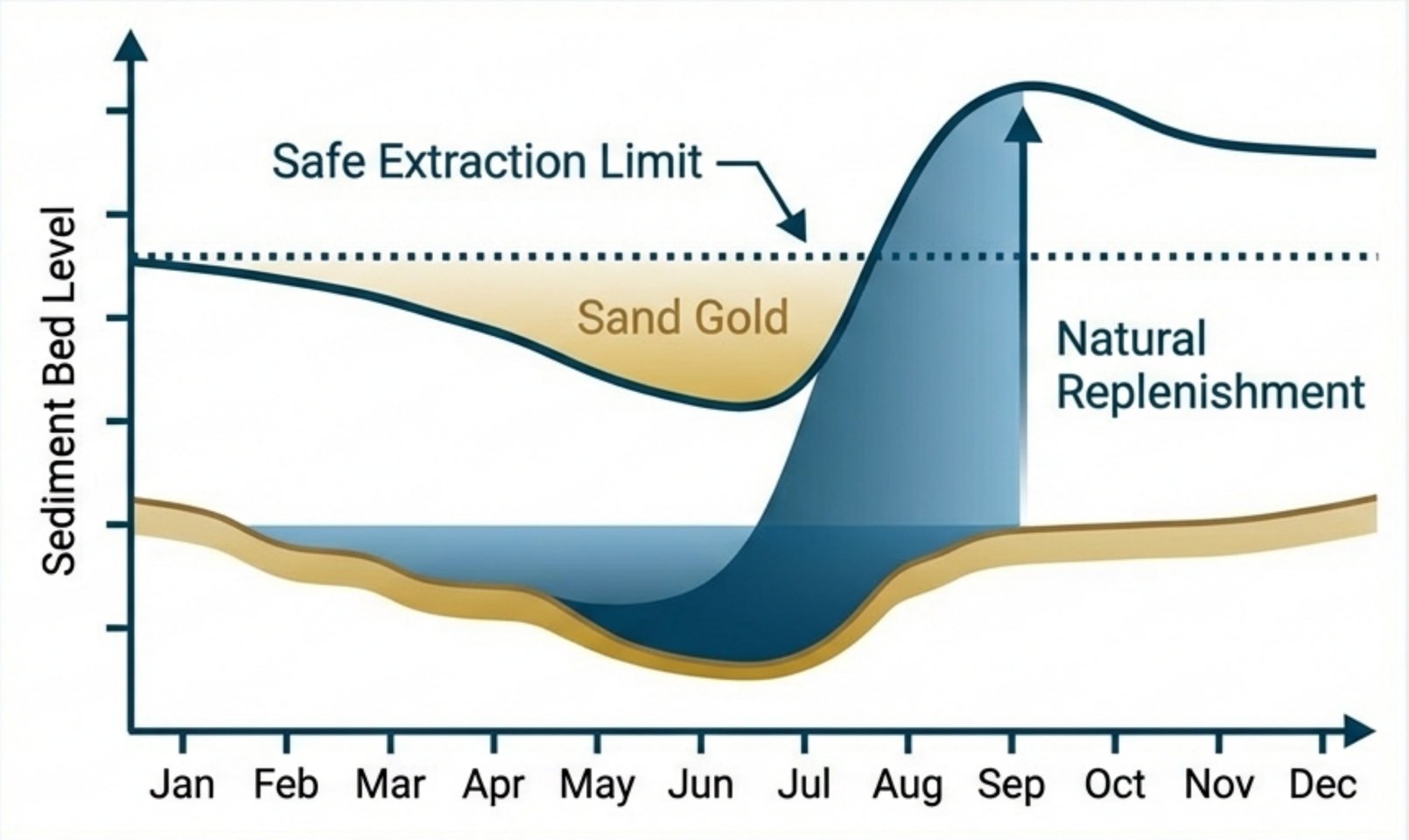
Methodology

Pre-Monsoon vs. Post-Monsoon Surveys.

Model

Ackers & White Equation used to calculate sediment transport capacity.

Hydrograph / River Cross Section



Integration with i4MS: The Digital Handshake

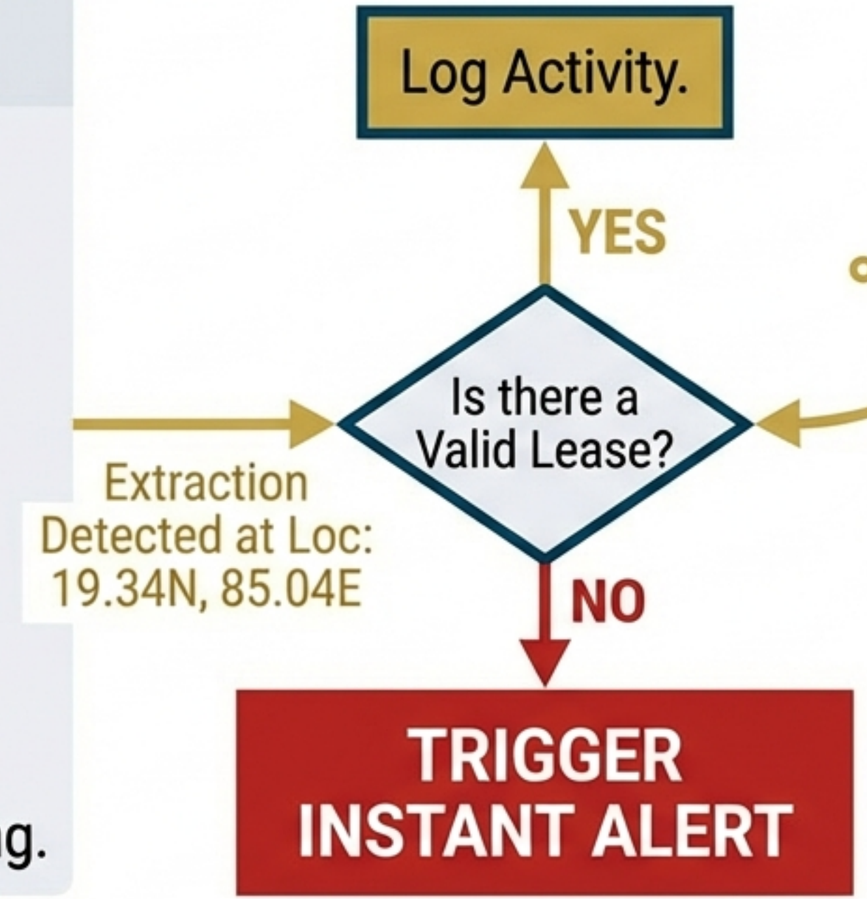
Domain 1: i4MS (The Gate)

Weighbridge

E-Pass Database

Check-post

Validates Transport Booking.



Domain 2: Basin Watchdog (The Source)

Drone

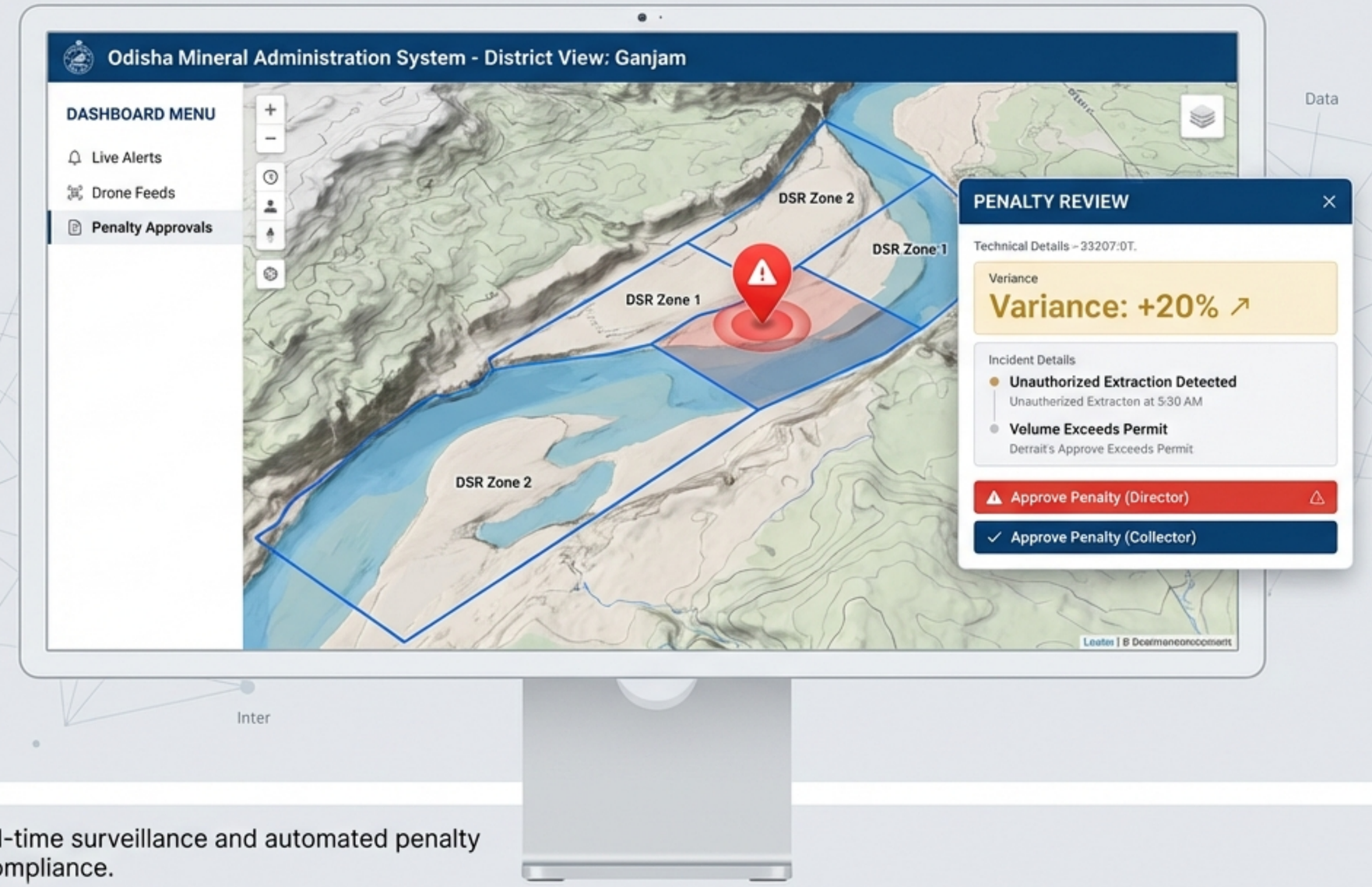
Satellite

AI Camera

Detects Extraction Activity.

Ghat Monitoring: AI Cameras (ANPR) link truck plates to permits in real-time.

The Command Center: 3D GIS Dashboard



Ghat Monitoring: Real-time surveillance and automated penalty processing for non-compliance.

Open Data Platform and Self-Certification

Platform Overview & Key Functions

Transparency:

Citizens can view valid lease boundaries, distinguishing legal mining from theft.

Self-Certification:

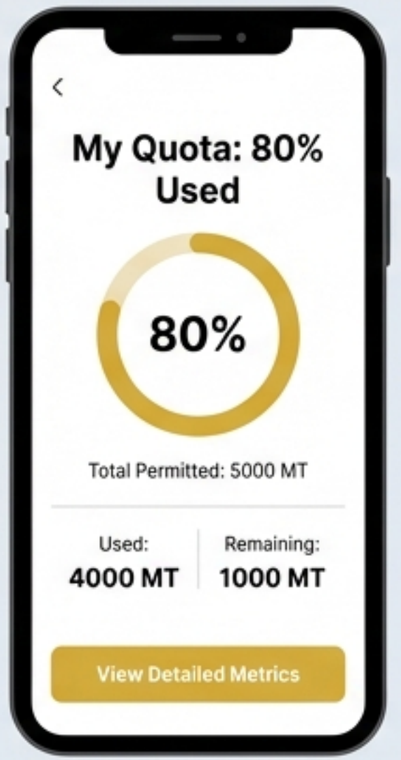
License holders access their extraction metrics to ensure compliance before audits.

Community Role:

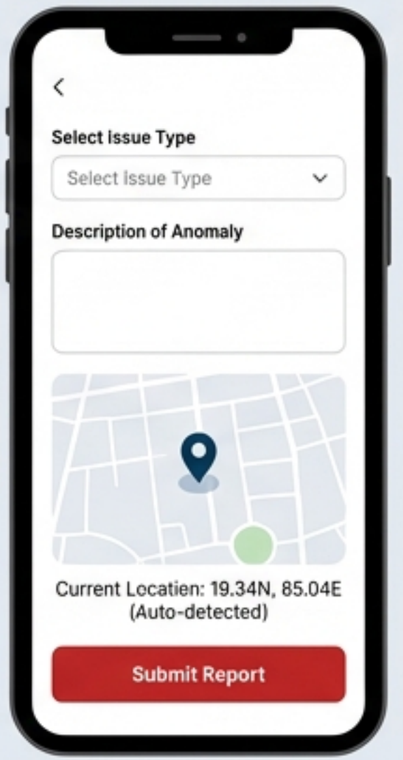
Crowdsourced anomaly reporting.

Public Map

Lessee View

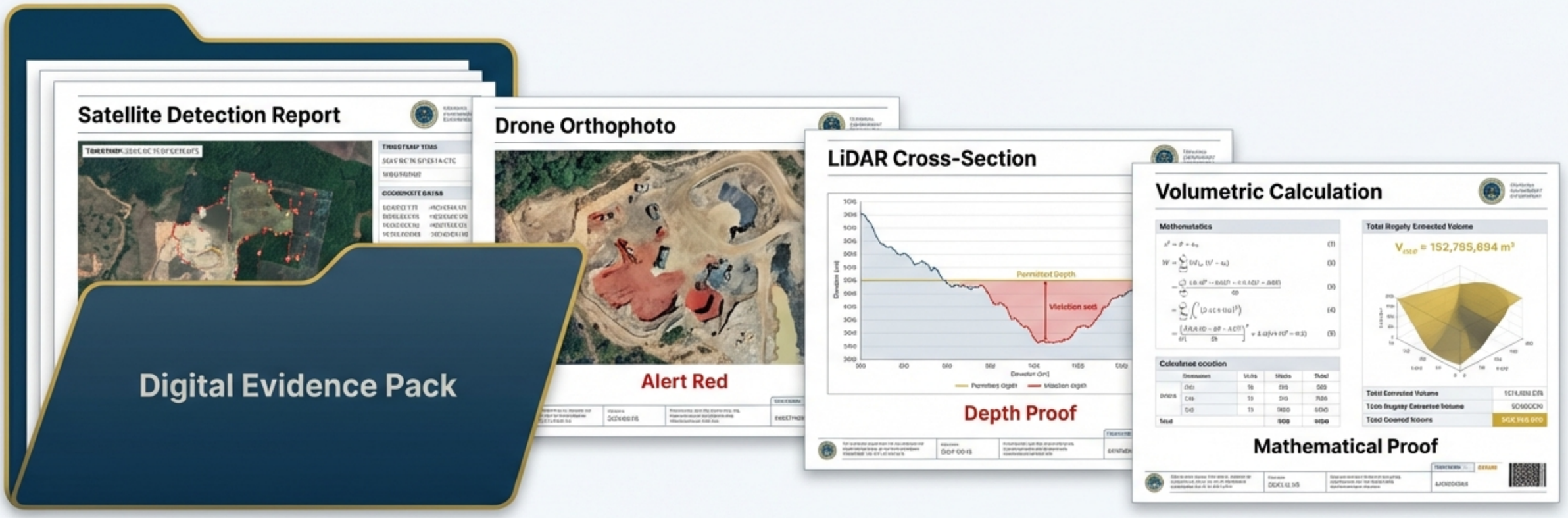


Report Issue



Community Empowerment & Compliance: Enabling citizen oversight and proactive self-regulation through transparent data access.

The Evidence-Based Penalty System



Graded Penalty Matrix

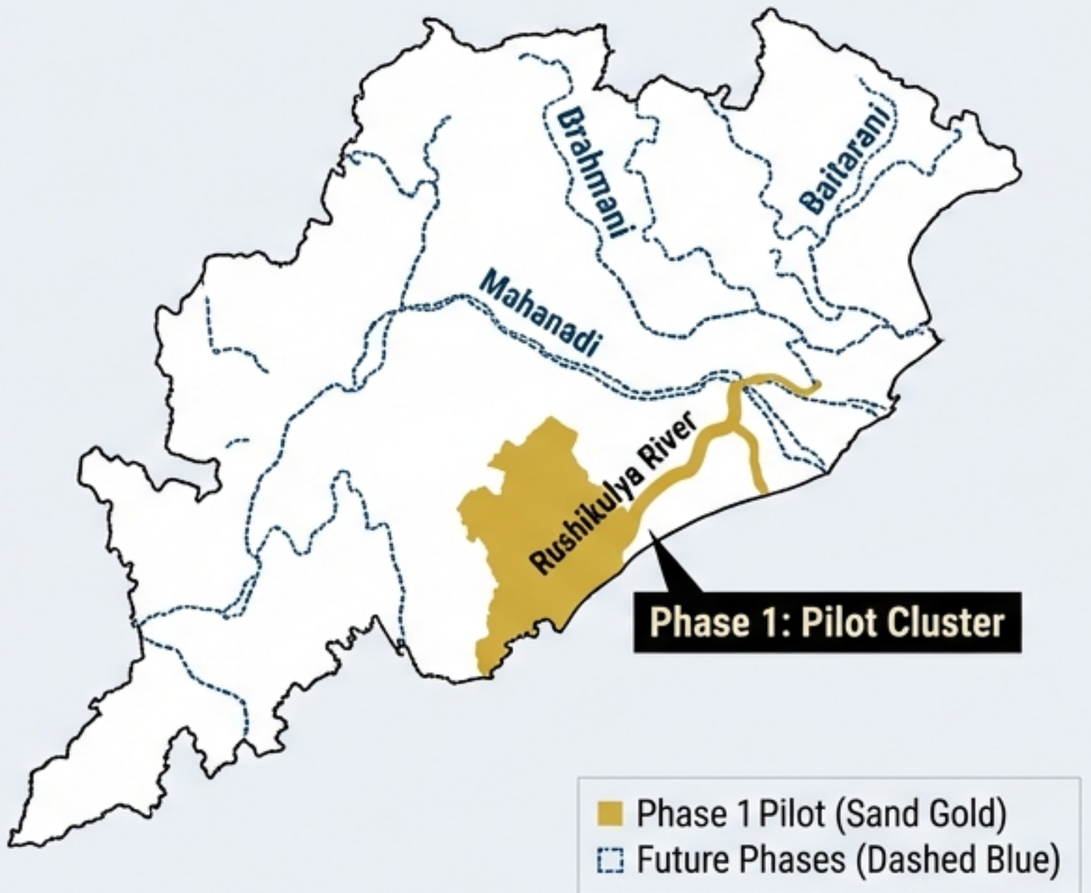
The points system in three evidencers in premium government, Volume Extracted, + Riverbank Damage, Alert and Waite and Alert Red, + Depth Violation prevencet:arcives total illegalily extracted volume of the three components.

Volume Extracted (Sand Gold value) + **Riverbank Damage** (Sand Gold value) + **Depth Violation** (Sand Gold value) = **Total Penalty Score** (Deep River Blue value)

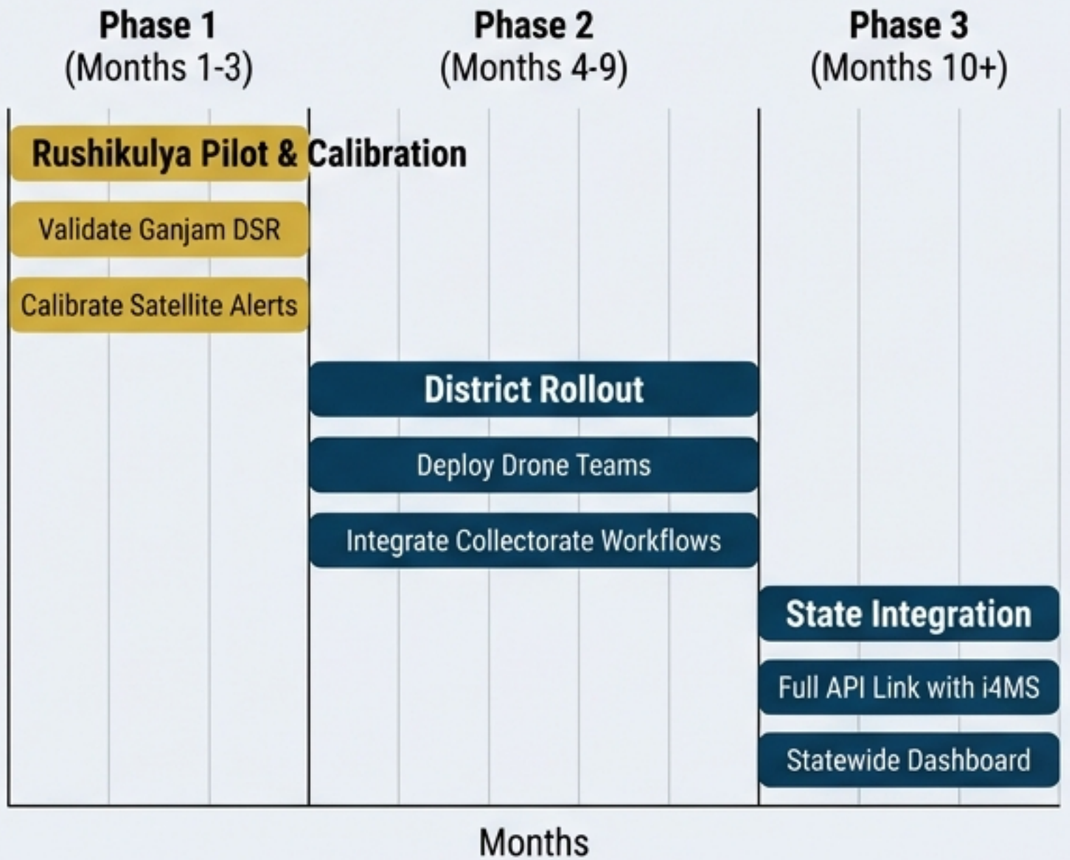
Outcome: Uncontestable evidence for revenue recovery.

Implementation Roadmap and Scope

Odisha State - River Systems



Phased Deployment Timeline & Key Deliverables



Conclusion: A Zero-Blind-Spot Regime

This framework creates a verifiable, practical, and legally robust mechanism to secure Odisha's riverine wealth.

Proceed with Rushikulya Pilot ↗