Seismic Risk to Transport Infrastructure in the Kyrgyz Republic

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Yannis Fourniadis[1], Matthew Free[1], Thomas Ader[1], Katherine Coates[1], Luis Sousa[2], Kevin Fleming[3], Massimiliano Pittore[3], Bolot Moldobekov[4] and Cholponbek Ormukov[4]

[1]Arup, 13 Fitzroy Street, W1T 4BQ, London, UK

[2]AIR Worldwide, London, UK

[3]German Research Centre for Geosciences (GFZ), Potsdam, Germany

[4]Central Asian Institute for Applied Geosciences (CAIAG), Bishkek, Kyrgyz Republic

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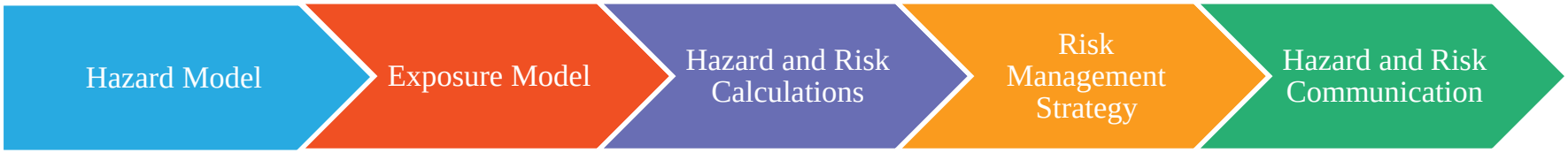
Scope of Work for the Project



1. Determination of seismic hazards.
2. Development of transport infrastructure exposure model.
3. Calculating seismic hazard and risk for buildings and **transport infrastructure**.
4. Development of a seismic risk management strategy.
5. Communication of the seismic hazard and risk results.

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The Government of the Kyrgyz Republic
The World Bank
Global Facility for Disaster Reduction and Recovery

Steering Committee

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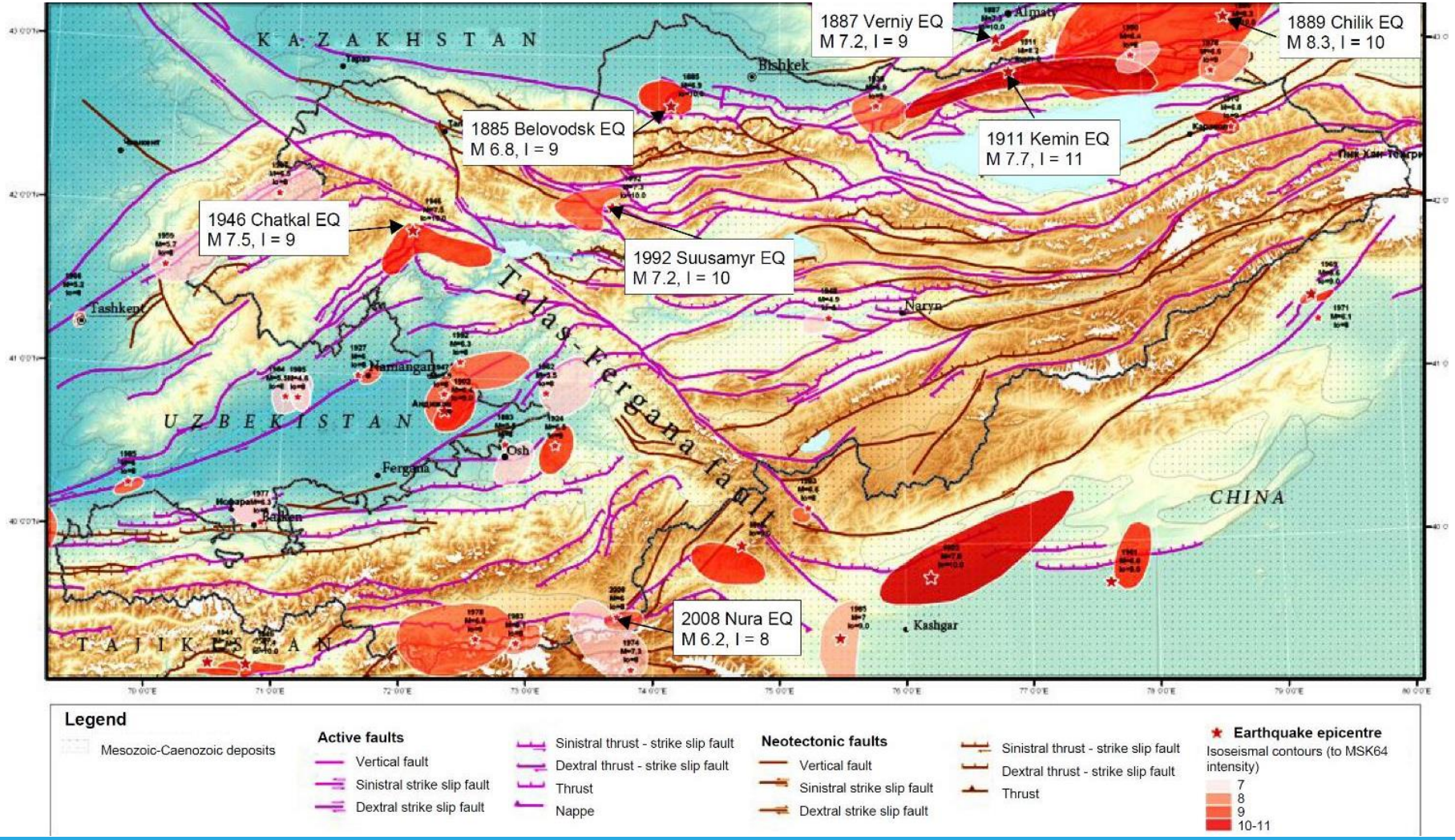
Impact of Earthquakes to Kyrgyz Republic

Several destructive earthquakes have struck the Kyrgyz Republic in the last 150 years, with dozens of fatalities and hundreds of million USD of damages



Nura Earthquake (Mw=6.6)

The Mw = 6.6 Nura earthquake (5 October 2008) resulted in 74 deaths (including 43 children).

References: Secretariat of the United Nations (2010) In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic; CAIAG (2009) The Atlas of Earthquakes in Kyrgyzstan.

Damage to Transport Infrastructure from Earthquakes

Damage to roads is associated with permanent ground deformations (PGD), which are mainly caused by liquefaction, and other earthquake-related phenomena (landslides, lateral spreading, surface fault ruptures)

Damage to roads from surface seismic waves (left) and from debris slides (right) as a result of the Nura earthquake (2008)

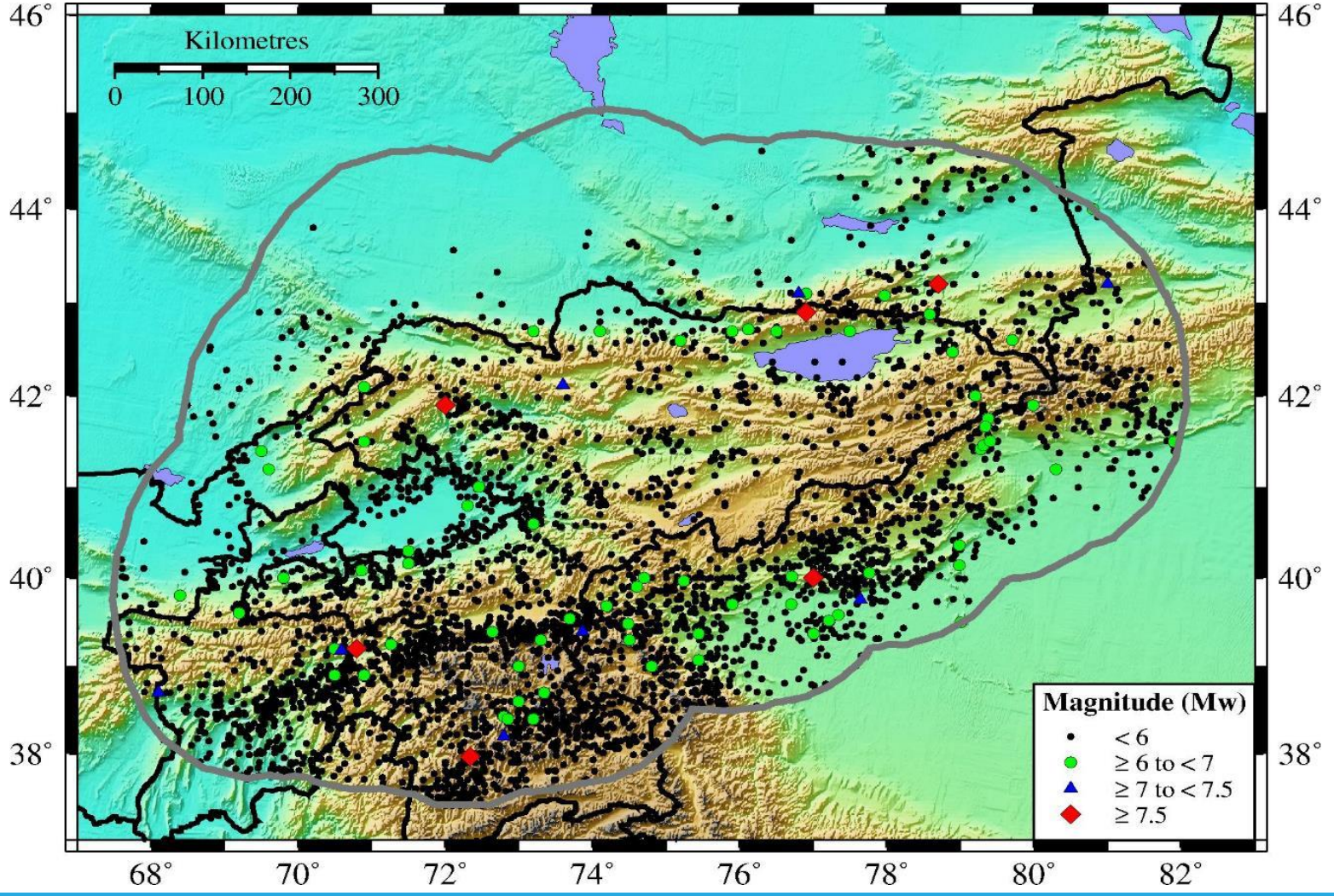
Transport Infrastructure - Bridges Exposure

Site inspection of Kyrgyz bridges in May 2015 – Mostly concrete simply supported structures

Damage to bridges is a function of peak ground acceleration (PGA), and depends on material type, complexity of the structure and the local ground conditions

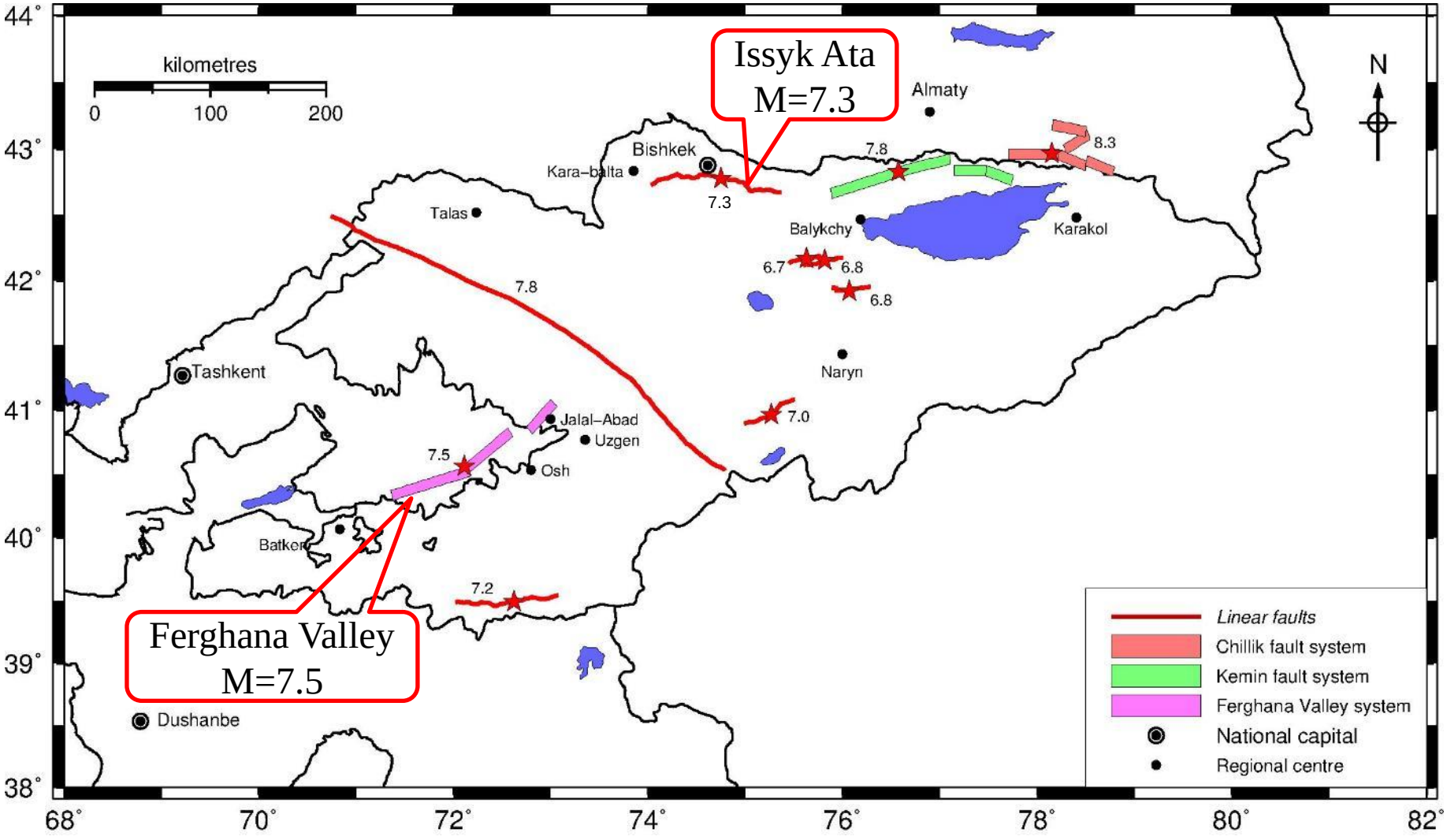
Earthquake Catalogue

The catalogue includes more than 3,000 earthquakes of moment magnitude greater than 4.5 that occurred between 250 BCE and 2014.



Scenario Earthquakes for Risk Assessment

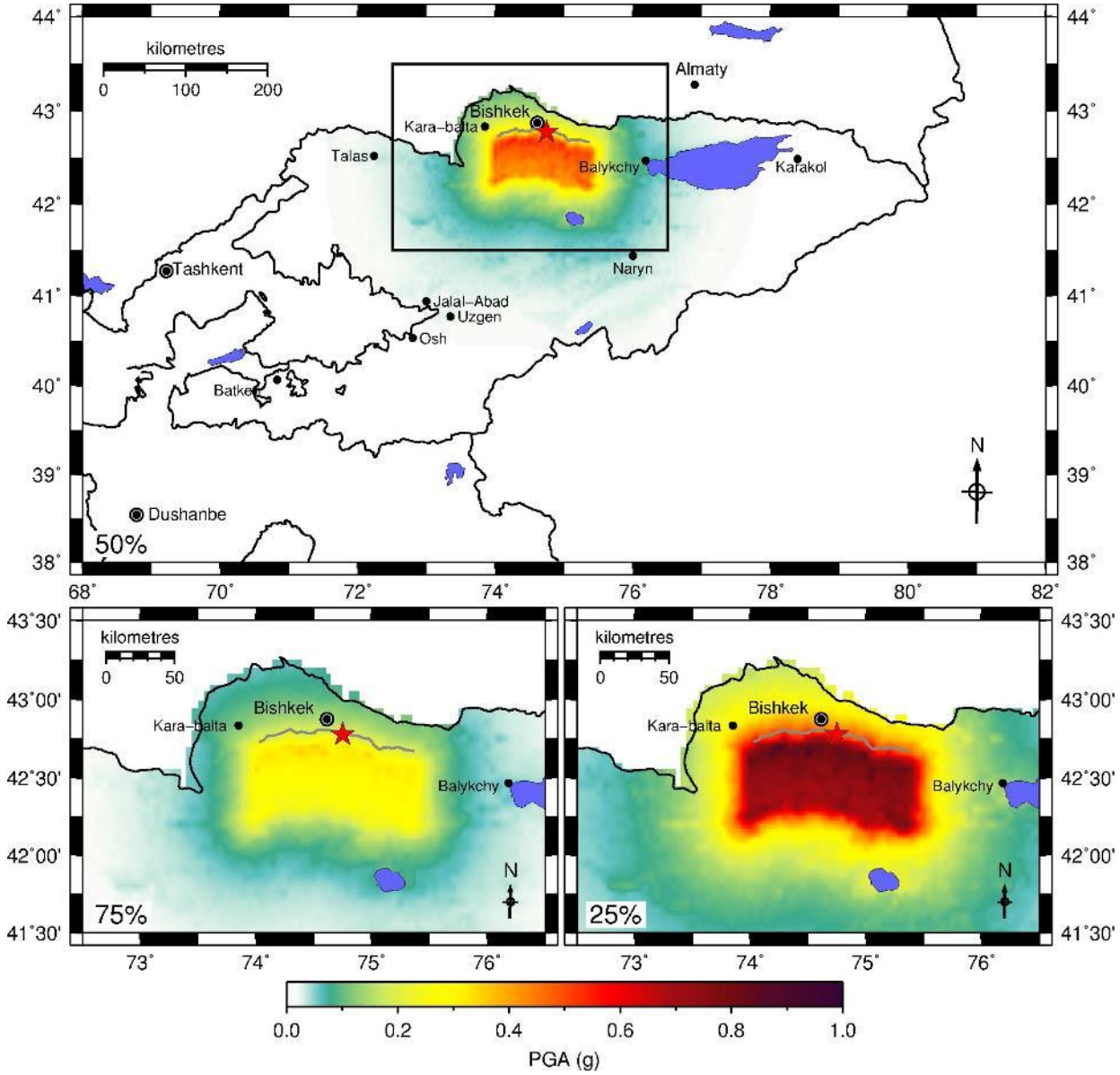
Ten scenario earthquakes were chosen on well-characterised, active geological faults, that could rupture near population centres



Selected Scenario Earthquakes

No.	Name	Magnitude (Mw)	Dip (degree)	Rake (degree)	Type of faulting	Type of modelling
1	Issyk Ata	7.3	21	50	Thrust	Linear simple fault
2	Chillik	8.3	60	170º	Strike-slip	Multiple plane rupture
3	Kemin	7.8	60º	50º	Thrust	Multiple plane rupture
4	Ferghana Valley	7.5	50	100	Thrust	Multiple plane rupture
5	South Kochkor	6.8	50	50	Thrust	Linear simple fault
6	Akchop Hills	6.7	9	50	Thrust	Linear simple fault
7	Telek Karakhudzhur	6.8	30	50	Thrust	Linear simple fault
8	Oinik Djar	7.0	29	50	Thrust	Linear simple fault
9	Talas Ferghana	7.8	70	170	Strike-Slip	Linear simple fault
10	Alai Pamir	7.2	40	50	Thrust	Linear simple fault

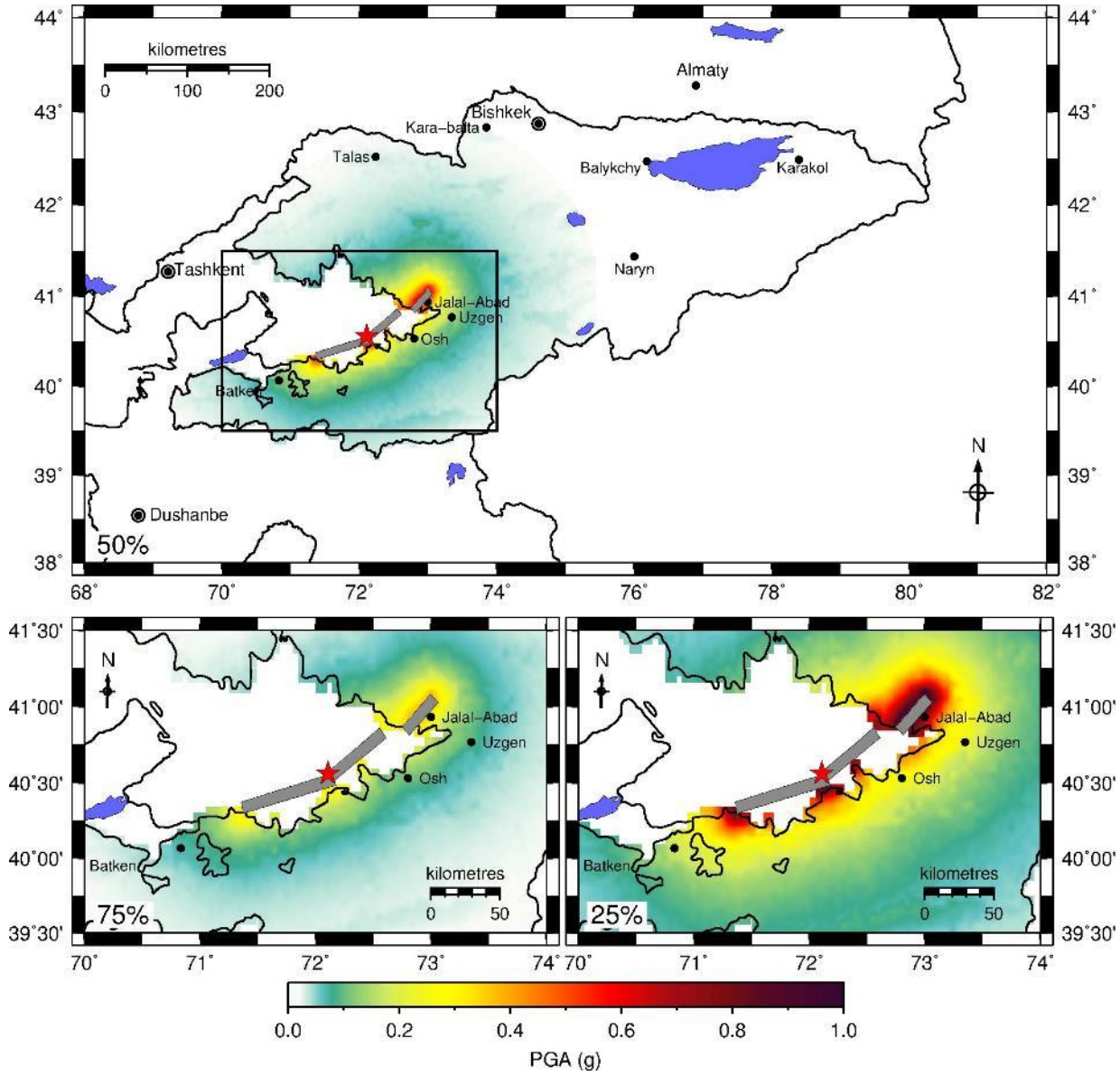
Issyk-Ata Fault Earthquake Scenario (Mw = 7.3)



Maps of distribution of ground shaking amplitude in terms of Peak Ground Acceleration (PGA).

High PGA values of around 0.5g can be expected at the capital city of Bishkek as a result of ground shaking from this scenario earthquake.

Ferghana Valley Fault Earthquake Scenario (Mw = 7.5)



Ferghana Valley Fault earthquake scenario Magnitude Mw = 7.5.

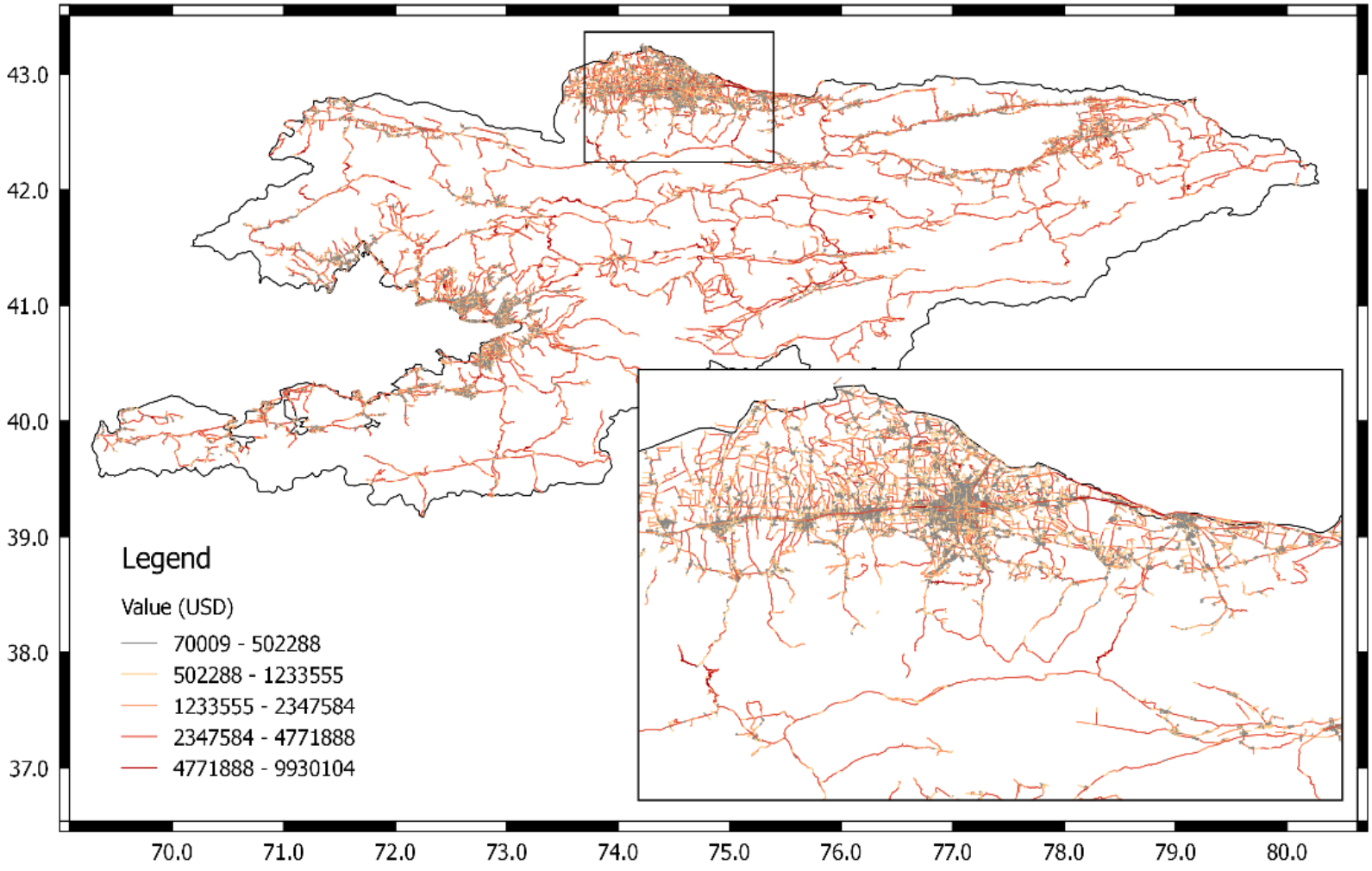
Maps of distribution of ground shaking amplitude in terms of Peak Ground Acceleration (PGA).

Very high PGA values of around 1g can be expected at the city of Jalal-Abad as a result of ground shaking from this scenario earthquake.

Transport Infrastructure - Roads Exposure

From OpenStreetMap database of roads in the Kyrgyz Republic

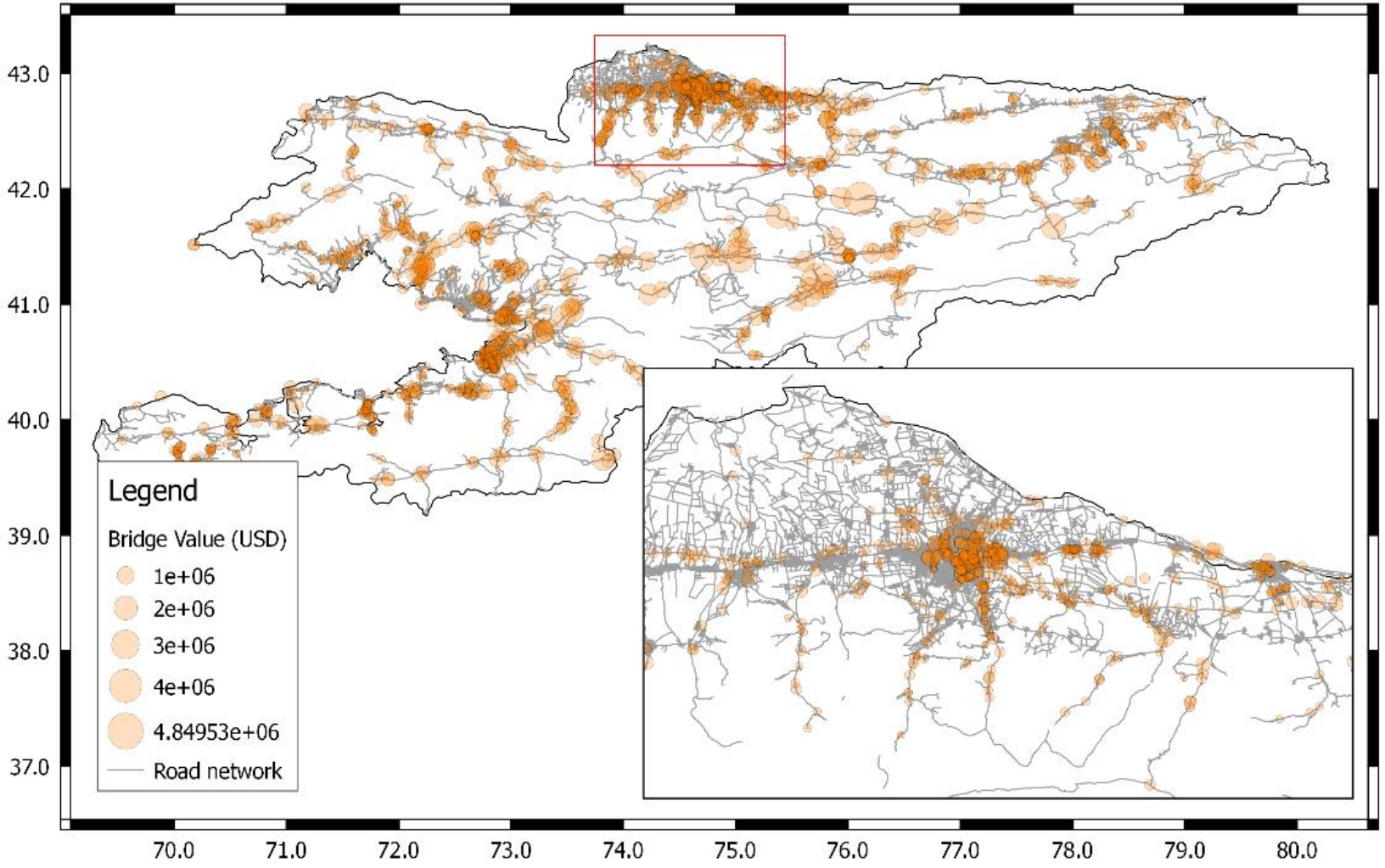
Roads total value: 33 billion USD



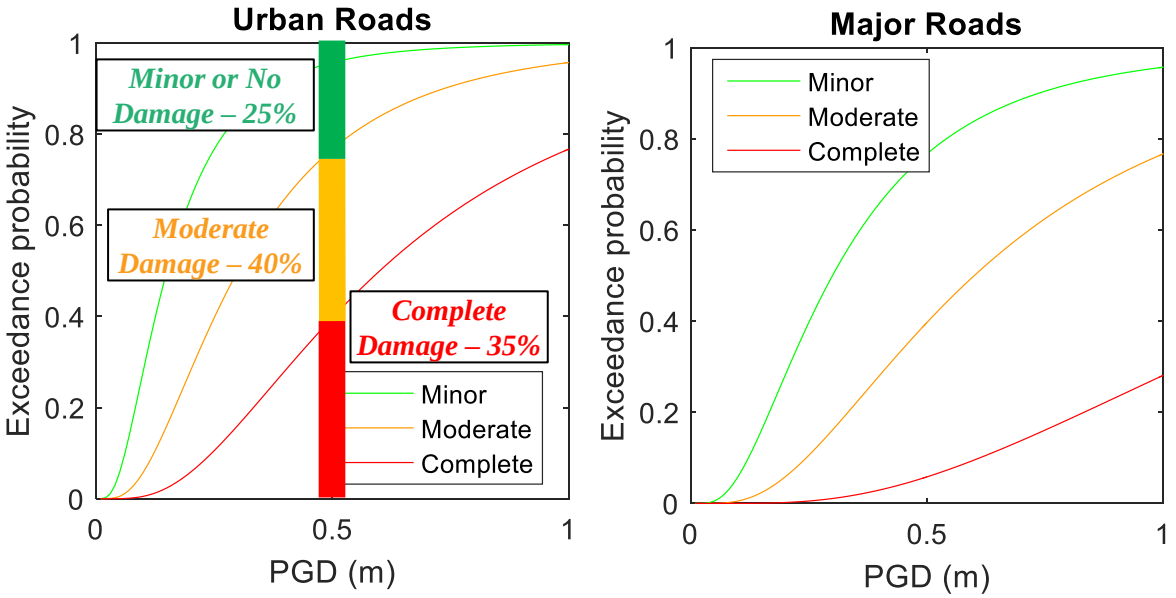
Transport Infrastructure - Bridges Exposure

From OpenStreetMap database of bridges in the Kyrgyz Republic

Bridges total value: 500 million USD



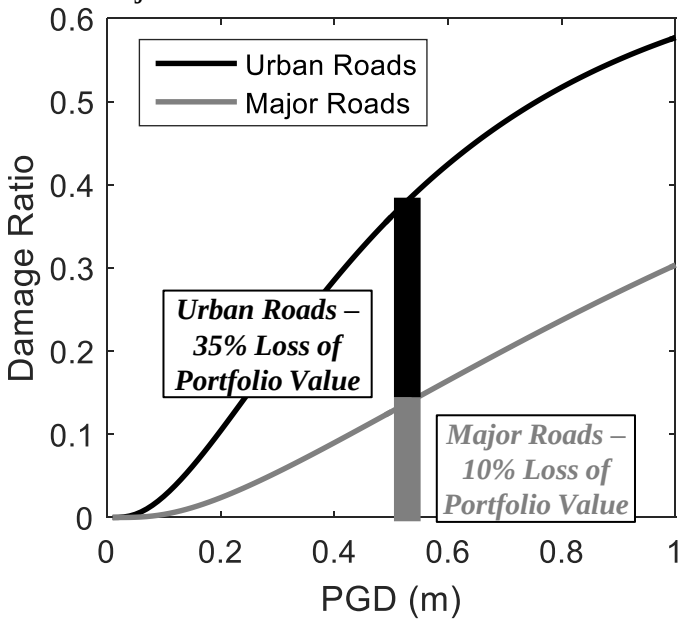
Fragility and Vulnerability of Roads



Fragility functions for urban and major roads in terms of permanent ground deformation (PGD) (FEMA, 2003)

E.g., permanent ground deformations (**PGD**) of **0.5m** would cause **10% loss** of the value of the **major road** segment that experiences that amount of deformation, and **35% loss** of the value of the **urban road** segment that experiences that amount of deformation

Vulnerability functions for urban and major roads



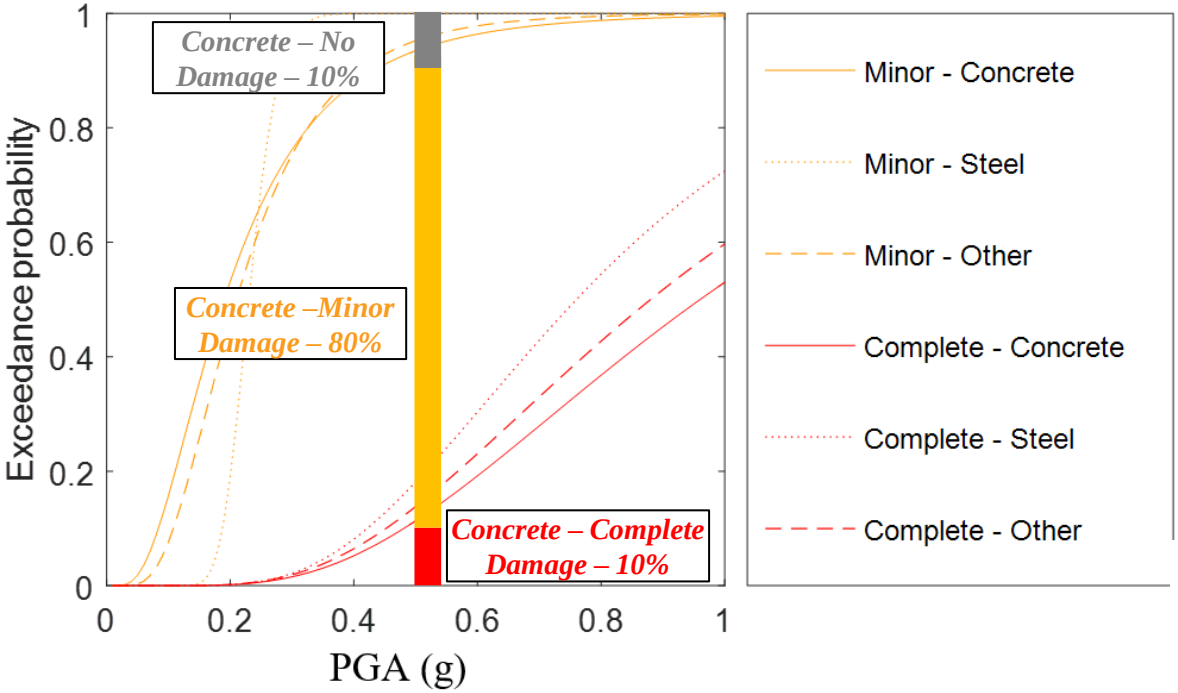
Damage-to-loss model for roads (FEMA, 2003)

Typology	Damage state	Damage Ratio*
2 traffic lanes (urban roads)	Minor	0.05
	Moderate	0.20
	Extensive/complete	0.70
≥ 4 traffic lanes (major roads)	Minor	0.05
	Moderate	0.20
	Extensive/complete	0.70

*Ratio between attained loss for a specific damage state and the total value of the affected road segment

Reference: FEMA (2003) HAZUS-MH Technical Manuals. Federal Emergency Management Agency, Washington, D.C.

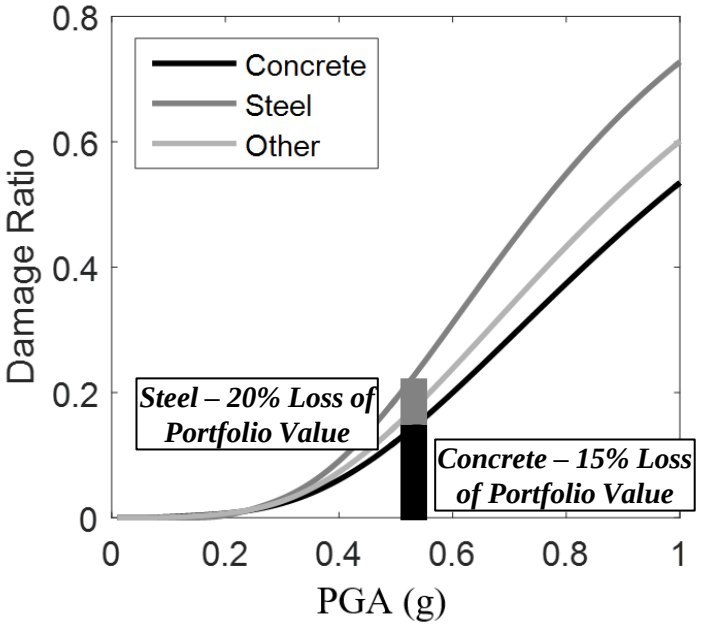
Fragility and Vulnerability of Bridges



Fragility functions for bridges, in terms of PGA (g) (FEMA, 2003)

E.g., peak ground acceleration (**PGA**) of **0.5g** would cause **15% loss** of the value of a **concrete bridge** that experiences that amount of acceleration, and **20% loss** of the value of a **steel bridge** that experiences that amount of acceleration

Vulnerability functions for bridges



Damage-to-loss model for bridges (FEMA, 2003)

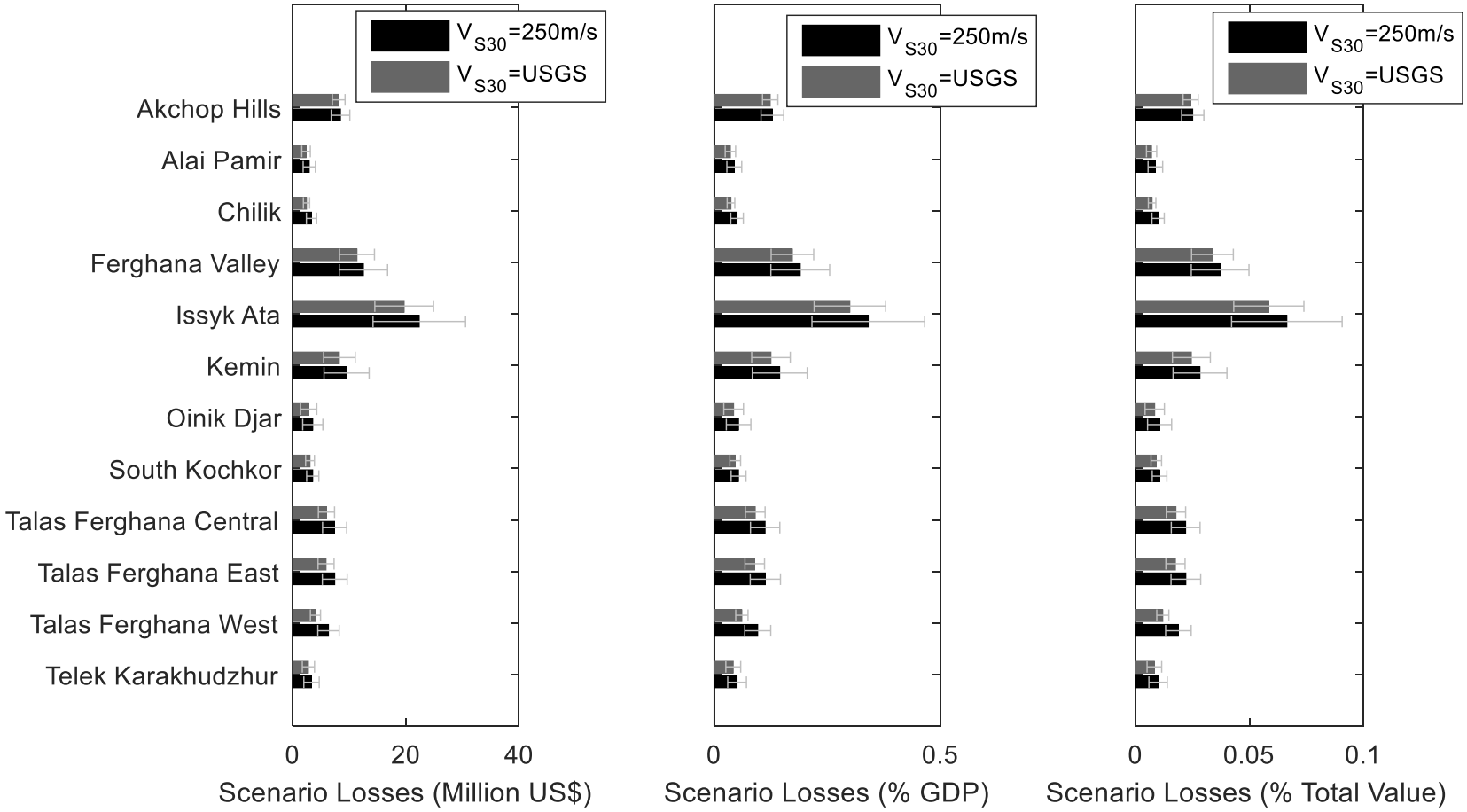
Bridge type	Damage state	Damage Ratio
Steel, concrete or "other"	Minor damage	0.01
	Extensive/complete	2/n*

*where n is the number of spans. If n≤2, a damage ratio of 1.00 shall be applied.

Reference: FEMA (2003) HAZUS-MH Technical Manuals. Federal Emergency Management Agency, Washington, D.C.

Loss Results for Bridges

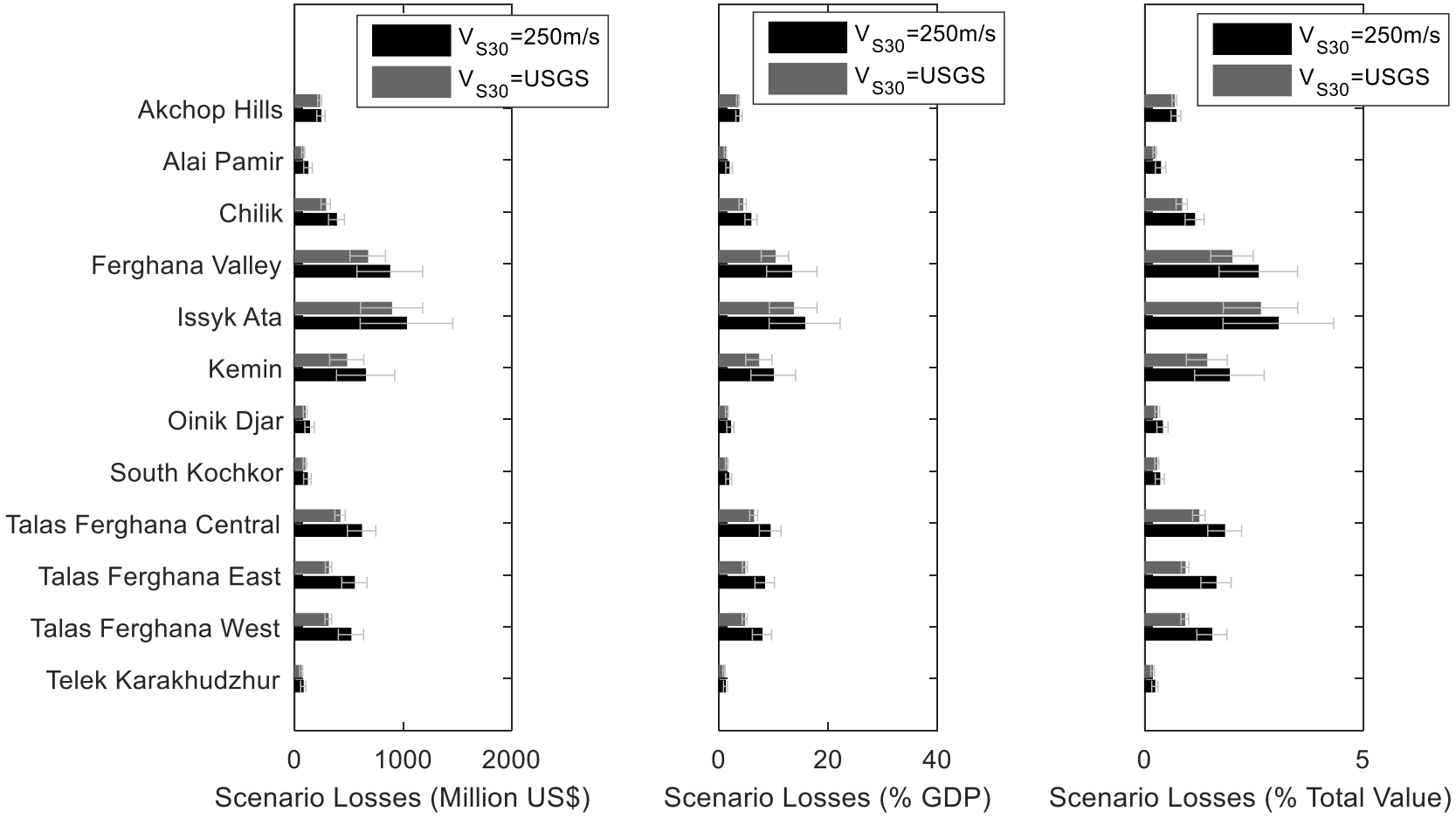
Asset portfolio	Scenario Results - Economic losses	
	USD	% GDP
Bridges	3 to 26 million	0.05% to 0.4%



Error bars represent the mean plus and minus one standard deviation.

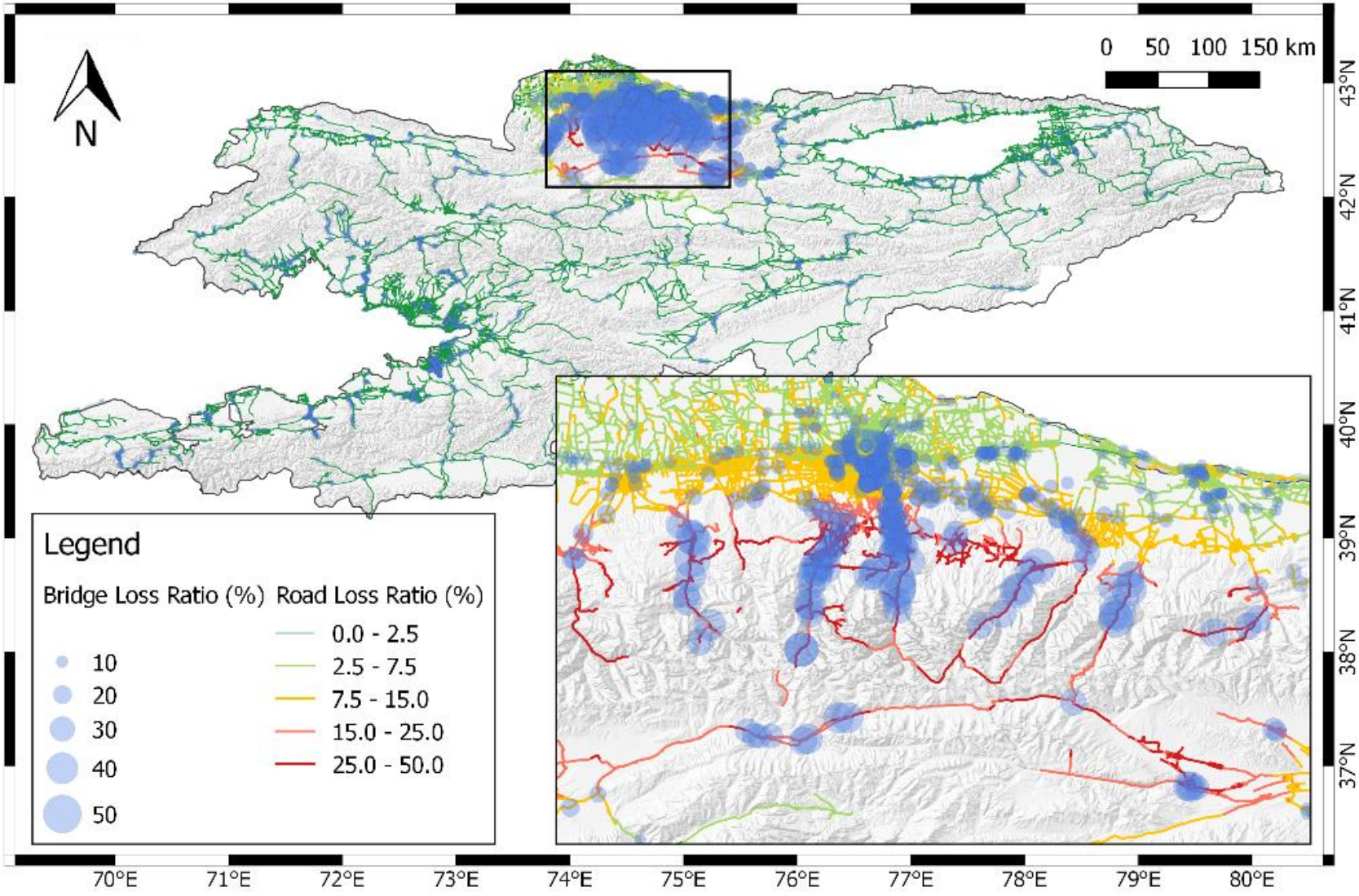
Loss Results for Roads

Asset portfolio	Scenario Results - Economic losses	
	USD	% GDP
Roads	100 million to 1 billion	1.5% to 17%



Error bars represent the mean plus and minus one standard deviation.

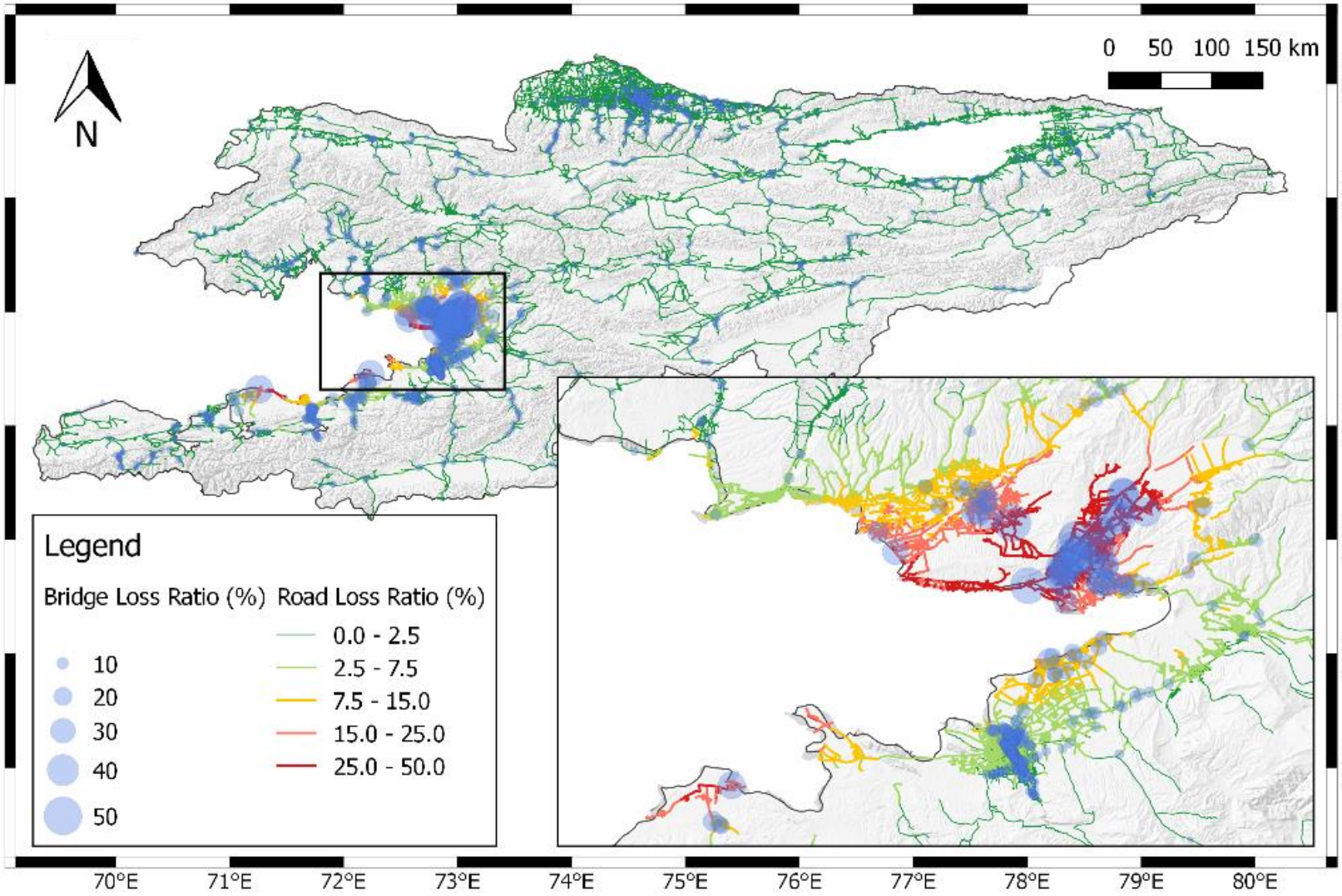
Issyk-Ata Scenario Risk Results – Roads and Bridges



Spatial distribution of mean loss ratios (ratio between attained loss and total value of the road or bridge segment), considering a V_{S30} distribution obtained from USGS.

Economic Losses roads: 0.9 to 1.1 billion USD
Economic Losses bridges: 20 to 25 million USD

Ferghana Valley Scenario Risk Results – Roads and Bridges



Spatial distribution of mean loss ratios (ratio between attained loss and total value of the road or bridge segment), considering a V_{S30} distribution obtained from USGS

Economic Losses roads: 0.7 to 1.0 billion USD
Economic Losses bridges: 15 to 17 million USD

Disaster Risk Reduction in the Kyrgyz Republic aligned with the Sendai Framework

Sendai Framework for Disaster Risk Reduction Strategy 2015 -2030

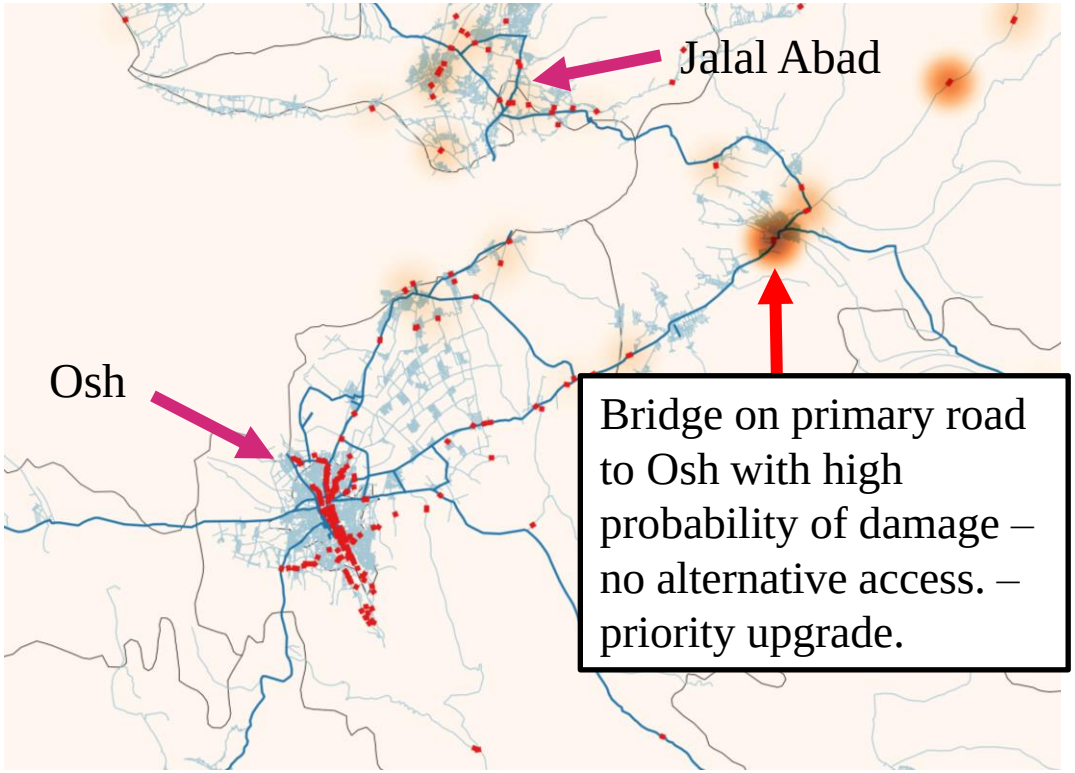
Seismic Risk Reduction Strategy Recommendations from this Project with Ongoing Programmes in the Kyrgyz Republic

- State Program 'Seismic Safety in the Kyrgyz Republic in the years 2012-2019'.
- 'Country Development Programme for the Kyrgyz Republic' includes DRR.
- Ongoing capacity building programmes in awareness of seismic risk and earthquake preparedness for communities.
- '2016 – 2030 Strategy of the Emergencies Protection of the Kyrgyz Republic' in development.

Risk Reduction Recommendations – Roads and Bridges

- Establish **database** of **critical roads** and **bridges**.
- Perform **detailed assessments** for critical bridges.
- **Update seismic risk management strategy** for bridges to inform prioritized replacements and retrofits.
- Perform **road network analyses** to identify critical roads and where redundancy is required.
- **Increase funding** for stakeholders and action.

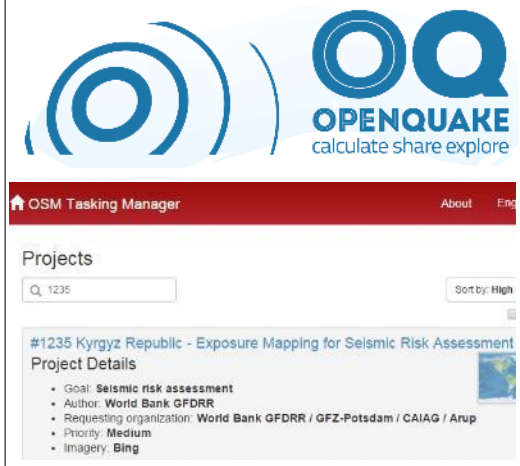
From scenario earthquake results, expected losses of:
100 million to 1.1 billion USD/year for Roads
3 to 26 million USD/year for Bridges



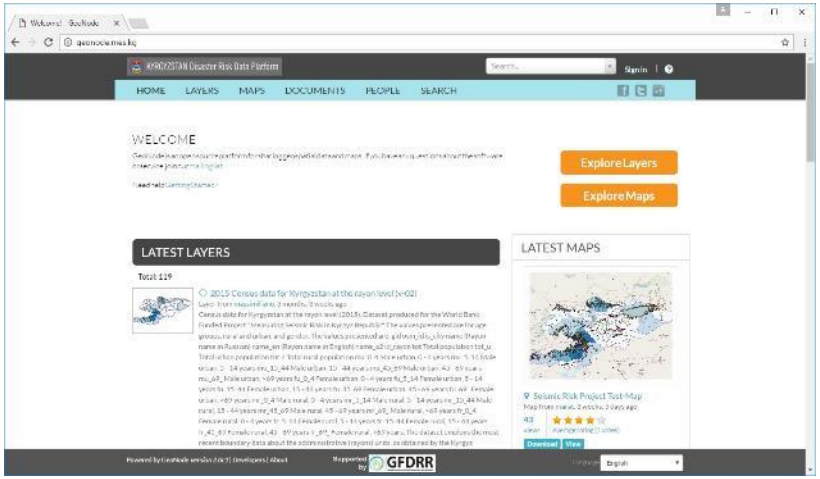
Example for a critical bridge near Osh for emergency response.

Communication of Risk and its Various Components

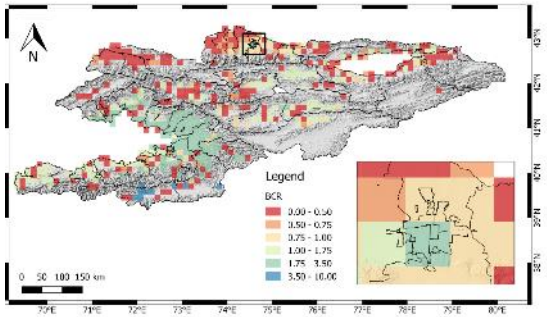
Technical communication of risk assessment practice



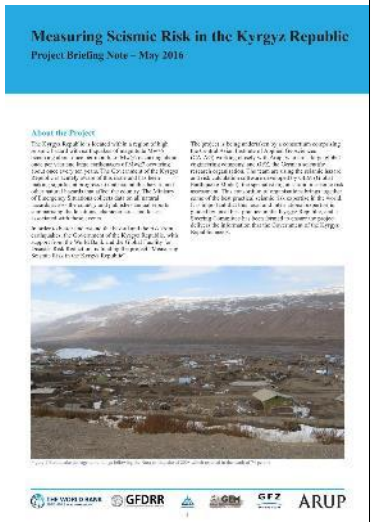
Technical communication of risk information



Technical communication of risk mitigation practice



Non-technical communication of risk mitigation practice

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