

From Landslide Detection to Multi-Source LLM-Based Reporting: A Complete Earth Observation Framework for Rapid Assessment of Post Disaster Scenarios

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DEGLI STUDI
FIRENZECentro per la
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1. Motivation & Objective

The Challenge

Timely landslide detection and rapid post-disaster assessment are essential for effective hazard management and risk mitigation. However, conventional approaches rely heavily on on-site surveys and manual expert assessment, which can be risky, costly, and time-consuming, delaying the availability of actionable information.

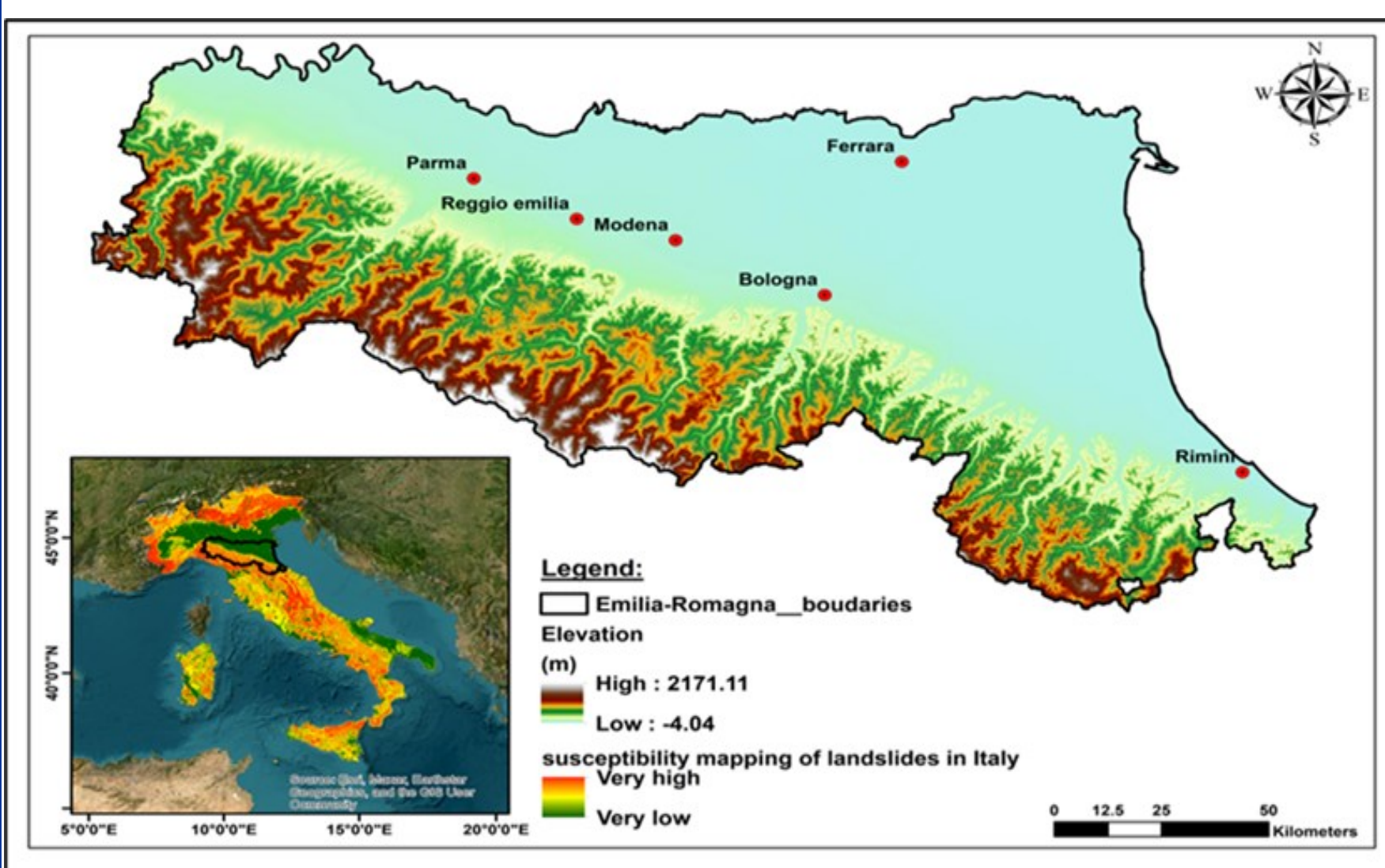
Our Objective

To develop an end-to-end Earth Observation framework that automatically transforms satellite imagery and geospatial data into terrain-aware, structured landslide reports to support rapid post-disaster assessment and preliminary decision-making.

2. Study Area & Dataset

Emilia-Romagna, Italy

May 2023 rainfall-induced landslide (200–250 mm)



26,758 (19,324 train, 4832 val, and 2602 test) PlanetScope RGB tiles (64x64)

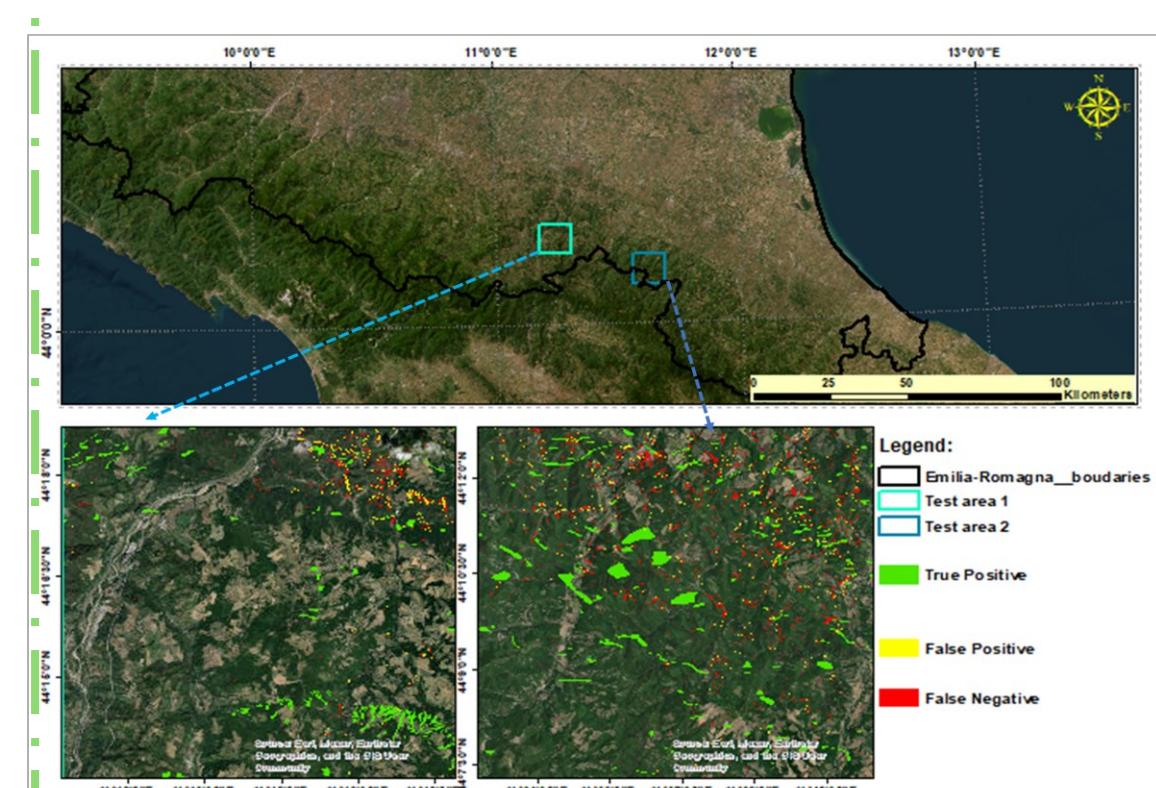
3 m Spatial resolution

80,997 Annotated landslide (Berti et al; 2025)

4. Results Evaluation

1 Landslide Detection

Tested on a geographically independent area comprising 2,602 tiles.



85.54% Precision

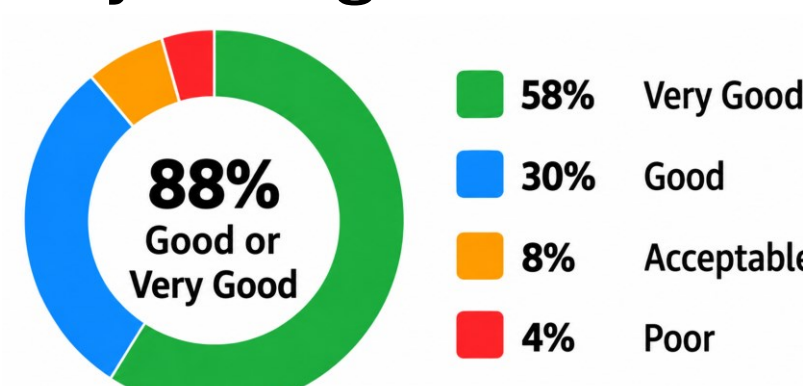
72.31% Recall

78.39% F1 Score

63.92% IoU

2 LLM Report Evaluation

100 generated reports independently evaluated by domain experts for technical quality, relevance, completeness, and consistency with ground truth.



6. Take-home message

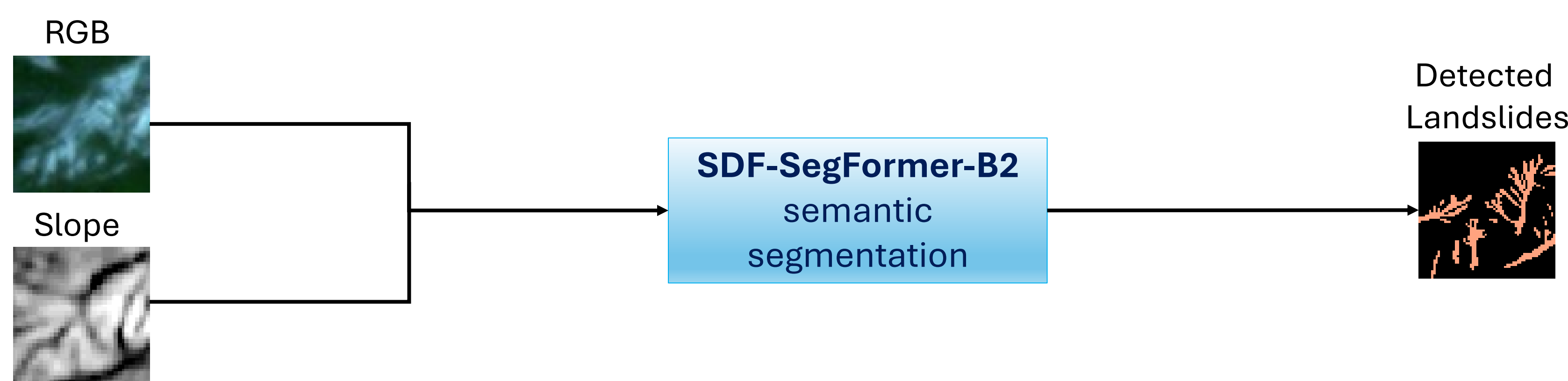
The proposed framework closes the gap between EO-based landslide detection and actionable post-disaster information by automatically transforming satellite observations and terrain data into structured, expert-style reports for rapid screening and preliminary decision support.

3. Proposed Framework

A Three-Stage Pipeline from Satellite Imagery to Structured Landslide Reports

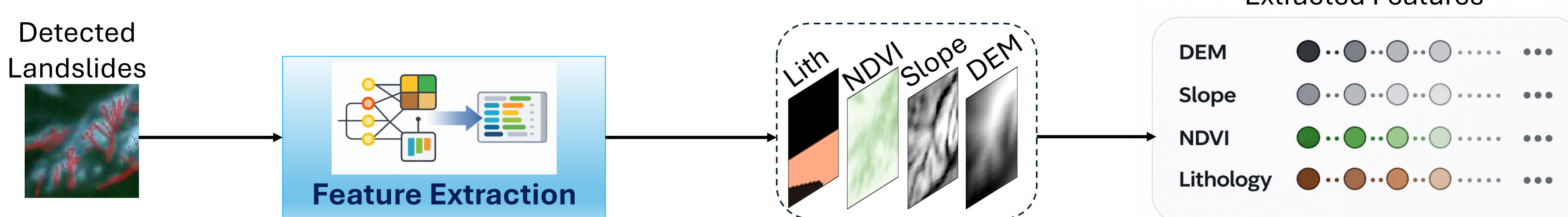
1 Landslide Localization

Landslides are identified and delineated at the pixel level using the proposed **SDF-SegFormer-B2** semantic segmentation model. Slope information is incorporated through a lightweight auxiliary encoder to improve landslide localization.



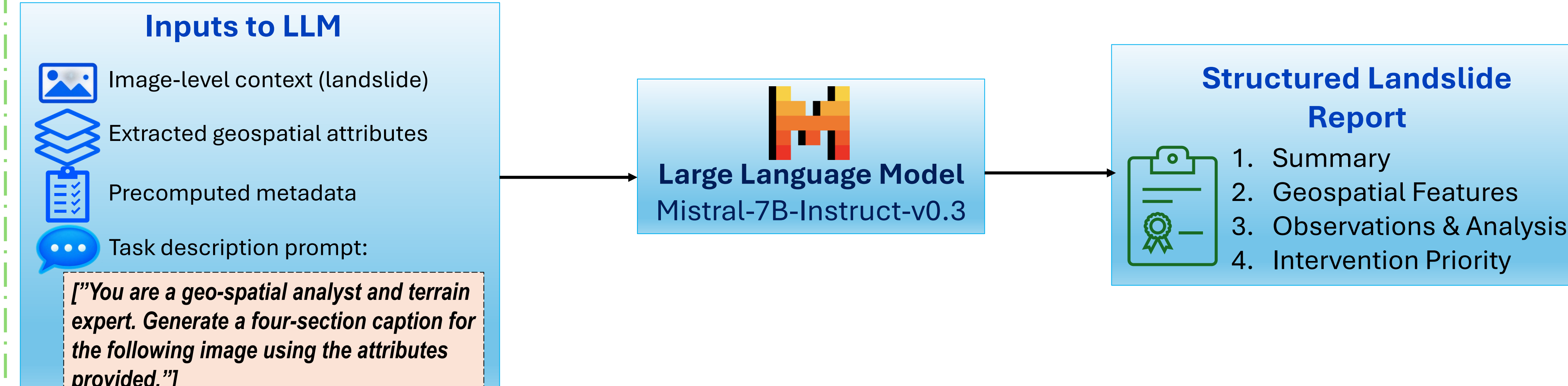
2 Geospatial Feature Extraction

For each detected landslide, relevant environmental and terrain information is extracted from four geospatial layers.



3 LLM-Based Landslide Report Generation

The extracted information is provided to **Mistral-7B-Instruct-v0.3** through structured prompting and expert-curated few-shot examples (6 examples) to generate domain-specific landslide assessment reports.



5. Example of Generated Report

Detected Landslides

1. SUMMARY

Finding: Three small slides are present in the image.

3. OBSERVATIONS AND ANALYSIS

The three small slides **are located in** a terrain with **extremely high elevation** and **moderate slopes**. The lithology consists of **sands, sandstones, and conglomerates**, and all slides exhibit **dense vegetation**. The absence of proximity and intersections suggests that the slides are not directly adjacent or overlapping, but their spatial arrangement may indicate a shared hydrologic control or slope-parallel seepage.

2. GEO-SPATIAL FEATURES

Slide 1: Located in the **middle-top**.
Slide 2: Located in the **top-right**.
Slide 3: Located in the **middle-center**.
All three slides occur at **extremely high elevation** on **moderate slopes**, within **sands, sandstones, and conglomerates**, and are covered by **dense vegetation**.
Conclusion: Dense vegetation and moderate slopes likely stabilized the terrain.

4. PRIORITY ASSESSMENT

✓ Overall risk is **Medium**, as the steep relief at extremely high elevation, weakly cemented clastic lithologies, and the absence of proximity and intersections suggest a potential for shallow translational movements.
✓ The probable velocity is **Moderate**, reflecting the shallow nature of the slides and the moderate slopes, with vegetation limiting acceleration.
✓ Likelihood **High** during short, intense rainfall due to rapid infiltration and potential pore-pressure rise in permeable clastics; **High** during prolonged wet periods or snowmelt as sustained saturation weakens contacts; and **Medium** following vegetation loss, where reduced root reinforcement and interception would further lower stability.

Limitations & future work

The generated reports support rapid qualitative screening and preliminary decision-making, but do not replace detailed geotechnical assessment or physically based forecasting. Future work will focus on broader geographic validation and framework robustness.

