BORIS

Cross BOrder RISk assessment for increased prevention and preparedness in Europe

Seismic risk assessment in transboundary regions

Work by partners included in the Work packages 4 and 5 of the BORIS project

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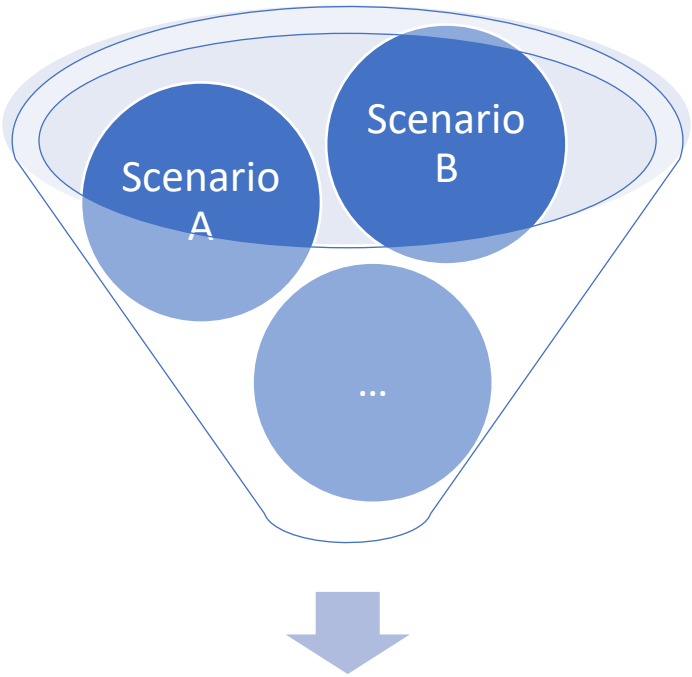
Seismic risk assessment

Time-based seismic risk assessment

- Considers all possible earthquake scenarios
  - All relevant source locations
  - All relevant magnitudes
  - Uncertainties, randomness

➢ <u>Average consequences in a given time frame</u>



Average losses per 1 year or 50 years

Seismic risk assessment

Models in a time-based seismic risk assessment

Exposure model	➢ What are the assets at risk and their characteristics?
Hazard model	➢ How frequent are earthquakes with given seismic intensities?
Vulnerability model	➢ What is the probability of assets reaching the designated damage states given the seismic intensity?
Consequence model	➢ What are the consequences of the designated damage states?

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Seismic risk assessment

Models in a time-based seismic risk assessment

- Exposure model
- Hazard model
- Vulnerability model
- Consequence model

- **Models often available at the national level**
- **Transboundary regions: Cross-border harmonization of the models needed**

Seismic risk assessment

BORIS: Exposure model

- Assets at risk:
  - Residential buildings and population
- Considered characteristics:
  - Number of res. buildings and population, buildings' floor area
  - Material of the load bearing structure, number of stories, period of construction
- Challenges:
  - Definition of the building classes → Harmonization of the building classification
  - Definition of the spatial scale → Harmonization of the data resolution (**Municipality spatial scale**)

Harmonization of the building classes for ITA-SLO cross-border area:

	ITALY	SLOVENIA
Material	masonry	masonry
	reinforced concrete	reinforced concrete
	other	other
Stories	1, 2, 3, >=4	1, 2, 3, >=4
Period	< 1919	< 1919
	1919 - 1945	1919 - 1945
	1946 - 1960	1946 - 1960
	1961 - 1970	1961 - 1964
		1965 - 1970
	1971 - 1980	1971 - 1981
	1981 - 1990	1982 - 1990
	1991 - 2000	1991 - 2000
	2001 - 2005	2001 - 2007
	> 2005	> 2007

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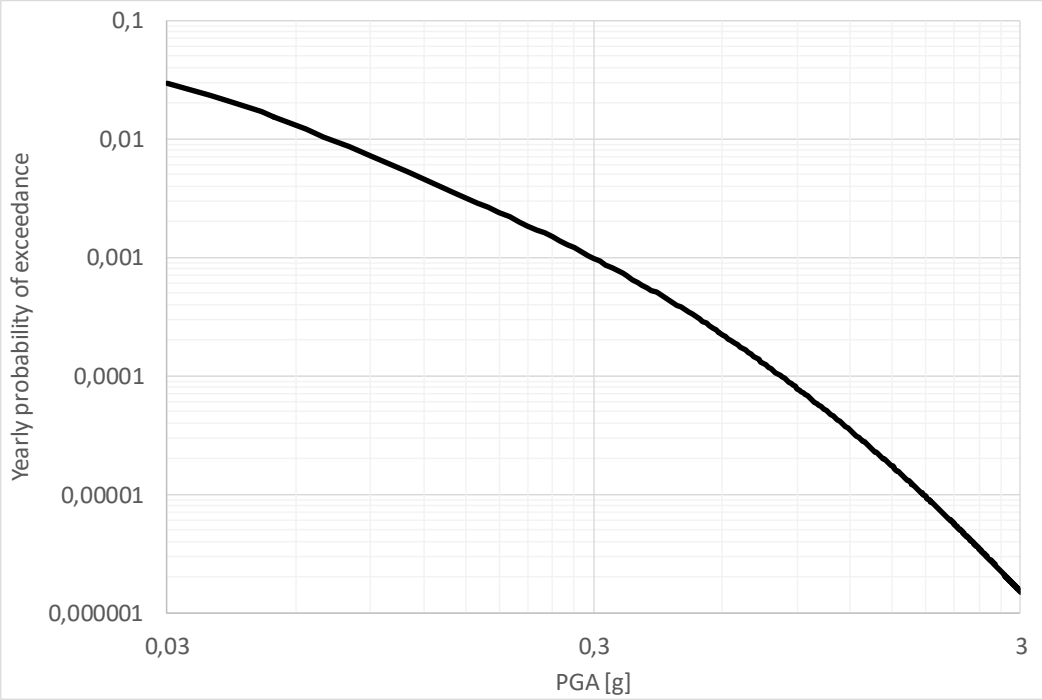
Seismic risk assessment

BORIS: Hazard model

- A hazard curve for each municipality
  - PGA as the intensity measure
- Basis:
  - PGA maps for various return periods
  - Vs30 maps used to model the local soil effects
- Challenge:
  - ➢ Discrepancies of the national hazard models at country borders
- Solution: European seismic hazard model ESHM 2020

Hazard curve for the municipality of Kanal:

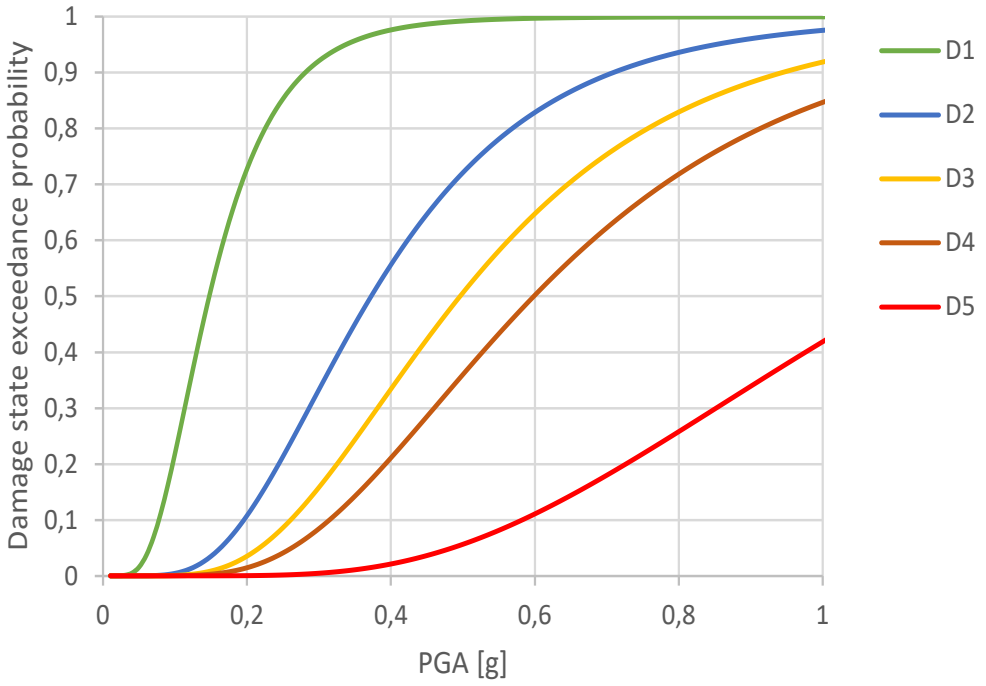


Seismic risk assessment

BORIS: Vulnerability model

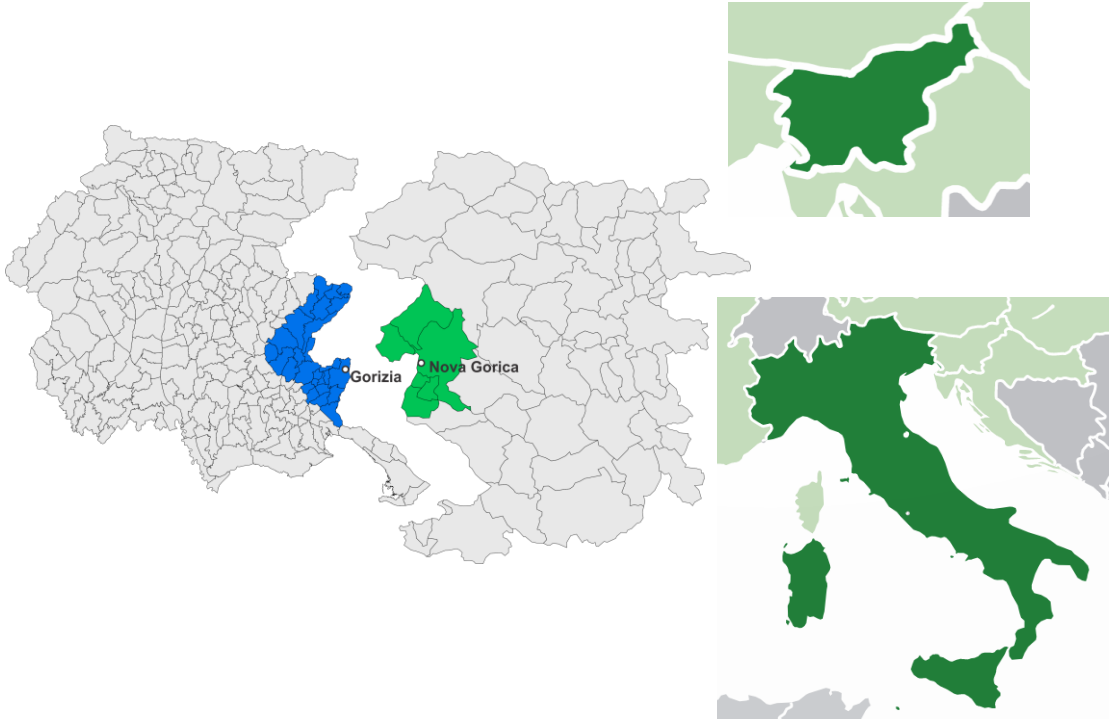
- Comprised of several sets of fragility curves
  - At the level of typological building classes
  - Based on PGA
  - EMS-98 damage scale (D0–D5)
- Challenge:
  - ➢ Differences in national vulnerability models
- Solution: Heuristic approach for cross-border harmonization

Comparison of Italian and Slovenian fragility curves for pre-code low-rise RC buildings:



BORIS: Vulnerability model

- Heuristic approach for cross-border harmonization of the fragility curves



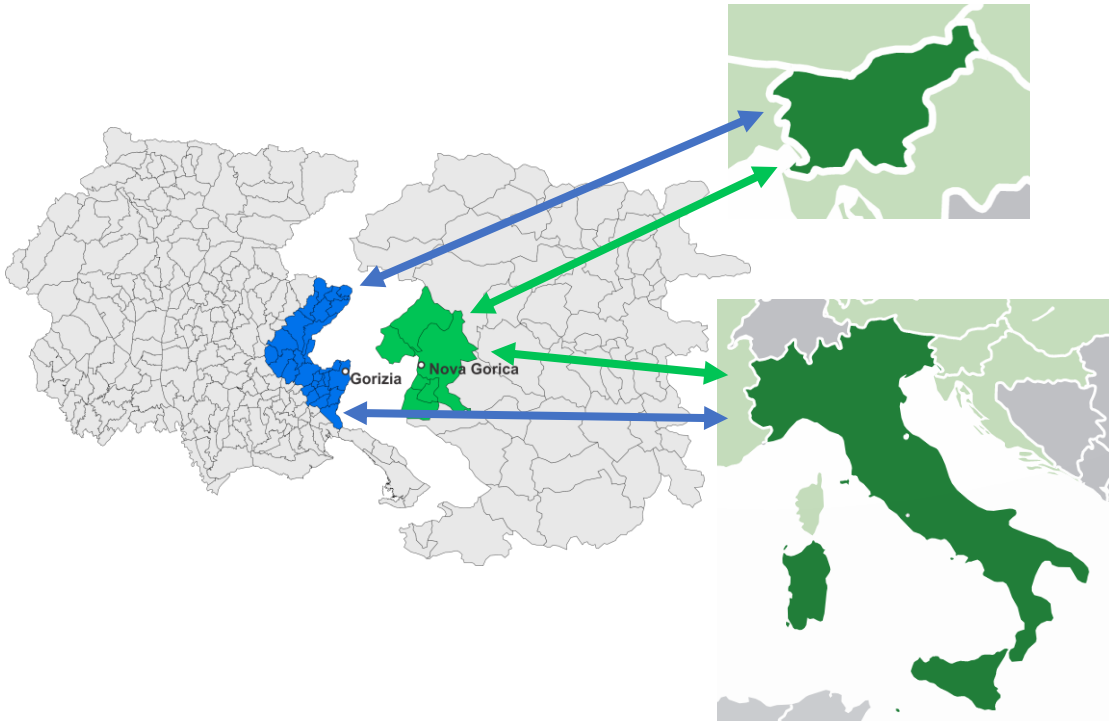
- **Goal**: derive fragility curves for 2 sub-areas in the transboundary region
- **Starting point**: fragility curves developed at the <u>national</u> level

$$M_{IT}^{comb} = w_{IT,IT} \cdot M_{IT} + w_{IT,SI} \cdot M_{SI}$$

$$M_{SI}^{comb} = w_{SI,IT} \cdot M_{IT} + w_{SI,SI} \cdot M_{SI}$$

BORIS: Vulnerability model

- Heuristic approach for cross-border harmonization of the fragility curves



<u>Weights defined based on</u>:

- Comparison of the **methodologies**
  - ➢ BORIS: Methodologies considered equally accurate
- Comparison of the **typologies**
  - Estimation of typological similarities
  - ➢ BORIS: Based on **vulnerability factors**

Seismic risk assessment

BORIS: Consequence model

- Comprises several damage-to-impact functions
- Each damage-to-impact function relates to one risk indicator
  - Number of fatalities
  - Number of injured people
  - Number of long-term and short-term unusable buildings
  - Monetary losses
- Straightforward cross-border harmonization due to similarity in damage-to-impact functions

Damage-to-impact function for the number of short-term unusable buildings:

Total number of short-term unusable buildings

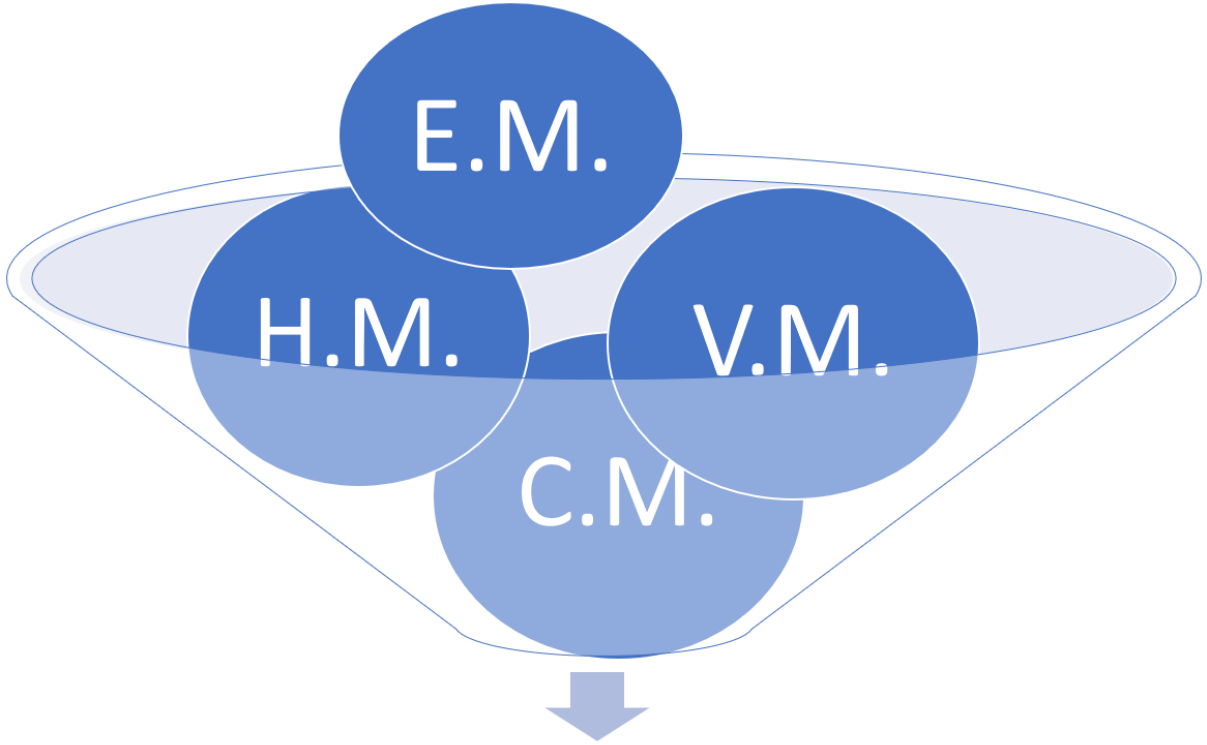
Numbers of buildings in damage state k

$$UB_{st} = \sum_{k=1}^{5} (N_k \cdot u_{stk})$$

Percentage of unsafe buildings in the short term in the case of damage state k

Seismic risk assessment

The risk integral



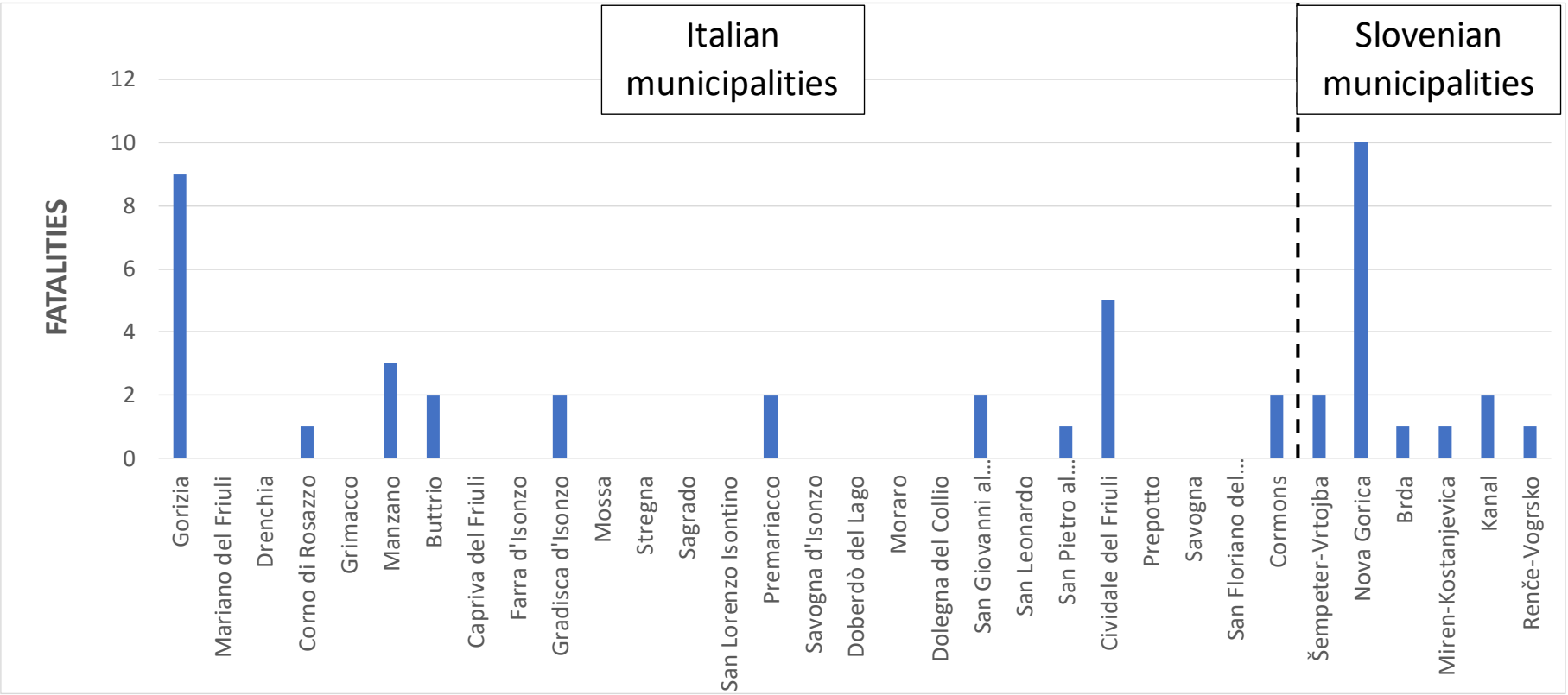
Average consequences per 1 or 50 years

The outcome useful for:

- **Evaluation of seismic risk in the municipality or the whole cross-border area**
- **Comparison/ranking with other risks**

Seismic risk assessment

Results: Expected number of fatalities in 50 years



In total

- Italy: 29
- Slovenia: 17
- Together: 46

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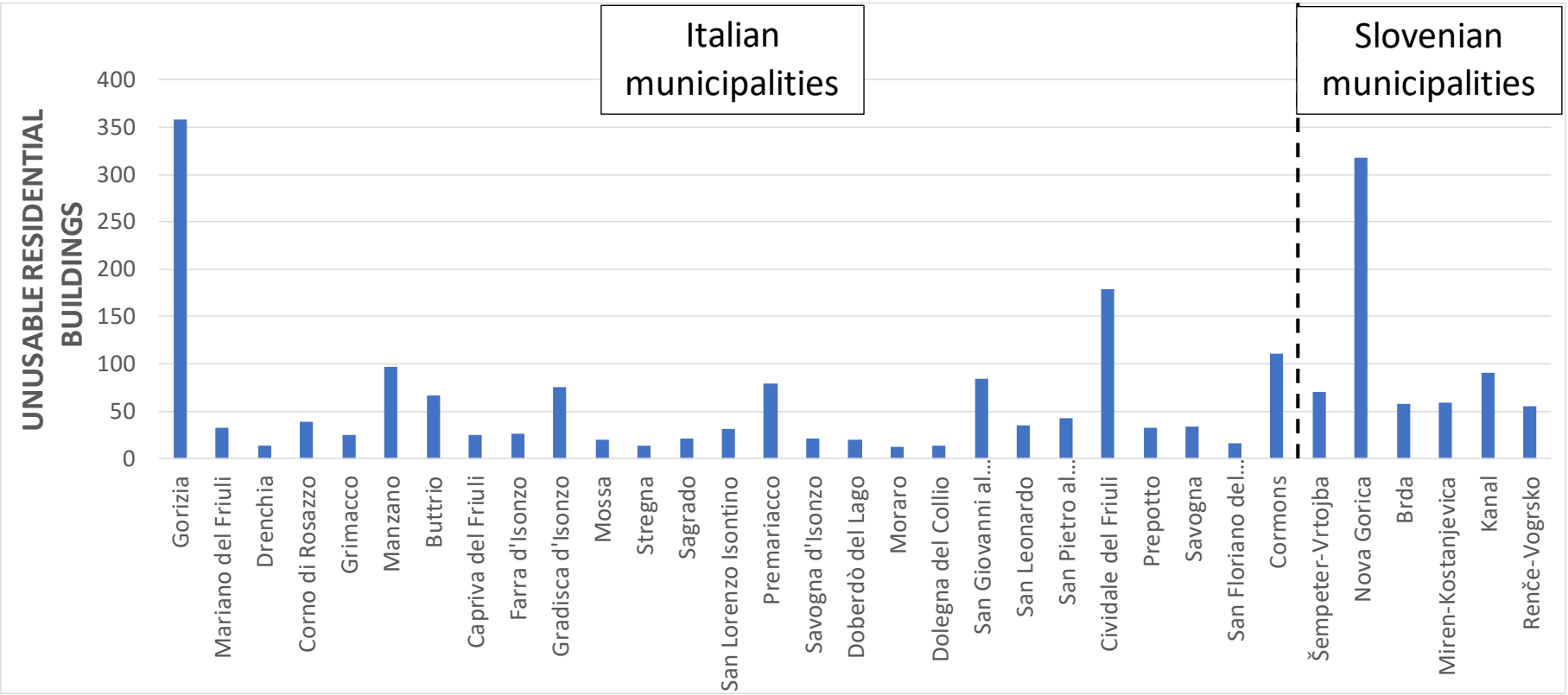
Seismic risk assessment

Results: Expected number of unusable residential buildings in 50 years



In total:

- Italy: 1521
- Slovenia: 649
- Together: 2170

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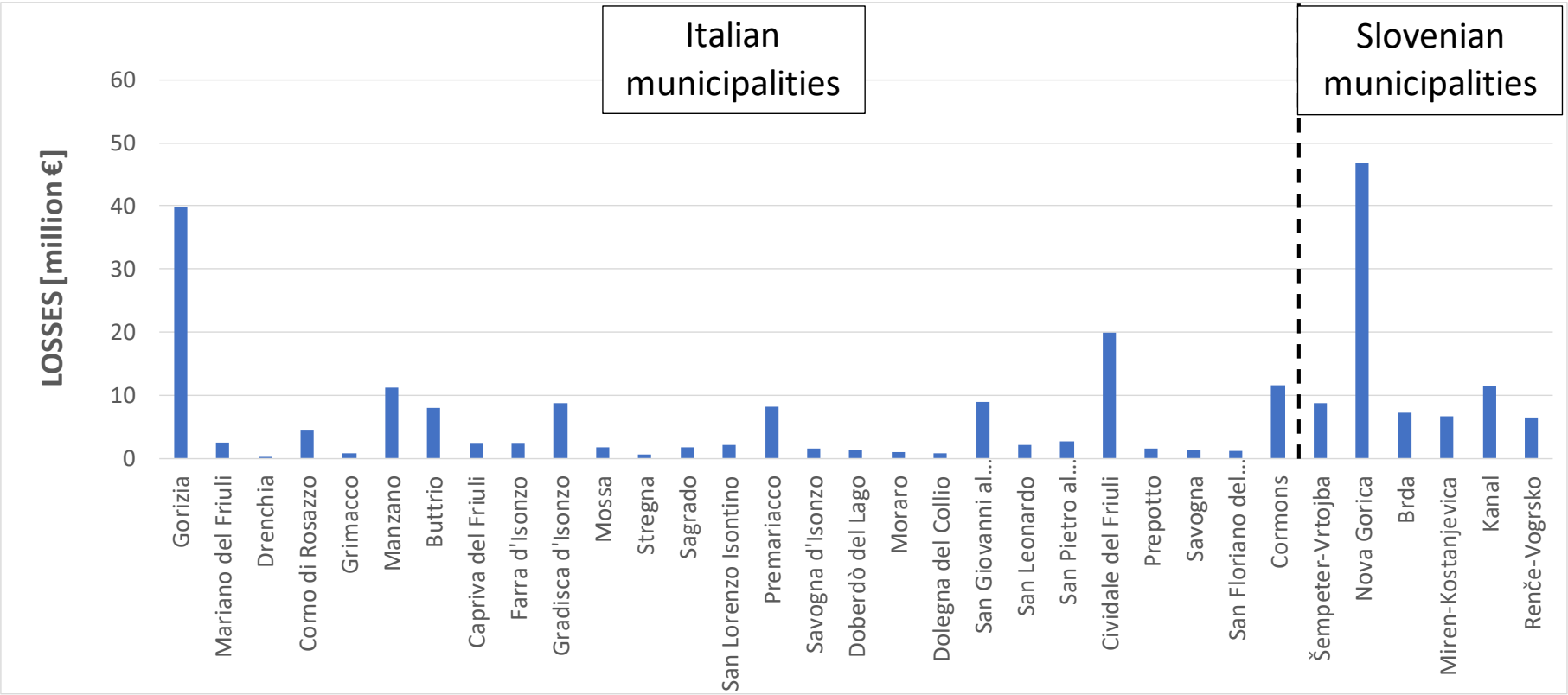
Seismic risk assessment

Results: Expected economic losses in 50 years



In total:

- Italy: 149 million €
- Slovenia: 87 million €
- Together: 236 million €

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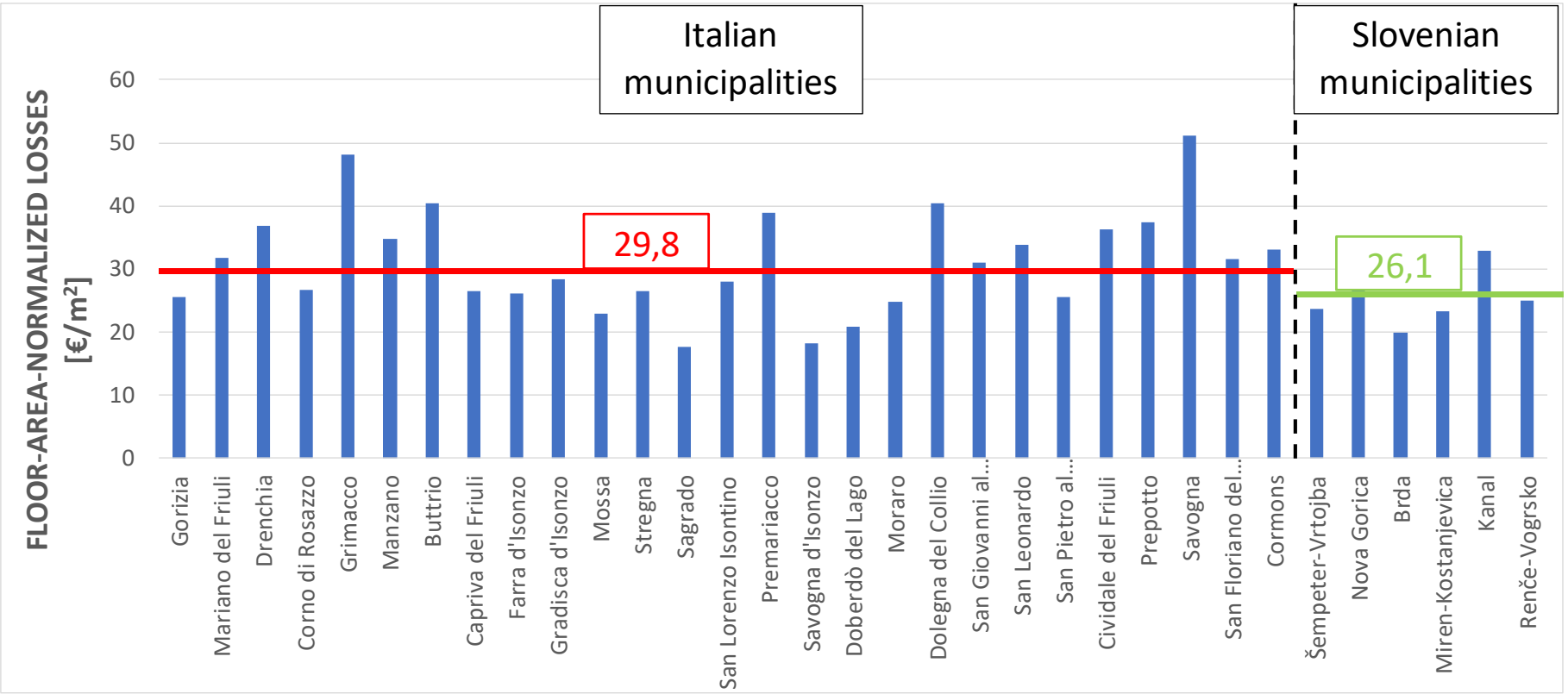
Seismic risk assessment

Results: Expected economic losses in 50 years



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Seismic risk assessment

Conclusions

- Time-based risk assessment was applied
- Existing models were used
- Cross-border harmonization of the models was performed
- The results can facilitate decision-making for development of risk mitigation measures

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