



# 2026 RESILIENCE LEARNING MONTH

KNOWLEDGE SHARING  
AND LEARNING EVENTS  
23 APRIL–7 MAY 2026

## Turning Data into Action: How Risk Information Systems Improve Disaster Resilience and Investment Decisions

28 April 2026 | 2:00–3:30 p.m. (Manila)

Virtual via Teams MEETING ID: 424 748 073 690 59 | PASSCODE: Zd6XE7kL

The session will focus on the importance of reliable risk information for resilient infrastructure and disaster loss reduction, highlighting the role of Risk Information Systems like the National Disaster Risk Information Systems being developed in Armenia with ADB support. Participants will learn about the fundamentals and key data sources of risk information systems, as well as practical applications in disaster risk management and infrastructure planning. Designed as an interactive learning exchange, it aims to demonstrate how improved risk data drives evidence-based policies, cross-sector coordination, and climate- and disaster-resilient investments for professionals in related fields.



### SPEAKERS



**ARTAK PIROYAN**

Head of the Chair of Cartography and Geodesy, Department of Geography and Geology, Yerevan State University



**YEVA DANIELYAN**

Project Assistant,  
ARRM



MODERATOR

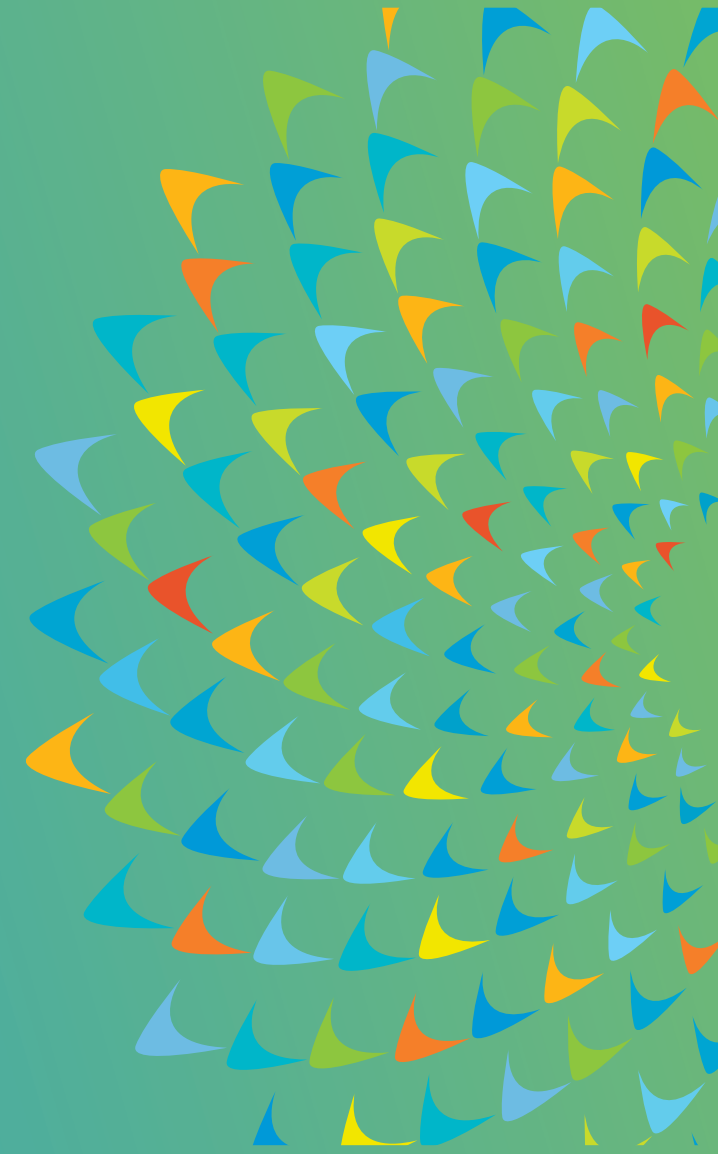
**ALEKSANDR ARAKELYAN**  
Disaster Risk Management  
Officer, CCSD, ARRM

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# Natural hazard impacts on road infrastructure:

## from analysis to adaptation planning

**Yeva Danielyan**  
Project Assistant, ADB, ARRM



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28 April 2026

# TA-10098 REG: Bridging the Gap Between Climate Adaptation Planning and Financing

## Output 1

**Comprehensive Risk Assessment And Mitigation Strategy  
for High-risk Sections of the Interstate Road Network**



## Output 2

**Transport Sector Climate Adaptation Plan and Investment Plan**





Black Sea

Caspian Sea

ISTANBUL

GEORGIA

Tbilisi

AZERBAIJAN

Baku

ARMENIA

Yerevan

TURKEY

Ankara

Bursa

Izmir

Konya

Adana

Aleppo

SYRIA

Damascus

Mosul

IRAQ

Baghdad

TEHRAN

IRAN

Esfahan

TURKMENISTAN

Ashkhabad

Mashhad

UZBEKISTAN

Aral Sea

KAZAN

UKRAINE

Odessa

Rostov

Astrakhan

Volgograd

Danube

Belgrade

CYPRUS

Beirut

LEBANON

ISRAEL

JORDAN

Jerusalem

Amman

# Climate-Related Risks Affecting the Transport Sector

Climate Risk Type	Hazard	Sector Impact
Acute Hazards	Flooding (river, flash, surface)	Flooding and destruction of roads, bridges, and railways; service disruptions
	Landslides, mudflows	Damage to mountain roads and rail lines; increased maintenance burden
	Rockfalls	Damage to roads and rail lines; operational risk; increased maintenance burden
	Extreme storms (hail, wind, thunderstorms)	Physical damage to infrastructure; visibility reduction; service disruptions Extreme wind causes structural damages to long-span bridges
	Snowstorms / heavy snowfall	Road and rail closures; increased accident risk; delays in service
	Heatwaves	Asphalt softening; rail track buckling; reduced vehicle and aircraft efficiency
Chronic Hazards	Rising temperatures	Material degradation; shortened asset lifespan; increased cooling needs
	Drought and reduced precipitation	Dust accumulation; subsidence; water scarcity affecting operations
	Desertification and soil erosion	Slope instability; increased risk of landslides; reduced vegetation cover
	Windstorms	Aviation disruptions; erosion of exposed surfaces; bridge risk

## 2024 Lori-Tavush Flood Impacts

The May 2024 flood event serves as a critical stress test validation for Armenia's infrastructure: M6 & M4 road link to Georgia cut off, 31 bridges destroyed or severely damaged



Snowstorm on M4 (2026)



Asphalt degradation

# Road Network Assets

Interstate roads (M- roads): 1,365 km, providing national and international connectivity.

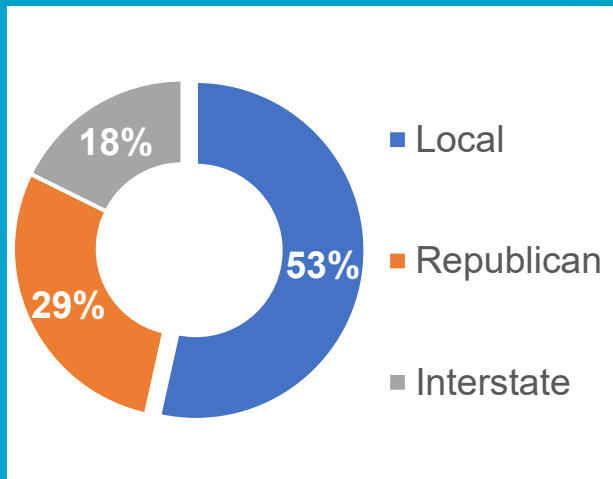
Republican roads (H- roads): 2,167 km, linking regional centers to interstate corridors.

Local roads: 4,002 km, connecting smaller settlements to higher-order roads.

## Interstate Roads



## Republican Roads





Project TA-10098 Reg:  
*"Bridging The Gap Between Climate Adaptation Planning and Financing -Climate and  
Disaster Risk Analysis for Armenia's Transport Sector (57013-001)"*

Third Interim Report



**COMPREHENSIVE RISK ASSESSMENT AND MITIGATION  
STRATEGY FOR HIGH-RISK SECTIONS OF THE INTERSTATE  
ROAD NETWORK**

Contract No. S202133 between  
ASIAN DEVELOPMENT BANK and "GEORISK" CJSC

February 2026



## Transport Sector

### Climate Adaptation Investment Plan

TA-10098 REG: Bridging the Gap Between Climate  
Adaptation Planning and Financing - Investment Plan and  
Policy Recommendations for Investment Programming

December 2025

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# Comprehensive Risk Assessment and Mitigation Strategy for High-risk Sections of the Interstate Road Network

1 

All available information related to natural hazards has been collected and analyzed

2 

The collected and analyzed information has been mapped and integrated into the GIS system, and a corresponding geodatabase has been developed

3 

Based on the selected methodology and the analysis of available data, Armenia's interstate roads have been classified according to their vulnerability index

4 

Based on the vulnerability index, field investigations were carried out along the most vulnerable segments of Armenia's interstate roads. Recommendations for risk reduction have been developed, and the proposed measures have been assessed together with their associated economic implications.

*Project Implementation Steps*

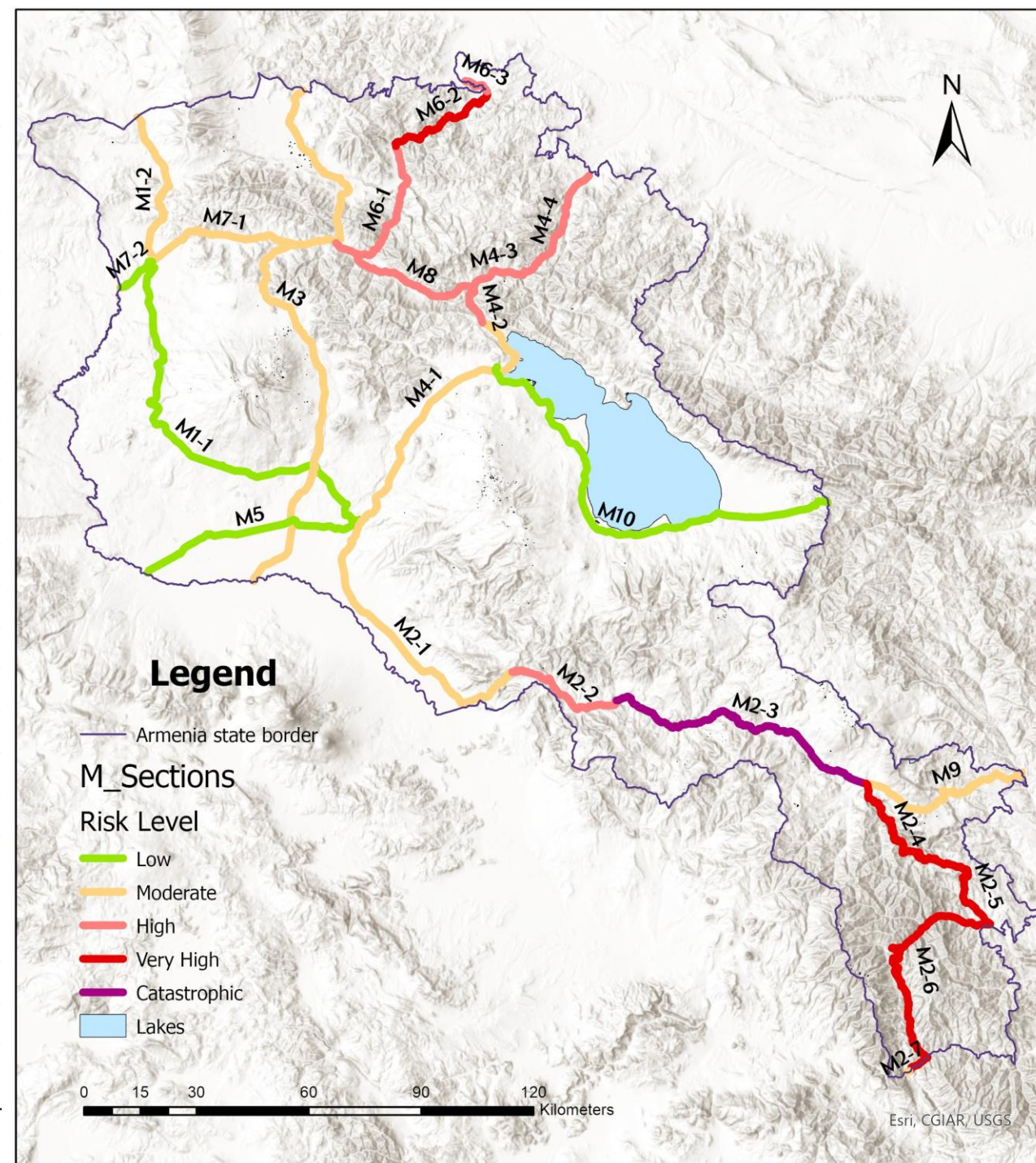
Natural Hazard Risk Matrix for Interstate Road Segments		Consequences				
		Negligible (1) High-capacity, reliable alternative routes available/ Minimal disruption; negligible economic loss	Minor (2) Moderate-capacity alternatives available but not optimal/ Minor delays or costs; localized impact	Significant (3) Limited alternative routes with capacity challenges/ Moderate economic losses; disruptions to small communities	Severe (4) Alternative routes are unavailable or highly unreliable/ Significant economic losses; impact on regional connectivity	Catastrophic (5) No alternative routes available; complete isolation / Widespread economic damage; severe disruption to livelihoods
Likelihood	Likely (3) Will probably happen / is likely to happen	Moderate	Moderate	High	Very High	Catastrophic
	Possible (2) Could happen or plausible	Low	Moderate	Moderate	High	Very High
	Very Unlikely (1) Rare / not expected but remotely possible	Low	Low	Moderate	Moderate	High



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Risk Levels by Interstate Road/Sector





## Fieldwork

## Rockfall ID: DR\_076

(M2 151+800, Point X: 552534,7965, Point Y: 4395705,538) (Map 2.1.2)



### Engineering-geological conditions

The rock mass consists of dense grey to dark-grey volcanic rocks (tuff-breccias). The exposure has a steep inclination (60–80°) and pronounced fracturing. Large blocks partially detached from the main rock mass are observed. Evidence of previous rockfalls is present—fragments of various sizes are accumulated at the base of the slope. The upper part of the rock mass shows signs of weathering, with patches of shrub vegetation whose root systems contribute to the weakening of fractures. The road runs directly at the base of the slope, increasing the potential hazard.

### Activation Risk Assessment

Activation probability — high.

Key contributing factors:

- presence of large unstable blocks in the upper part of the slope;
- steep slope angle and a well-developed fracture system;
- signs of weathering and evidence of previous rockfalls;
- vibrations generated by traffic.

Even under moderate external influences (precipitation, thermal expansion, freeze-thaw weathering), the detachment of individual blocks with a mass of up to 2–5 tons is possible.

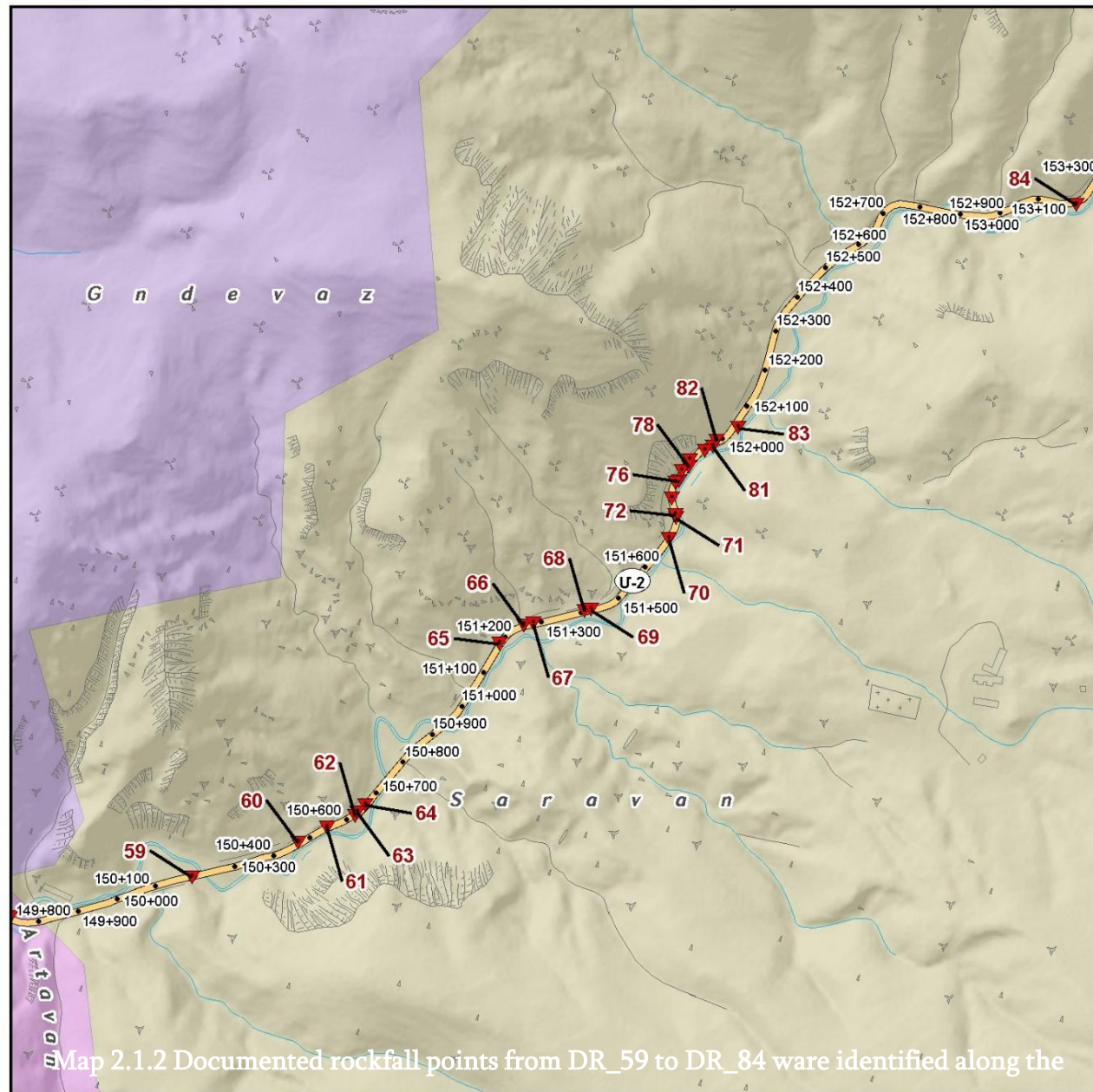
### Approximate volume of the potential rockfall

Estimated volume: 10–20 m<sup>3</sup>.

The expected failure mechanism involves the fall of several large blocks, with possible secondary fragmentation upon impact with the roadway.

### Recommendations

1. Conduct a fracture survey with an assessment of block dip directions.
2. Remove overhanging fragments from the upper part of the slope.
3. Install rockfall barriers or catch nets along the hazardous section.
4. It is recommended to reduce vehicle speed and install warning signs.



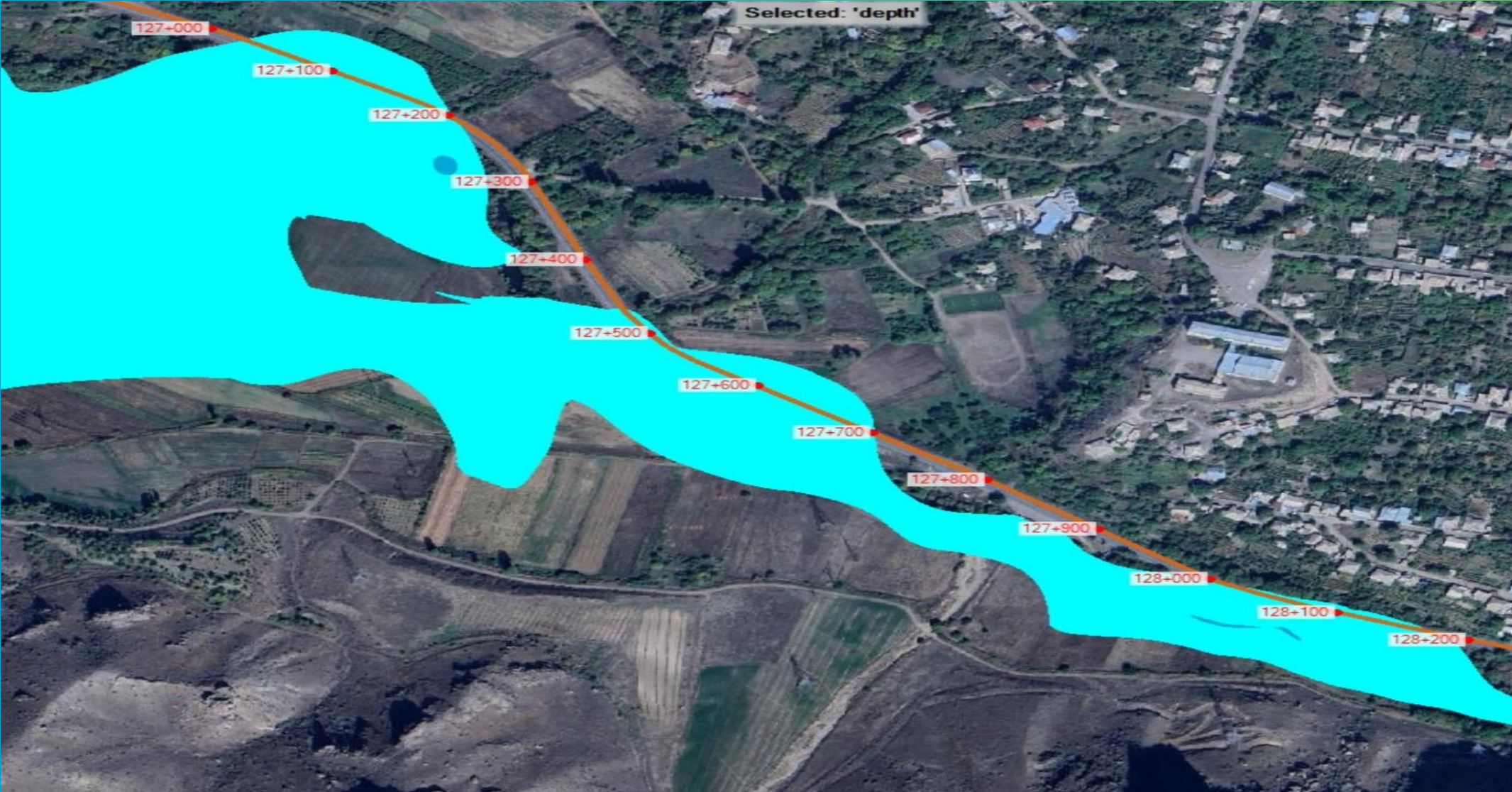
Map 2.1.2 Documented rockfall points from DR\_59 to DR\_84 were identified along the

M2 Yerevan – Yerashk – Noravan – Tatev – Kapan – Meghri – IRA Border

0 0,475 0,95 km



# Hydrological Risk Assessment and Modelling



# Integral Vulnerability Index

## Integral Vulnerability Index (IVI)

**TIVI** = Transport Infrastructure Vulnerability Index

**HMVI** = Hydrometeorological Vulnerability Index

**CCVI** = Climate Change Vulnerability Index

$$IVI = TIVI \times HMVI \times CCVI$$

## Transport Infrastructure Vulnerability Index (TIVI)

**RNH** = Risk of Natural Hazard Activation

**RIA** = Road Importance & Availability of Alternative Roads

**SEI** = Socio-Economic Impact

$$TIVI = RNH \times RIA \times SEI$$

# Integral Vulnerability Index

Sector Code	Integral Risk Index	Marz
M2-5	8.6	Syunik
M6-2	8.3	Tavush,Lori
M2-6	8.0	Syunik
M2-3	7.9	Syunik, Vayots Dzor
M2-4	6.7	Syunik
M6-3	6.5	Tavush,Lori
M4-4	6.2	Tavush
M2-2	5.2	Vayots Dzor, Ararat
M6-1	5.0	Lori
M4-3	4.9	Tavush
M8	4.5	Tavush,Lori
M4-2	4.4	Gegharkunik,Tavush
M2-7	4.2	Syunik
M2-1	3.9	Ararat, Yerevan
M9	3.5	Syunik
M3	3.4	Lori, Aragatsofn, Gegharkunik, Armavir
M4-1	3.0	Gegharkunik, Kotayk, Yerevan
M7-1	3.0	Lori, Shirak
M1-2	2.8	Shirak
M5	2.1	Yerevan, Armavir
M1-1	1.9	Aragatsofn, Shirak, Kotayk, Yerevan
M7-2	1.6	Shirak
M10	1.0	Gegharkunik

# Adaptation Measures and Costing

**High-Energy Rockfall Barriers (Catch Fences)**



**Protective Concrete Walls / Rigid Rockfall Barriers**



**Live Crib Walls and Brush Layering**



**Draped Mesh Systems / Rockfall Netting (Active and Passive)**



**Deep-Rooted Vegetation (Vetiver System)**



**Rockfall Galleries / Tunnels**



At the network level, the total estimated capital investment required for the proposed adaptation measures amounts to approximately **\$3.24 million**, distributed as follows:

- Protective nets (mesh systems): approximately **\$1.06 million** (about one-third of total capital costs).
- Protective concrete barriers: approximately **\$ 2.05 million**
- Other adaptation measures: approximately **\$ 130 thousand**

Typical risk reduction ranges from **65% to >90%** across segments

Annual maintenance costs are low (~1% of CAPEX)

# Risks: Approach and Methodology

Identification and clustering of hazard-prone locations

Estimation of Annual Expected Losses (AEL)

Screening of Adaptation Measures

Lifecycle Cost-Benefit Analysis

Climate Scenario Testing

Transport Sector Climate Adaptation Plan and Investment Plan

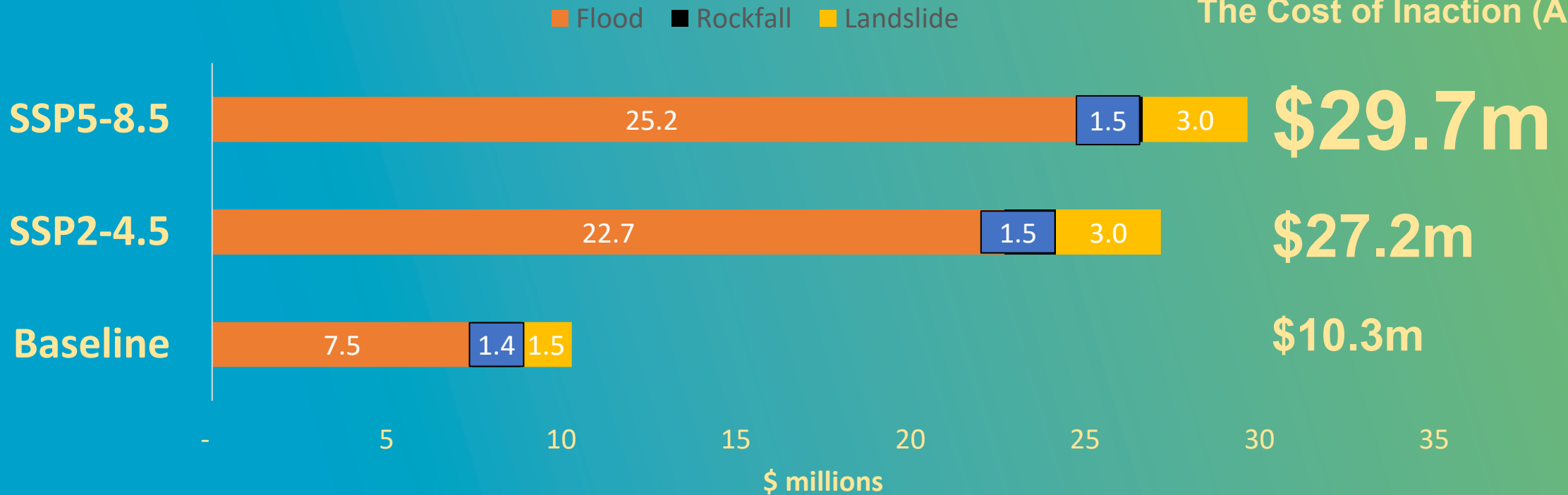
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# Economic Burden of Climate Risk for Roads Sector

The Cost of Inaction (AEL)



**73%- 85%**

**\$7.5m- \$25.2m**

**Flood Risk**

**13%- 5%**

**\$1.4m - \$ 1.5m**

**Rockfall Risk**

**14%- 10%**

**\$1.5m - \$3m**

**Landslide Risk**

# Phased and Tiered Approach to Investment

## Investment Tiers

### Tier A: Finance now

High-return, low-cost investments (mainly rockfall and selected floods); implementation-ready and deliver immediate safety and resilience benefits

### Tier B: Re-scope and optimize

Economically weaker flood projects; to be redesigned, phased, or cost-optimized before financing

### Tier C: Pipeline preparation

Landslide sites with high risk but uncertain costs; advance geotechnical studies and concept designs before committing capital

## Phase 2

Tier A Flood Schemes

## Phase 4

Tier C Landslides

## Phase 1

Rockfall "Quick Wins"

## Phase 3

Tier B Re-scoping

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# Program Overview

# \$69-\$87M

Grand Total Program Envelope



**8 Road Packages:** M1, M2, M4, M6, M7, M8, H-46, H-58



**AEL Protected:** \$8.73 million annually (baseline)



**Horizon:** 5-year sequenced rollout



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# Thank you

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