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Recent advances in vulnerability assessment for the built environment exposed to dynamic flooding

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Major hazards in mountain areas

Storms

Dynamic inundation

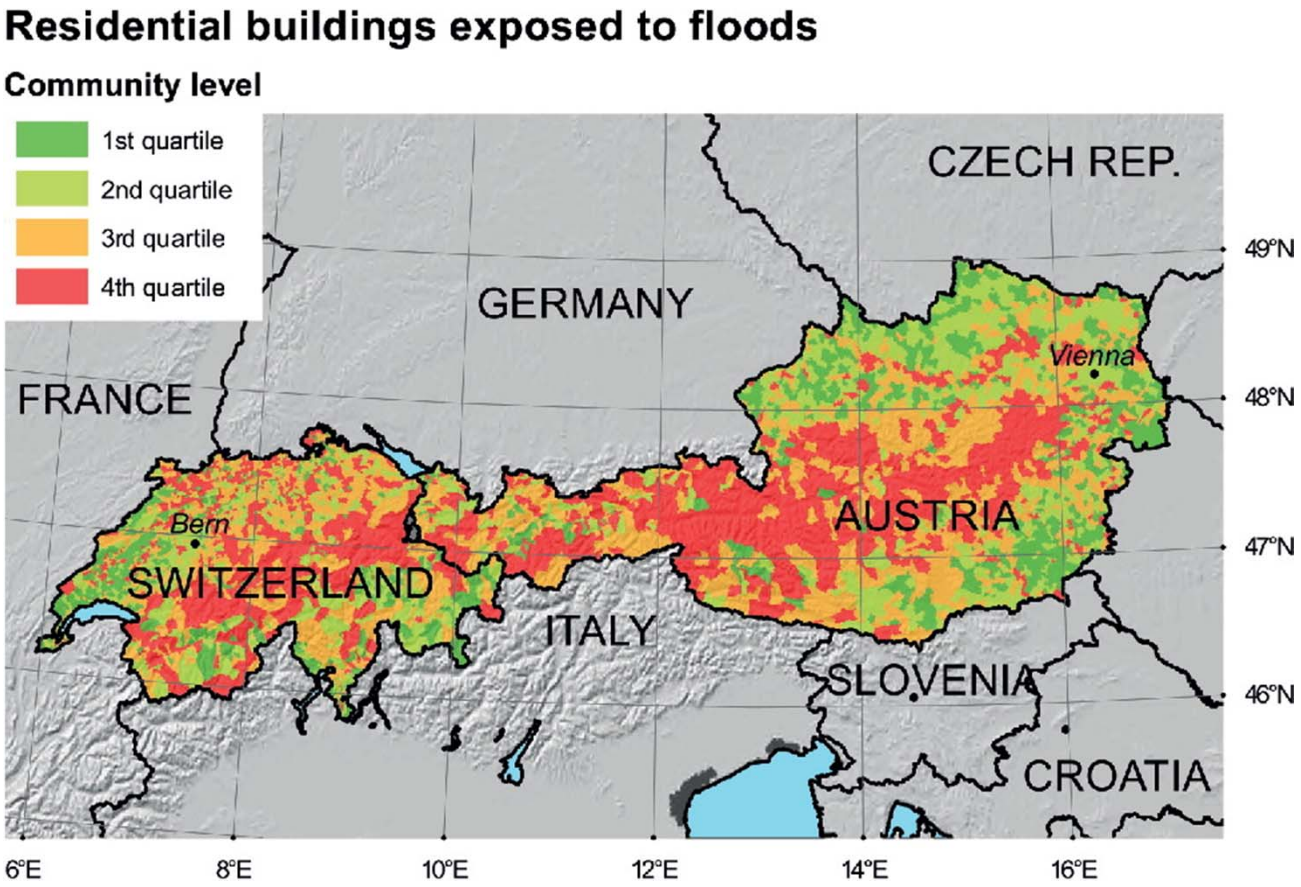
Static inundation

Debris flows

Heat wave

Snow avalanches

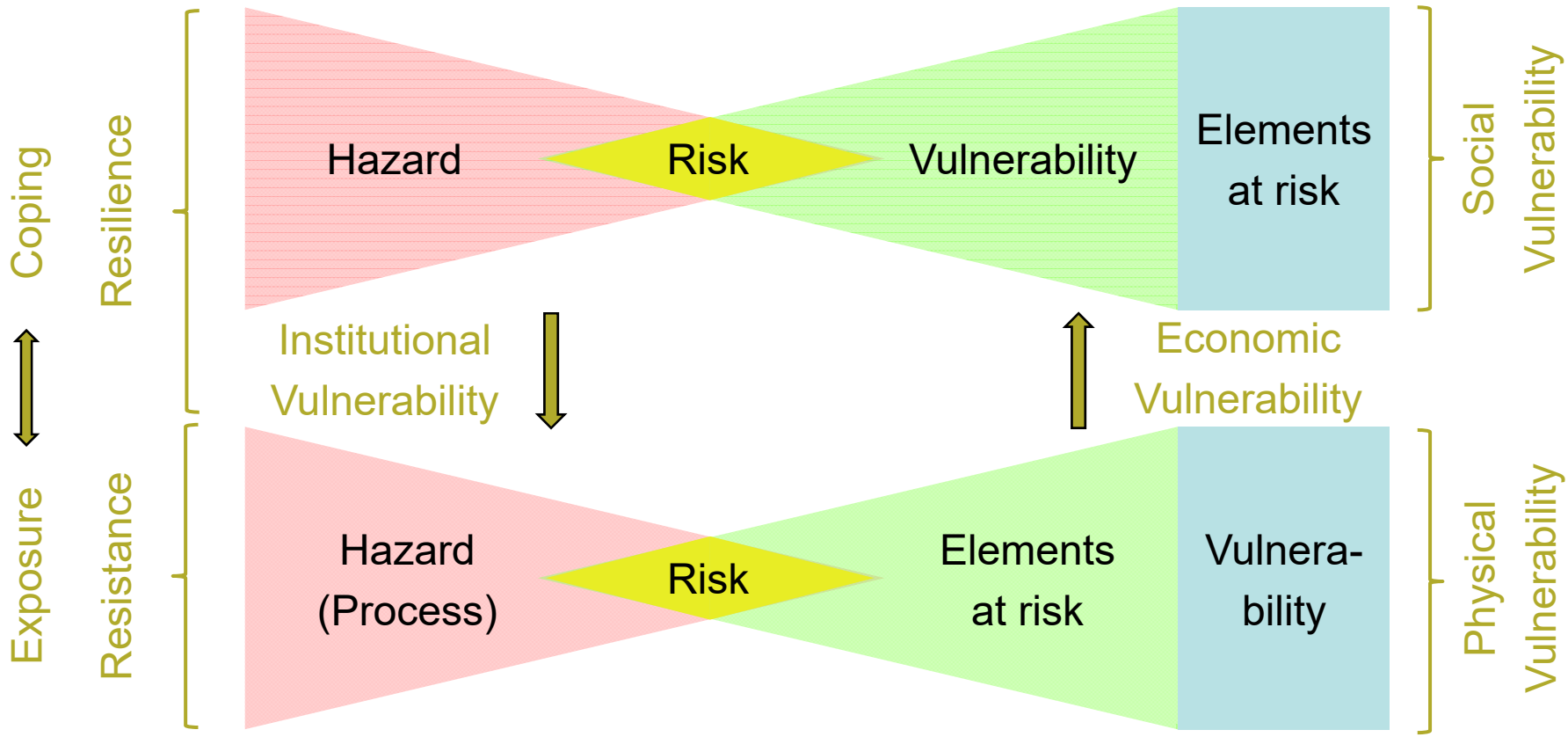
Exposure in Austria and Switzerland – the built environment



Exposure rate of residential buildings to hydrological hazards in Austria and Switzerland (exposed buildings to all buildings within a local authority, shown in terms of quartiles).

Fuchs, Röthlisberger, Thaler, Zischg, Keiler (2017): Natural hazard management from a co-evolutionary perspective: exposure and policy response in the European Alps. *Annals of the American Association of Geographers* 107 (2): 382-392

Exposure → Vulnerability



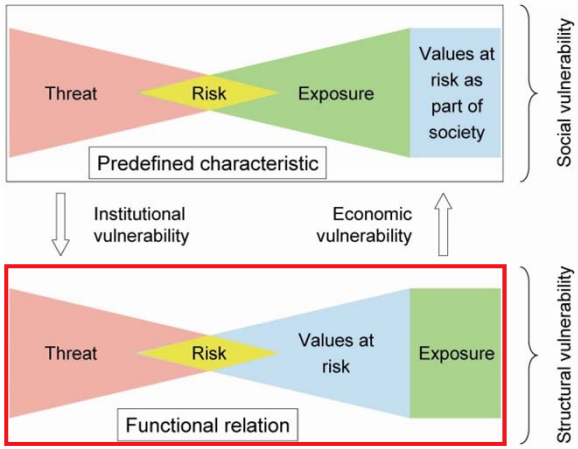
Fuchs (2009): Susceptibility versus resilience to mountain hazards in Austria – Paradigms of vulnerability revisited. *Natural Hazards and Earth System Sciences* 9 (2): 337-352

Assessing vulnerability: Existing methods for dynamic flooding

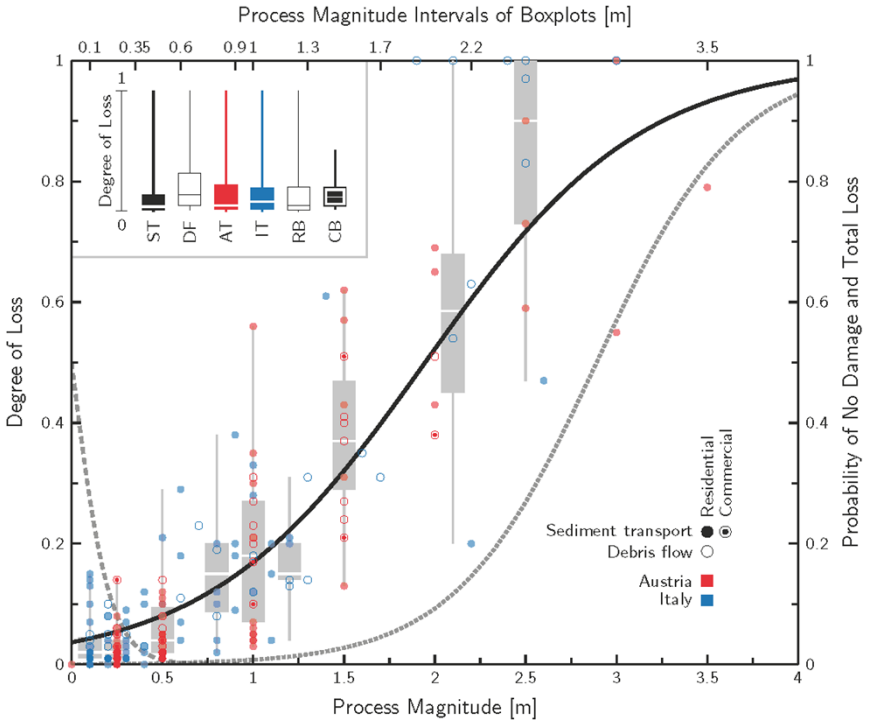
Method	Advantages	Shortcomings
Vulnerability matrices	Qualitative method, no need for ex-ante data or detailed information	Results may not be translated into monetary loss. Assessment of damage under specific intensities or process characteristics is objective
Vulnerability curves	The method is quantitative and may "translate" an event into monetary cost	Important characteristics of the natural process (e.g. velocity, duration, direction etc.) as well as the element at risk (number of floors, construction material) are ignored. Highly-demanding in ex-post information
Vulnerability indicators	Characteristics of the element at risk are taken into consideration	The intensity of the process is not considered, demanding in data (detail, amount quality)

Fuchs, Keiler, Ortlepp, Schinke, Papathoma-Köhle (2019): Recent advances in vulnerability assessment for the built environment exposed to torrential hazards: challenges and the way forward. *Journal of Hydrology* 575: 587-595

Physical vulnerability



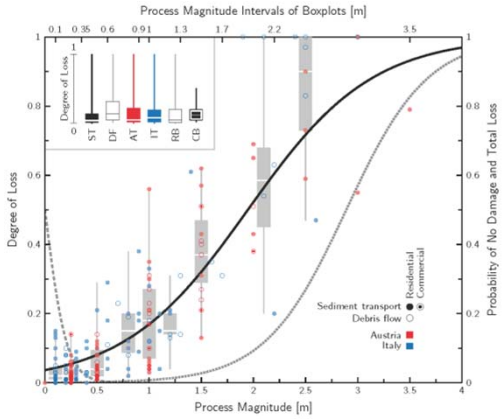
Exposition of values against process impact, **relation between degree of loss** and **process intensity**



Fuchs, Heiser, Schlögl, Zischg, Papathoma-Köhle,, Keiler (2019): Short communication: A model to predict flood loss in mountain areas. *Environmental Modelling and Software* 117: 176-180

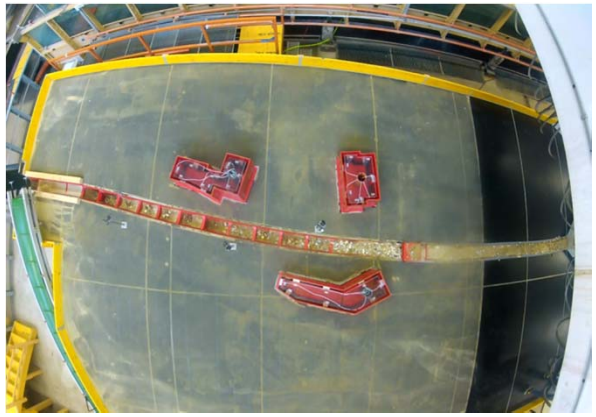
Focus: vulnerability curves

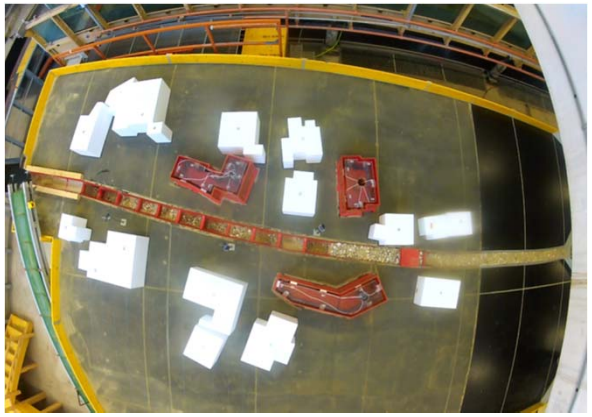
- Vulnerability functions are continuous curves that relate the intensity of a hazardous process (X-axis) to the damage state of a building (Y-axis).
- Depend on data availability and data quality.
- Detailed event documentation is required.
- However, interaction between exposed buildings and the process is challenging to record and to investigate closely.
- Uncertainties, high range in data:
  - Hazard intensity
  - Monetary damage, degree of loss
  - Building design, building materials
  - Damage-generating factors

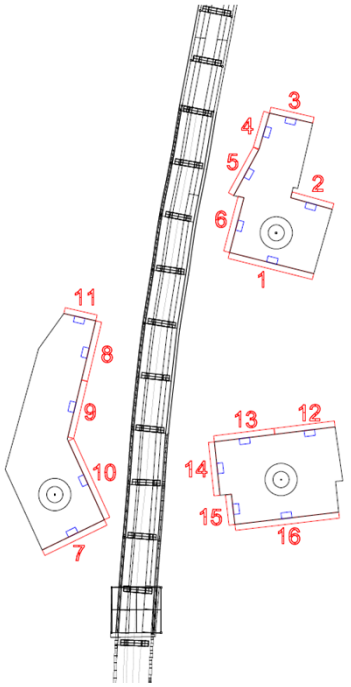


Alternative methods: Laboratory experiments

- To capture impact pressure and flow velocities.





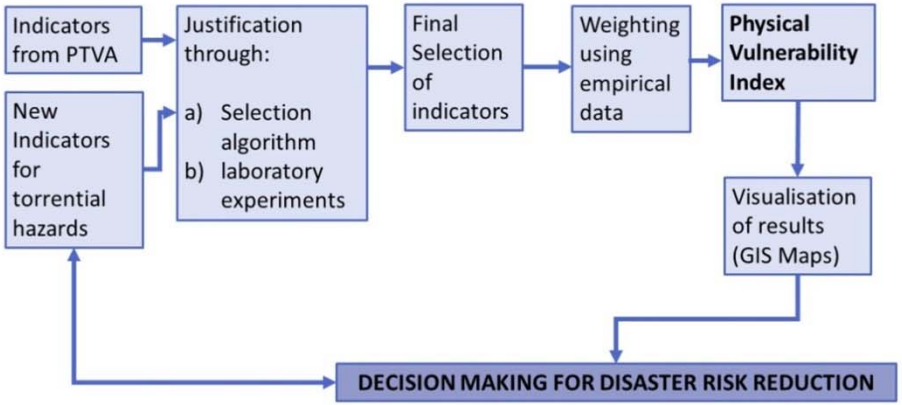


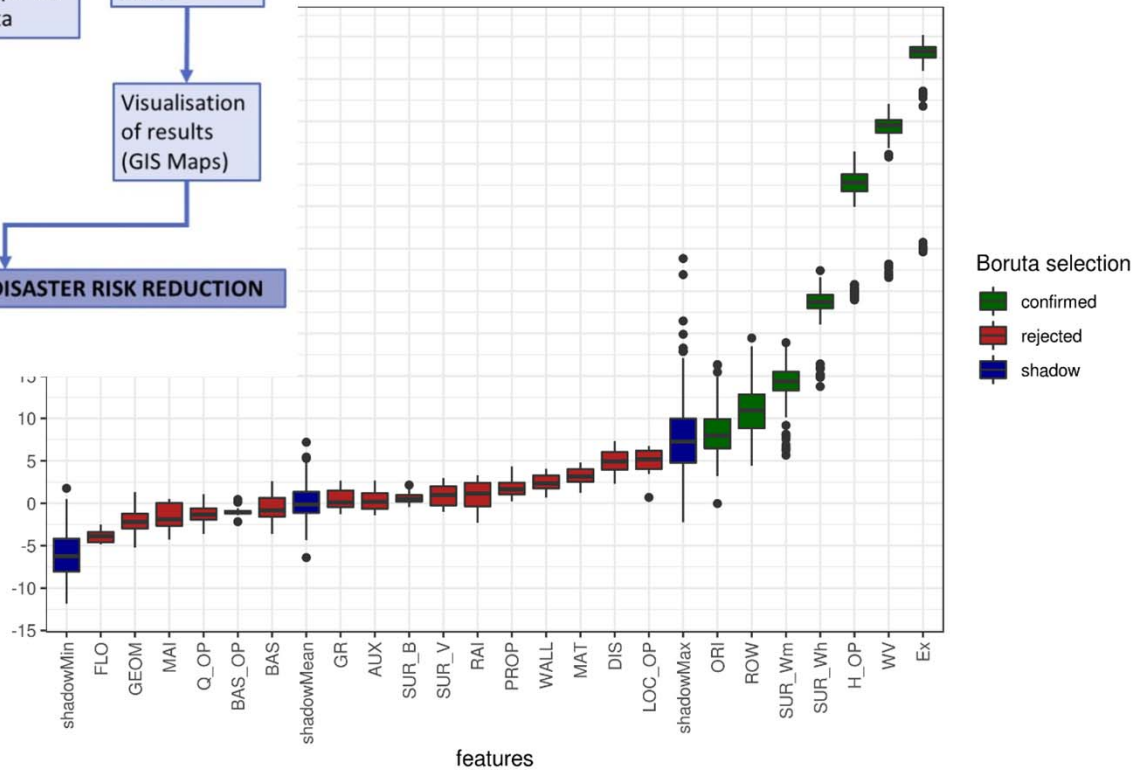
Schnannerbach 2005 event

Sturm, Gems, Keller, Mazzorana, Fuchs, Papathoma-Köhle, Aufleger (2018): Understanding impact dynamics on buildings caused by fluviatile sediment transport. *Geomorphology* 321: 45-59

Alternative methods: Vulnerability indicators

- Indicators responsible for damage generation and extent.





Papathoma-Köhle, Schlögl, Fuchs (2019): Vulnerability indicators for natural hazards: an innovative selection and weighting approach. *Scientific Reports* 9: 15026

Conclusion

- Recent advances in vulnerability assessment methods for buildings threatened by dynamic flooding clearly show that there is still a need for further research in this field.
- Existing vulnerability curves may be improved with the availability of additional damage data and alternative methods may be used alone or in combination to shed light on the interaction between natural processes and elements at risk.
- All this knowledge will contribute to the enhanced assessment of risk and to the design of adequate risk reduction strategies.

Additional references (others are given on respective slides)

- Papathoma-Köhle, Cristofari, Wenk, Fuchs (2019): The importance of indicator weights for vulnerability indices and implications for decision making in disaster management. International Journal of Disaster Risk Reduction 36. Article 101103
- Sturm, Gems, Keller, Mazzorana, Fuchs, Papathoma-Köhle, Aufleger (2018): Experimental analyses of impact forces on buildings exposed to fluvial hazards. Journal of Hydrology 565. p. 1-13
- Papathoma-Köhle, Gems, Sturm, Fuchs (2017): Matrices, curves and indicators: a review of approaches to assess physical vulnerability to debris flows. Earth-Science Reviews 171. p. 272-288
- Fuchs, Thaler (2018): Vulnerability and resilience to natural hazards. Cambridge University Press