

Efficient Quantification of Risk for Linear Engineering Projects under Landslide Hazards:

---A Novel Proposal Based on Slope Unit



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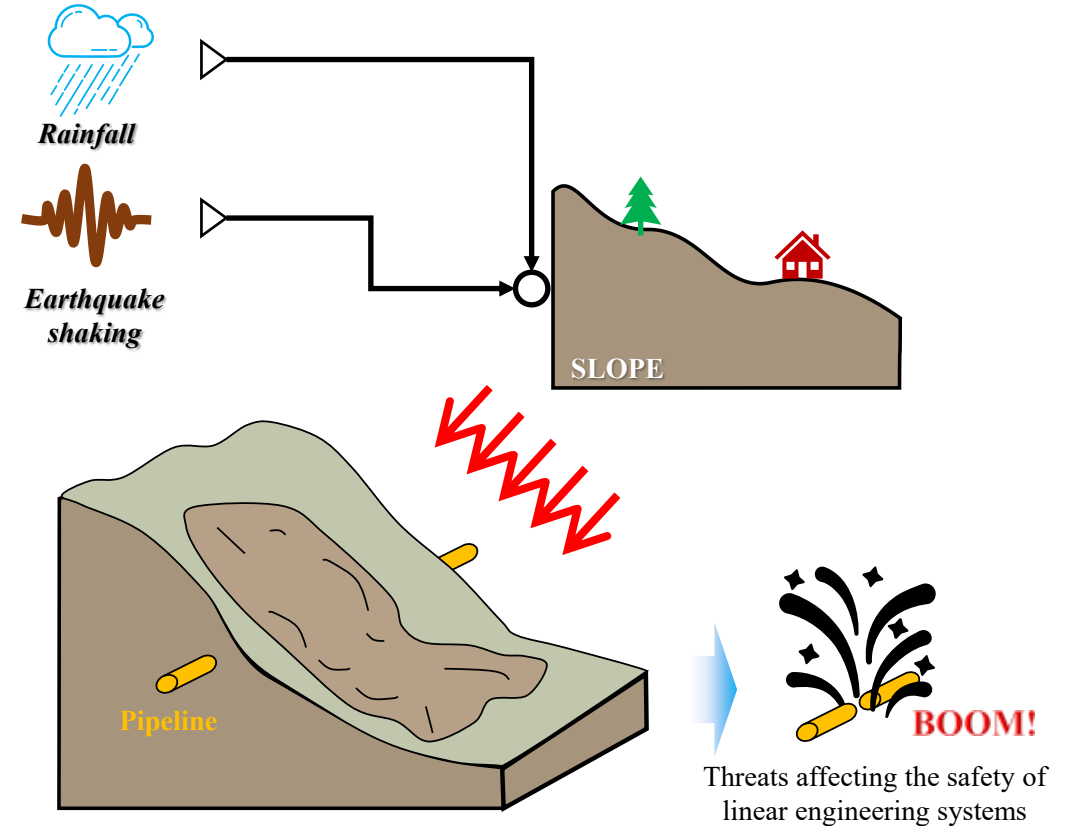
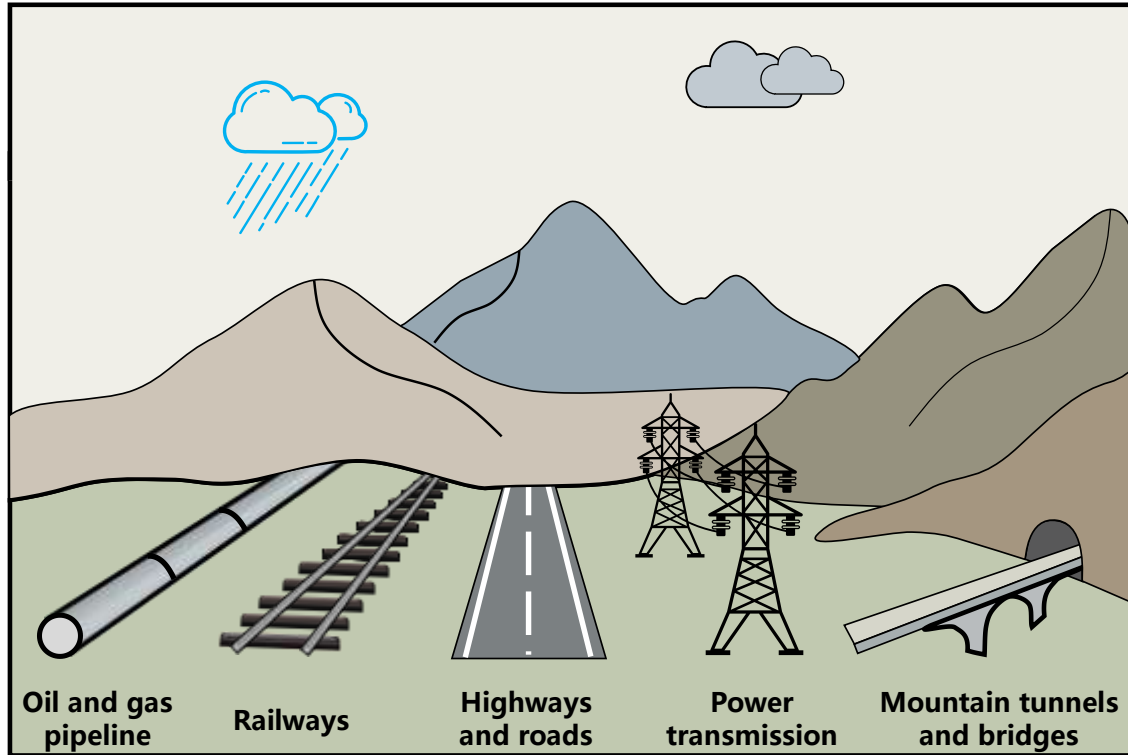
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- 1、 Background**
- 2、 Current Practice**
- 3、 New Proposal**
- 4、 Summary**

1 Background

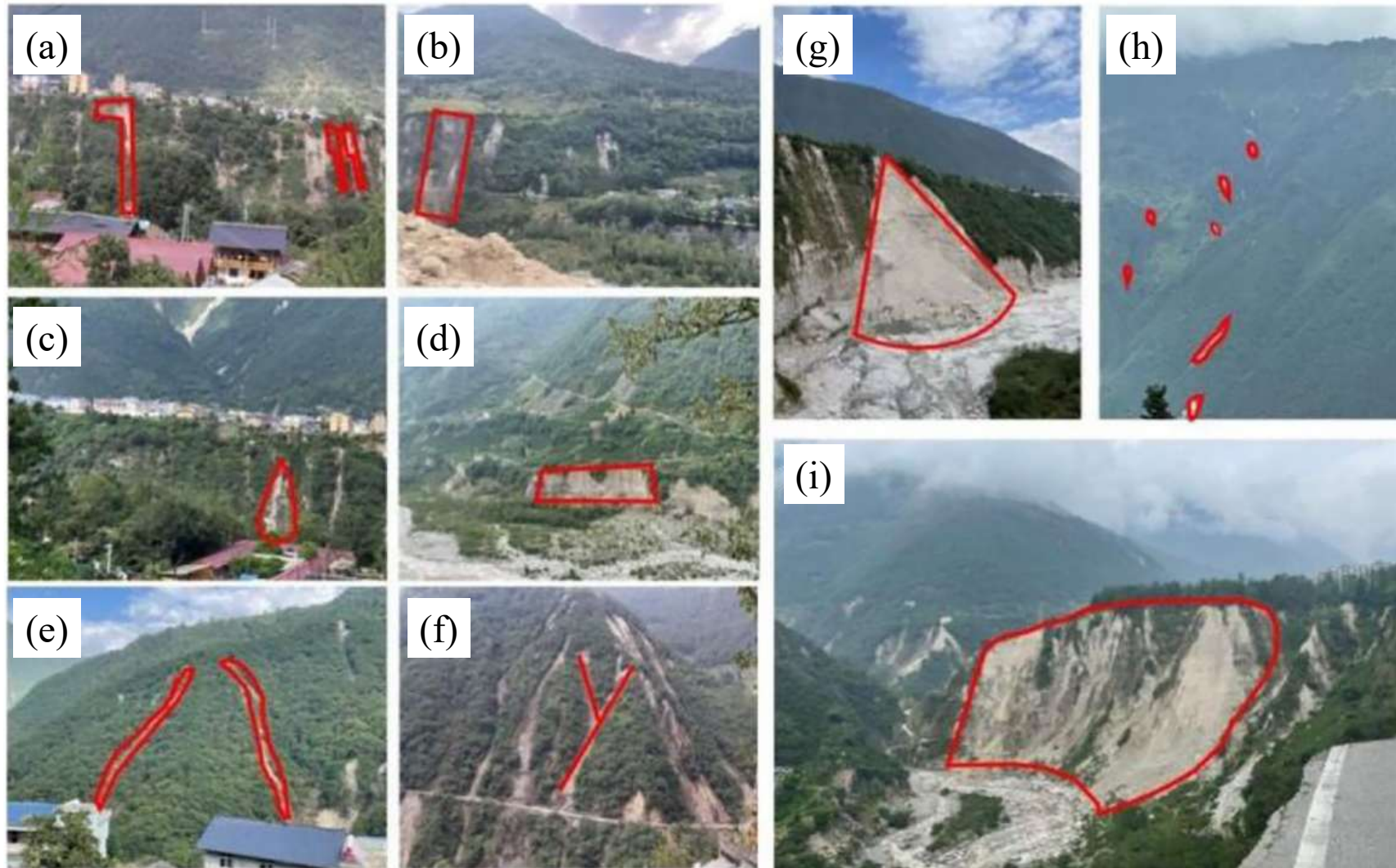
Lifeline infrastructure, including pipelines, highways, and railways, et, constitutes critical infrastructure that underpins economic activity, social functioning, and regional connectivity



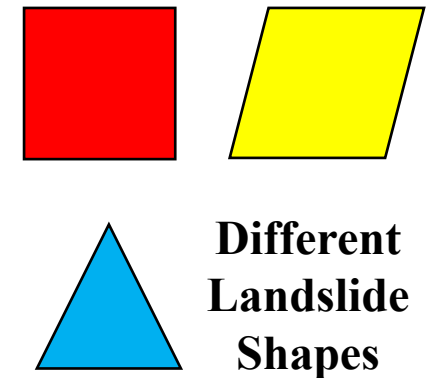
- Mountainous lifeline infrastructure is continuously exposed to landslide hazards;
- Intense rainfall and earthquakes can trigger slope instability, leading to **infrastructure damage, service interruption, and cascading disaster consequences.**

1 Background

Landslide morphology is usually controlled by the combined effects of topography, geological structure, slope protection measures, and engineering modifications.



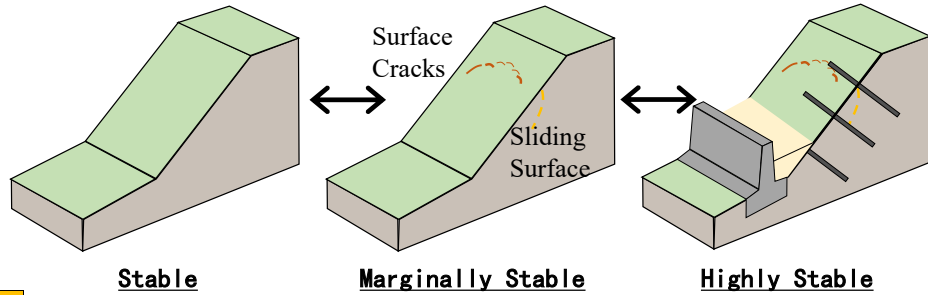
Nine representative landslide shapes in the study area of the Luding Ms6.8 earthquake, Sichuan, China: (a) knife, (b) vertical rectangle, (c) water drop, (d) horizontal rectangle, (e) strip, (f) Y-shape, (g) fan, (h) sporadic, and (i) sheet (Liu et al., 2023)



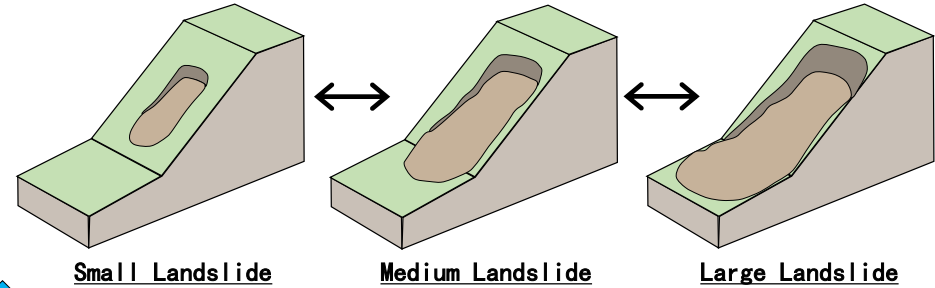
1 Background

The landslide risk to linear infrastructure is mainly controlled by four factors:
initial slope conditions, potential landslide scale, engineering vulnerability, and failure consequence.

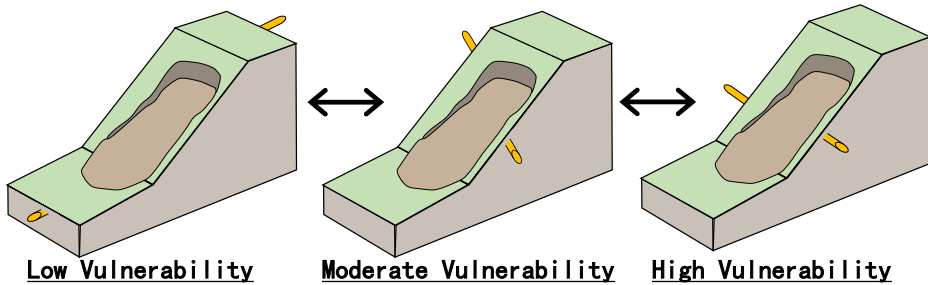
● Different Initial Slope Conditions



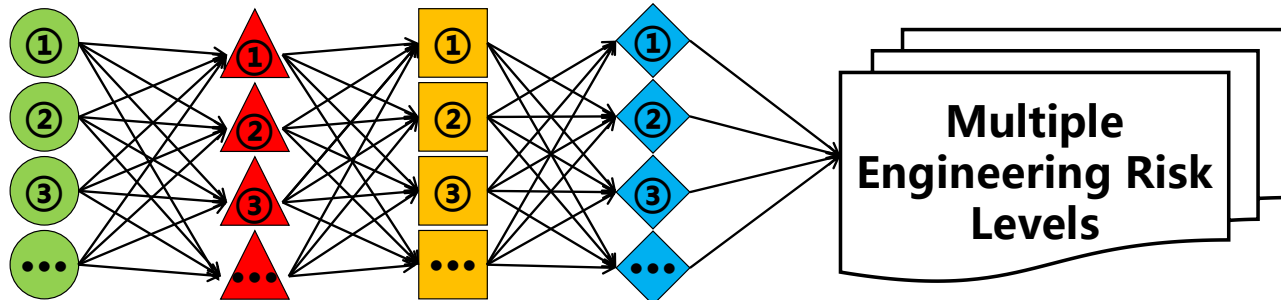
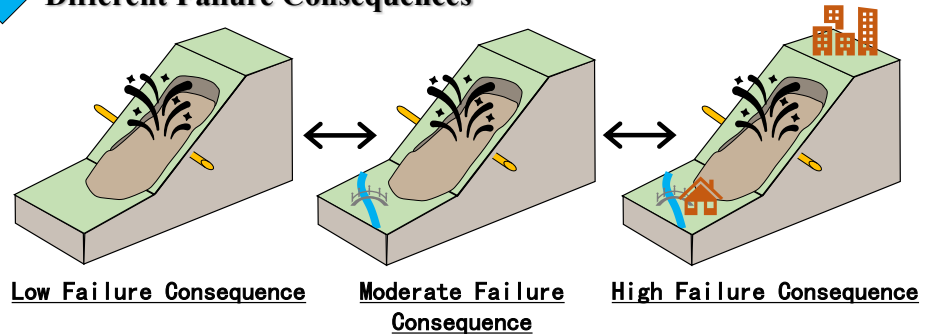
▲ Different Landslide Scales



■ Different Engineering Vulnerabilities



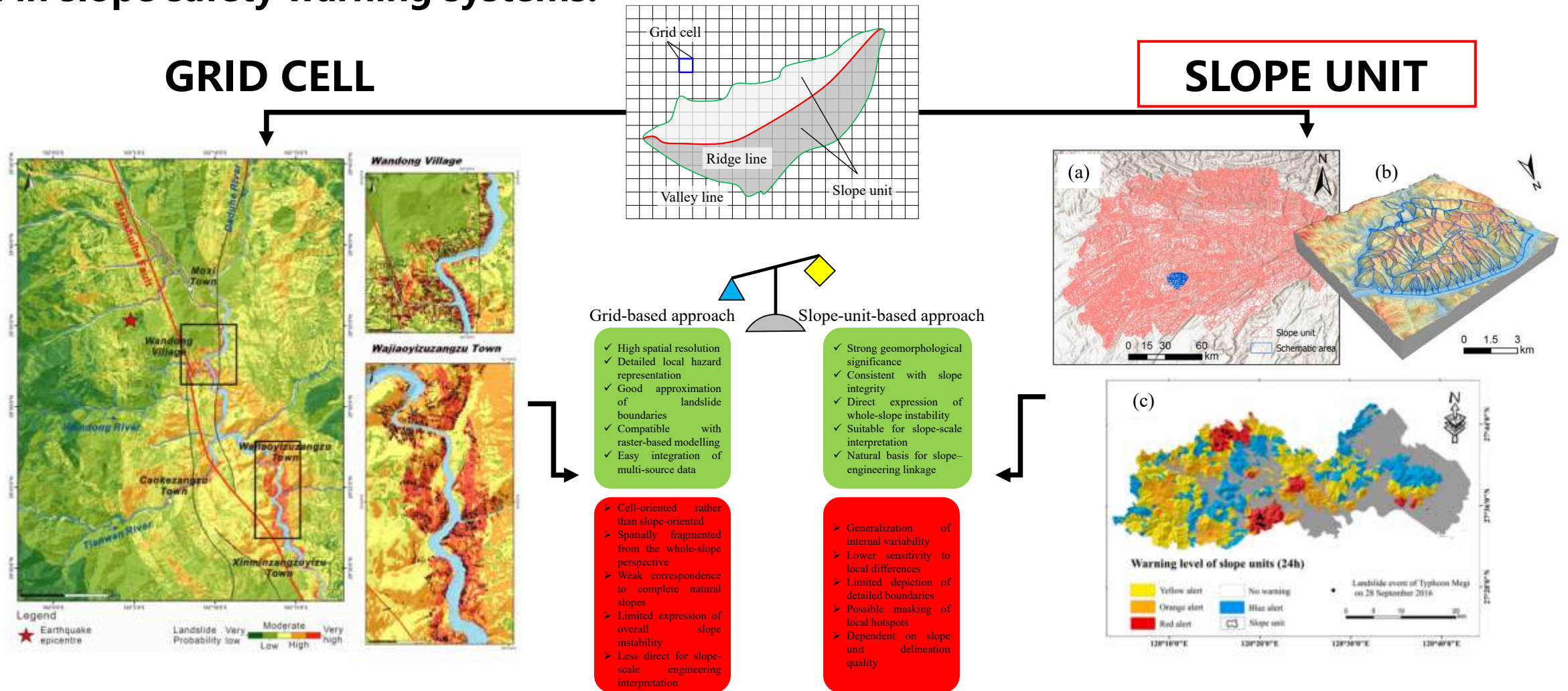
◆ Different Failure Consequences



Traditional assessment methods based on case-specific assumptions are difficult to satisfy the need for rapid and standardized risk identification at the regional scale.

2 Current Practice

Grid cells & slope units are now mainly used as assessment units, and slope units are widely used in slope safety warning systems.



Dai, L., et al., 2023. Co-seismic landslides triggered by the 2022 Luding Ms6.8 earthquake, China. *Landslides* 20, 1277-1292.

Xie, X., et al., 2025. Slope-specific rainfall thresholds for regional landslide early warning systems. *Eng. Geol.* 355, 108249.

Zhu, Y., et al., 2025. Leveraging artificial intelligence to quantify slope rainfall sensitivity for refining regional landslide rainfall thresholds. *Eng. Geol.* 355, 108260.

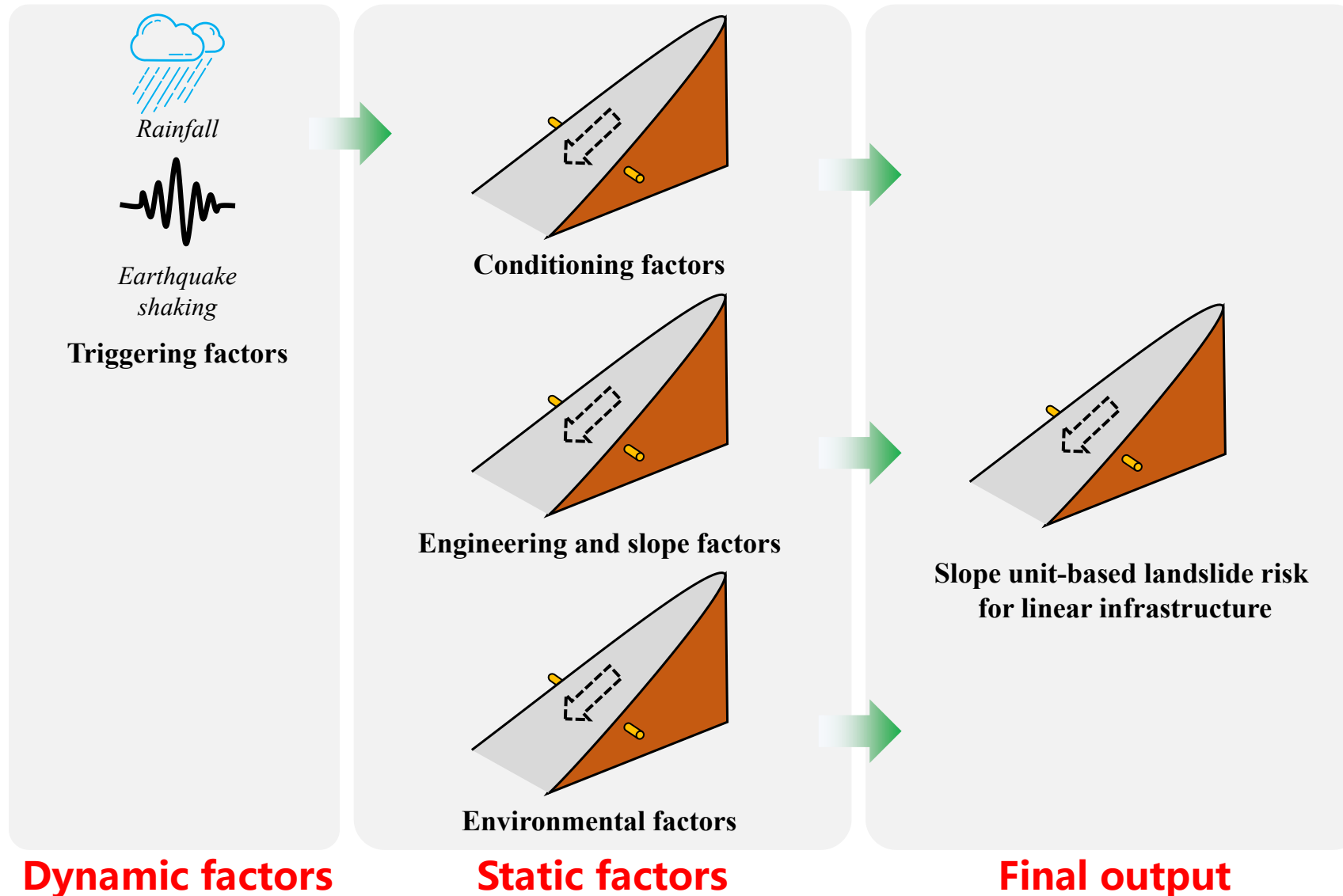
3 New Proposal

We propose a fundamental paradigm shift----Employing **slope units** as assessment units, Thus, the risk to linear engineering projects under landslide influence is simplified into a standardized formula

**Unit Risk = F(Landslide Probability,
Engineering Vulnerability,
Engineering Failure Consequence)**

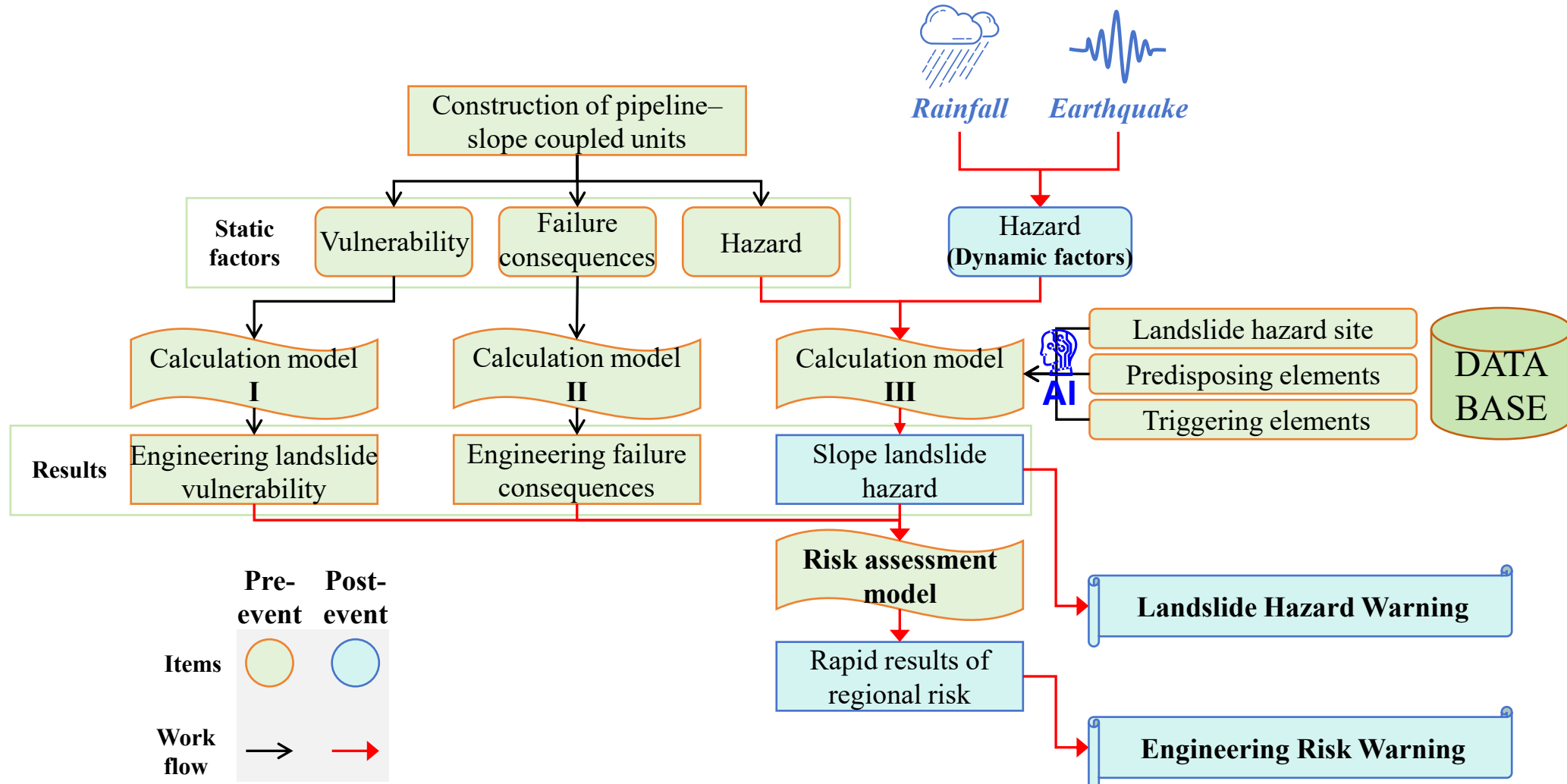
3 New Proposal

STEP 1: Clarify the relationships among data.



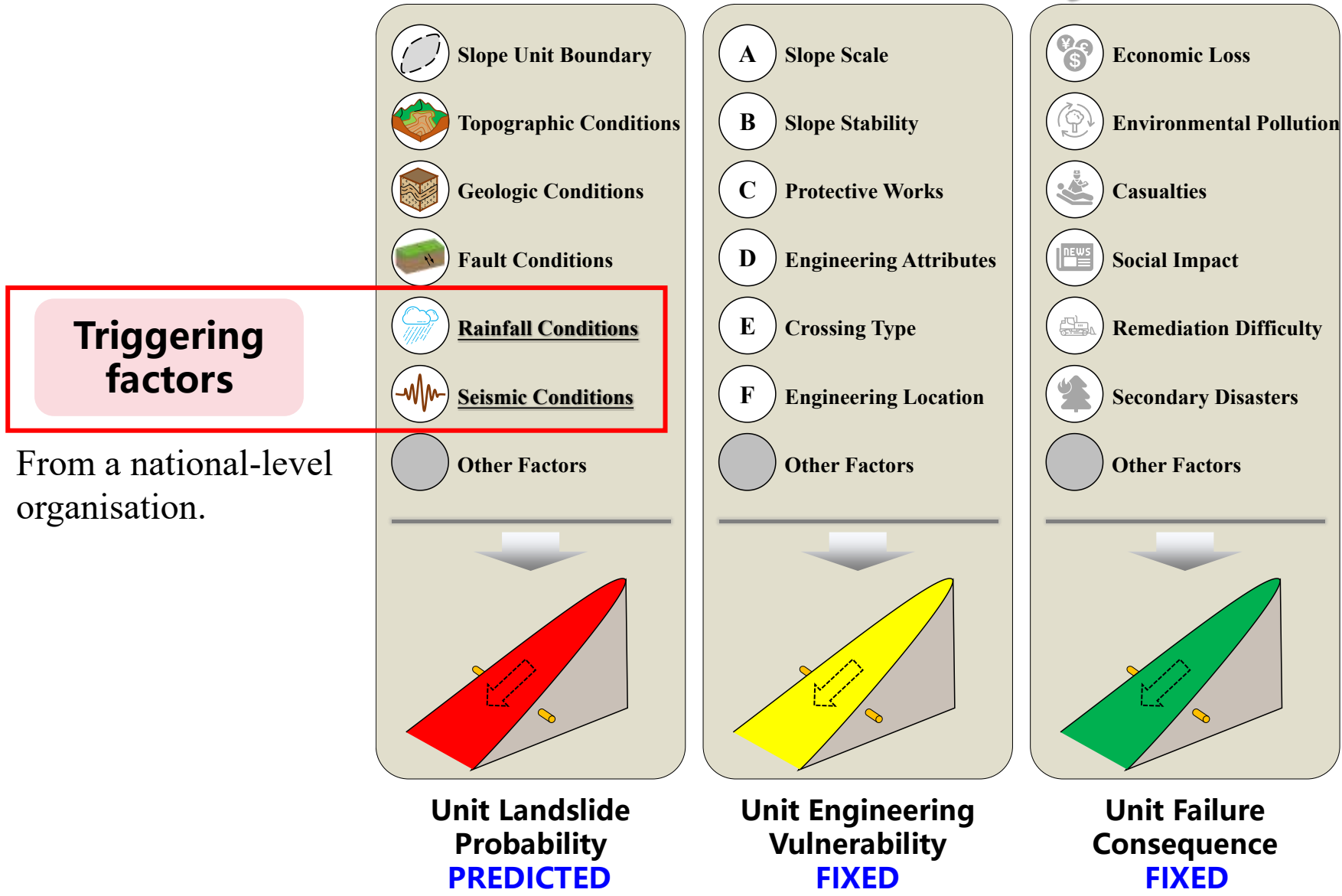
3 New Proposal

STEP 2: Establish an evaluation process.



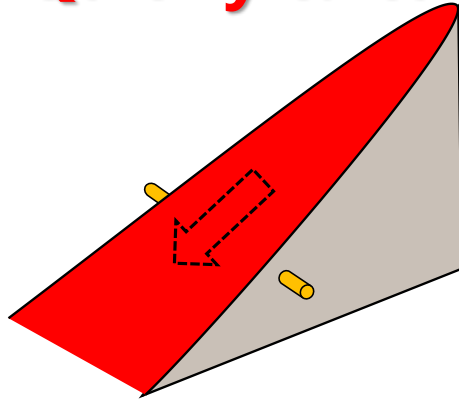
3 New Proposal

STEP 3: Collect data on hazards, vulnerability, and failure consequences.

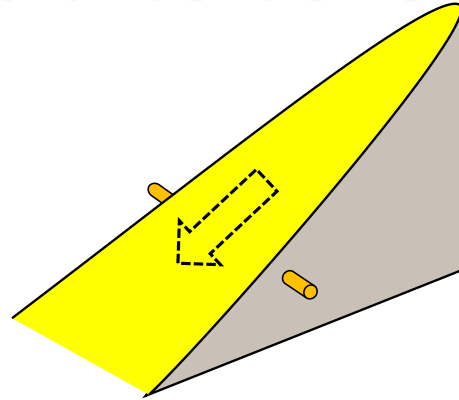


3 New Proposal

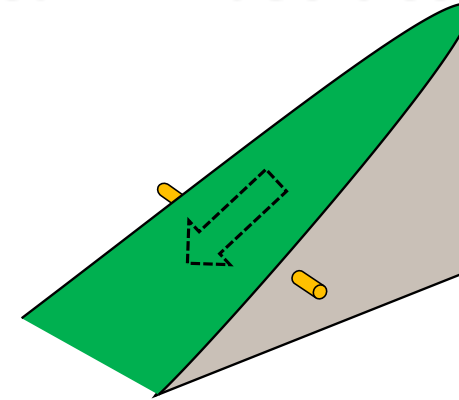
STEP 4: Quickly calculate the landslide risk of linear infrastructure.



Unit Landslide
Probability
(predicted)



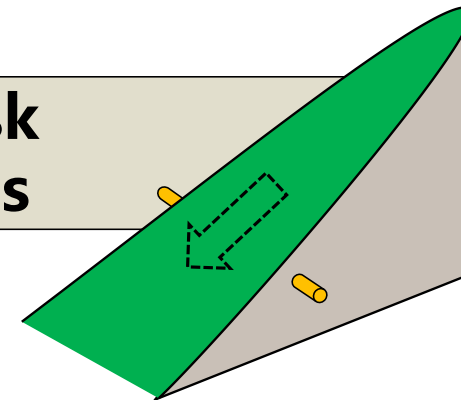
Unit Engineering
Vulnerability
(fixed)



Unit Failure
Consequence
(fixed)

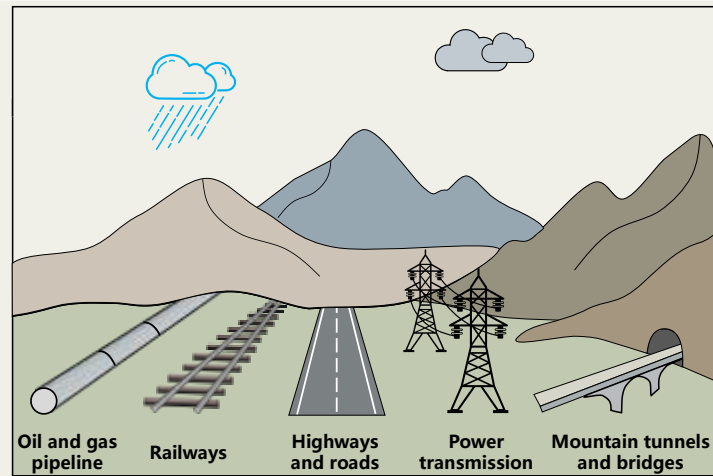


**Slope-Unit Engineering Risk
under Landslide Conditions**



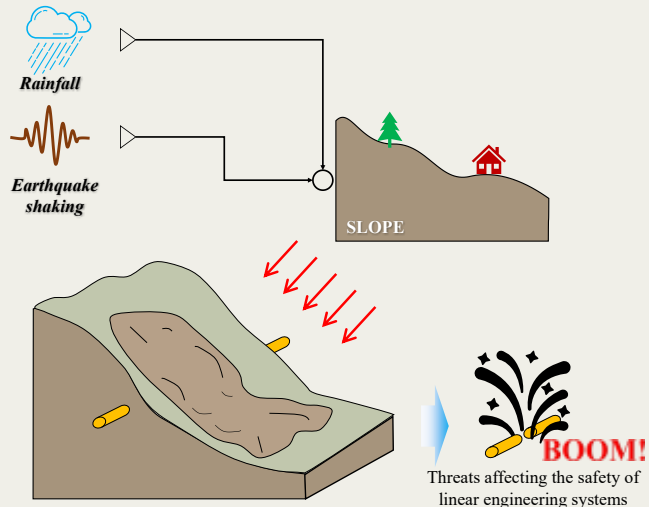
4 Summary

BACKGROUND / MOTIVATION



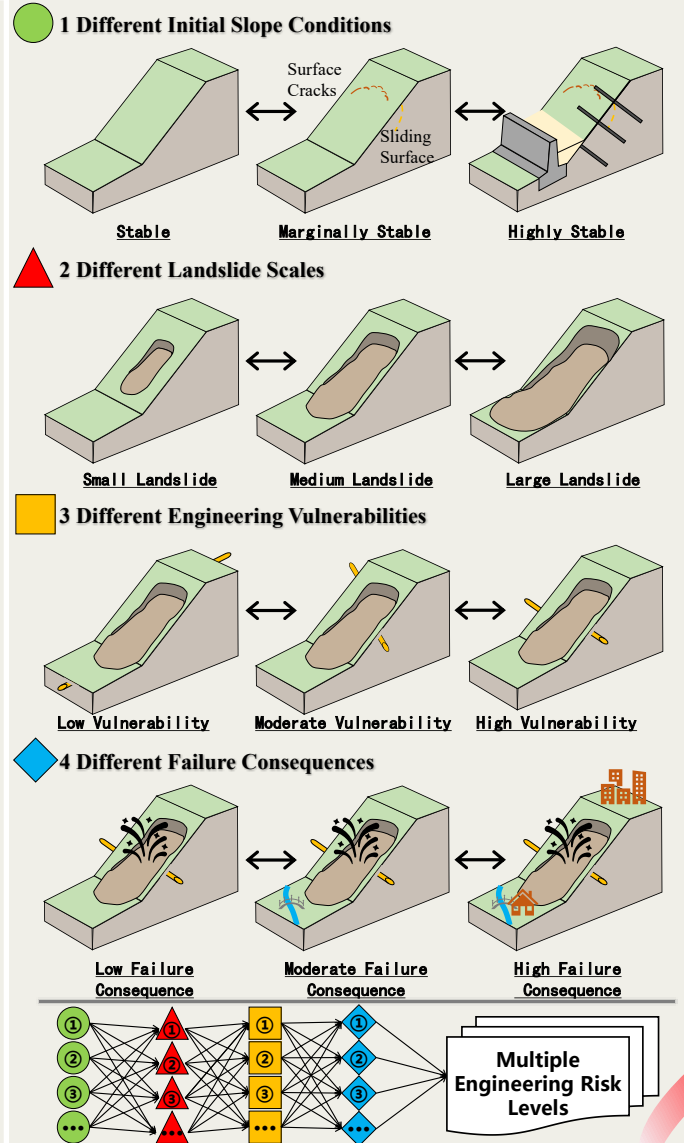
Lifeline engineering systems traverse complex mountainous terrain and are exposed to landslide risks.

Major triggering factors that can induce slope instability and landslides



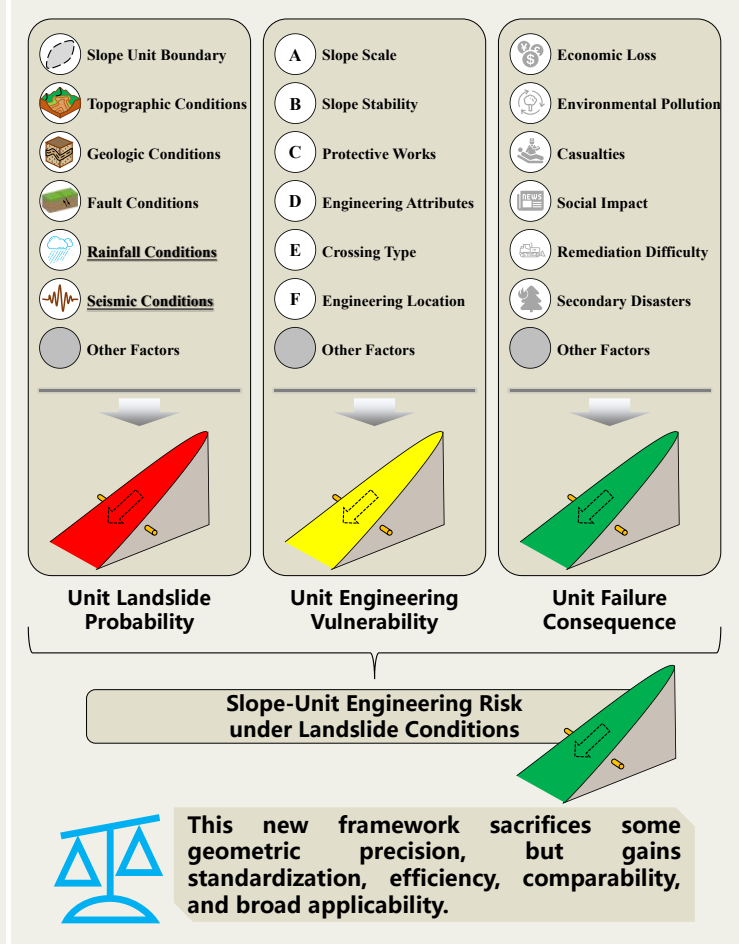
Linear engineering systems face severe landslide risks

REAL-WORLD SITUATION



Engineering landslide risk is complex

PROPOSED FRAMEWORK



Standardized Case-Based Paradigm

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4 Summary

Highlights

- (1) A slope-unit-based framework is proposed for rapid regional risk screening of lifeline infrastructure after earthquakes or extreme rainfall.
- (2) The framework transforms post-trigger risk assessment from case-by-case judgment to standardized unit-based calculation.
- (3) The framework supports post-event prioritization of inspection, monitoring, mitigation, and emergency management resources.



Sharing is encouraged



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THANK YOU !

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