MATRIX

New Multi-Hazard and Multi-Risk Assessment Methods for Europe

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Problem of > 1 Hazard & associated Risk

Individual hazards and their associated risk are usually treated **separately** by scientists, engineers and civil protection, **ignoring** the frequent **spatial, temporal and causal relationships** between them.

However, these relationships may *amplify the risk to a community*

Rock falls triggered by an earthquake, in turn disrupting a transport lifeline on Guadeloupe, French West Indies.

Single- versus Multi-Risk

Carpignano *et al., Journal of Risk Research,* (2009) comments:

- ***Single-risk*** approaches tend towards a hazard-centred perspective.
  - Significant gap between relatively high hazard assessment methodological development and lower vulnerability analysis, although dependent on scale.
- ***Multi-risk*** perspective is more towards assessing territorial vulnerability against multiple sources of hazard (multi-hazard).
  - State of the art focuses on risk assessment, not risk management.
  - Uncertainties in the estimated risk are ignored in most studies reviewed.

Spatial and temporal interactions (1)

On the hazard level, multi-type interactions include:

- An initial event triggering (cascade, domino) other (possibly worse) events.
  e.g., earthquakes and tsunamis.

2004 Indian Ocean tsunami (Wikipedia)

- Simultaneous or near-simultaneous unrelated events.
  e.g., an earthquake and major storms.

- An event leading to increased likelihood of another.
  e.g., heavy rains and landslides, drought and wildfires.

2009 Victoria bushfire (Wikipedia)

Spatial and temporal interactions (2)

On the vulnerability level, multi-type interactions have an effect on the physical, social and economic levels.

- Variety of exposed elements (e.g., population, buildings etc.). Each target has a different vulnerability to different hazards, requiring different prevention and coping strategies.

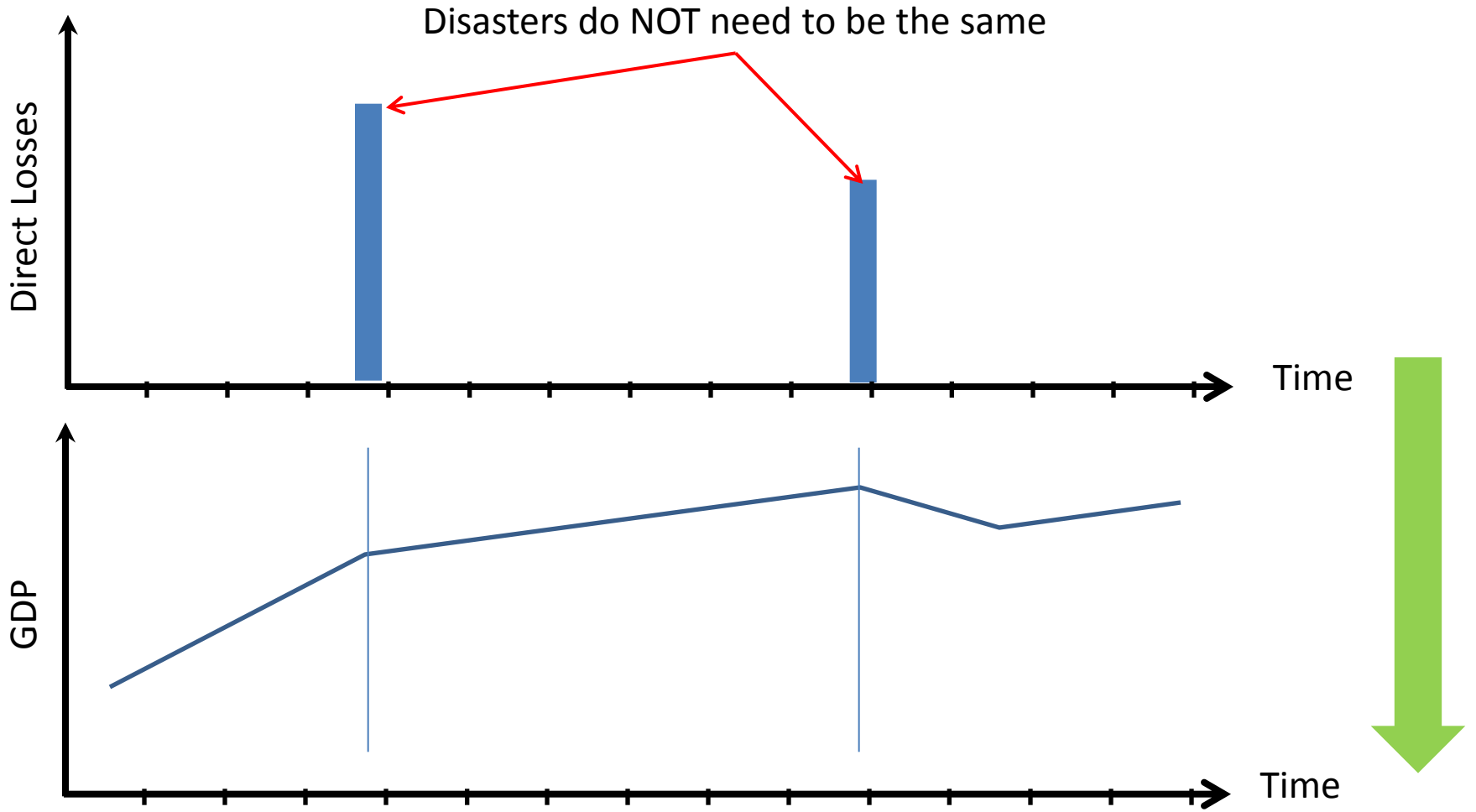
- On the physical, a given event may increase the vulnerability of a system to future events.

  e.g., earthquakes weaken buildings, increasing their vulnerability to future earthquakes or other events.

Baptist Church after the 2010 Canterbury earthquake, later destroyed in an aftershock. (Wikipedia)

Spatial and temporal interactions (3)

- On the social-economic level, a population may have the resources to cope with 1 disaster, but not more.



(Stefan Hochrainer, IIASA)

Spatial and temporal interactions (4)

On the exposure level, changes in the extent and nature of human populations.

e.g., expansion of mega-cities, rural depopulation.

Istanbul (Wikipedia)

Abandoned rural building, Russia (Wikipedia)

May also act back on the hazard and vulnerability levels.

Difficulties in multi-type comparability (1)

- Comparability of hazardous events with each other.
  Different return periods, effects, measures of intensity, probability.

  e.g., high-probability/low-magnitude floods may cause as much loss as a low probability/high magnitude earthquake.

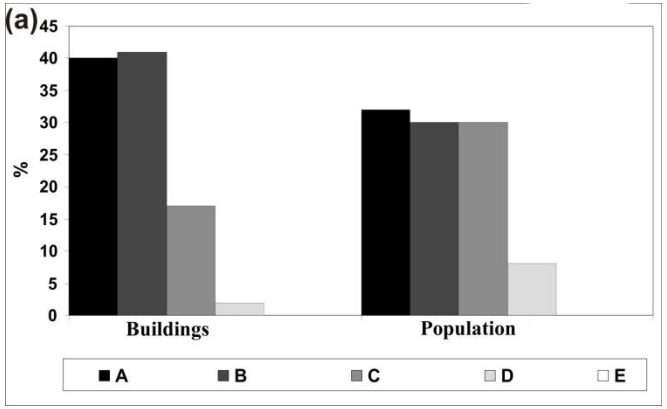
  Carpignano *et al., Journal of Risk Research*, (2009)

- Example, Cairns, Northern Australia.
  - Impact of a cyclone with 150-year return period would be more severe than an earthquake of the same return period.
  - Impact of maximum credible earthquake much greater than maximum credible cyclone.

Granger *Aust. Jour. of Emergency Management*, (1999)

Difficulties in multi-type comparability (2)

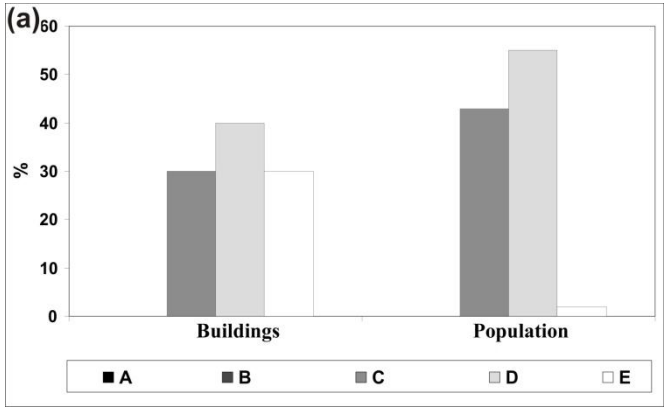
- Comparison of the vulnerability of exposed elements, different measures of vulnerability.
  e.g., potential casualties versus destroyed buildings.
  May not be able to use a single value.



Developing

Industrialised

(A-E, EMS98)



- Weighting the relevance of certain hazards or exposed elements.
  Decision makers/stakeholders may have different/conflicting views on the relative importance.

Difficulties in multi-type comparability (3)

- Need to account for difficulties in collecting data, information, and knowledge in a coherent and easily accessible way.

  e.g., data on past losses may be very sparse.

  Especially relevant for vulnerability.

- Harmonizing spatial and temporal data from single-risk assessments for multiple hazards/comparability.

Difficulties in multi-type comparability (4)

- More complex, hence more difficult decision making.
- This ranges from the individual to institutional levels.

How would this impact upon "community programs"?

- Multi-risk is therefore more than the simple aggregation of single-risks.

Not only does 1 + 1 ≠ 2,
but possibly
1 + 1 >> 2

Benefits of multi-risk assessment

- Quantification of the potential total risk from multiple hazards and/or multi-hazards (i.e., cascade events).

- Comparing risks from different hazards and return periods for a given asset.

  Identify dominant risks over different time scales. Important for long-term planning in the insurance industry, and for regional and local governments.

- Assessment of different spatial patterns of risk from different hazards. Important for emergency planning.

Schmidt *et al., Natural Hazards,* (2011)

The MATRIX Project

The “New Multi-Hazard and Multi-Risk Assessment Methods for Europe”

An FP7 Collaborative project under the Environment theme “New Methodologies for multi-hazard and multi-risk assessment”.

Coordinated by Prof. Dr. Jochen Zschau of GFZ.

- 12 partners
- 10 countries (including Canada)
- 10 research institutions
- 1 end-user
- 1 industry

MATRIX will run from 01.10.2010 to ~~30.09.2013~~

31.12.2013

Aims of MATRIX

Core objective of MATRIX is

"to develop methods and tools to tackle multiple natural hazards in a common framework "

Develop new methodologies for multi-type hazard and risk assessment

Compare new multi-type methods with state-of-the-art probabilistic single-risk analysis.

Establish an IT framework for test case analysis within a multi-risk environment

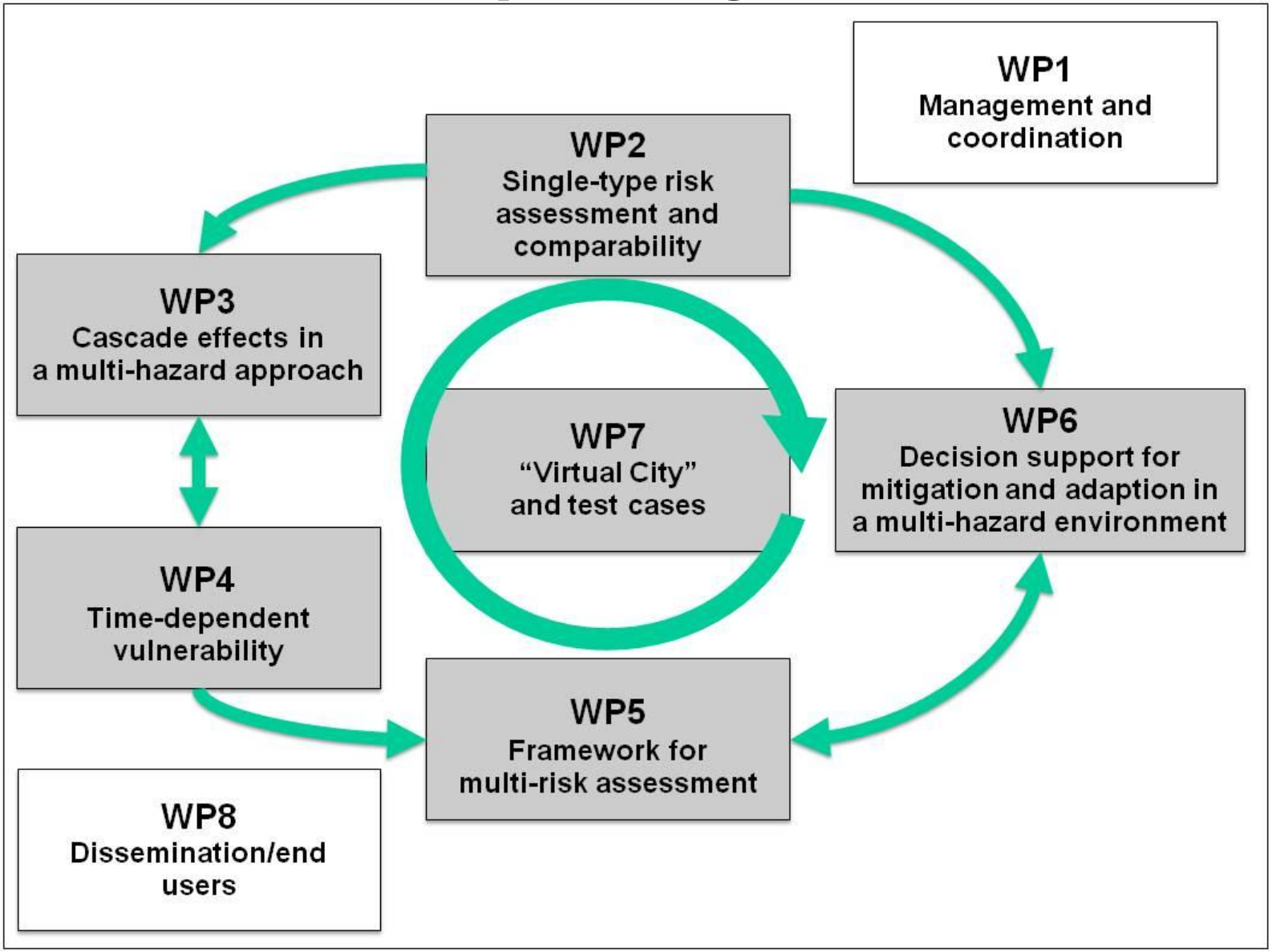
Disseminate the results to the relevant professional communities

Hazards of interest

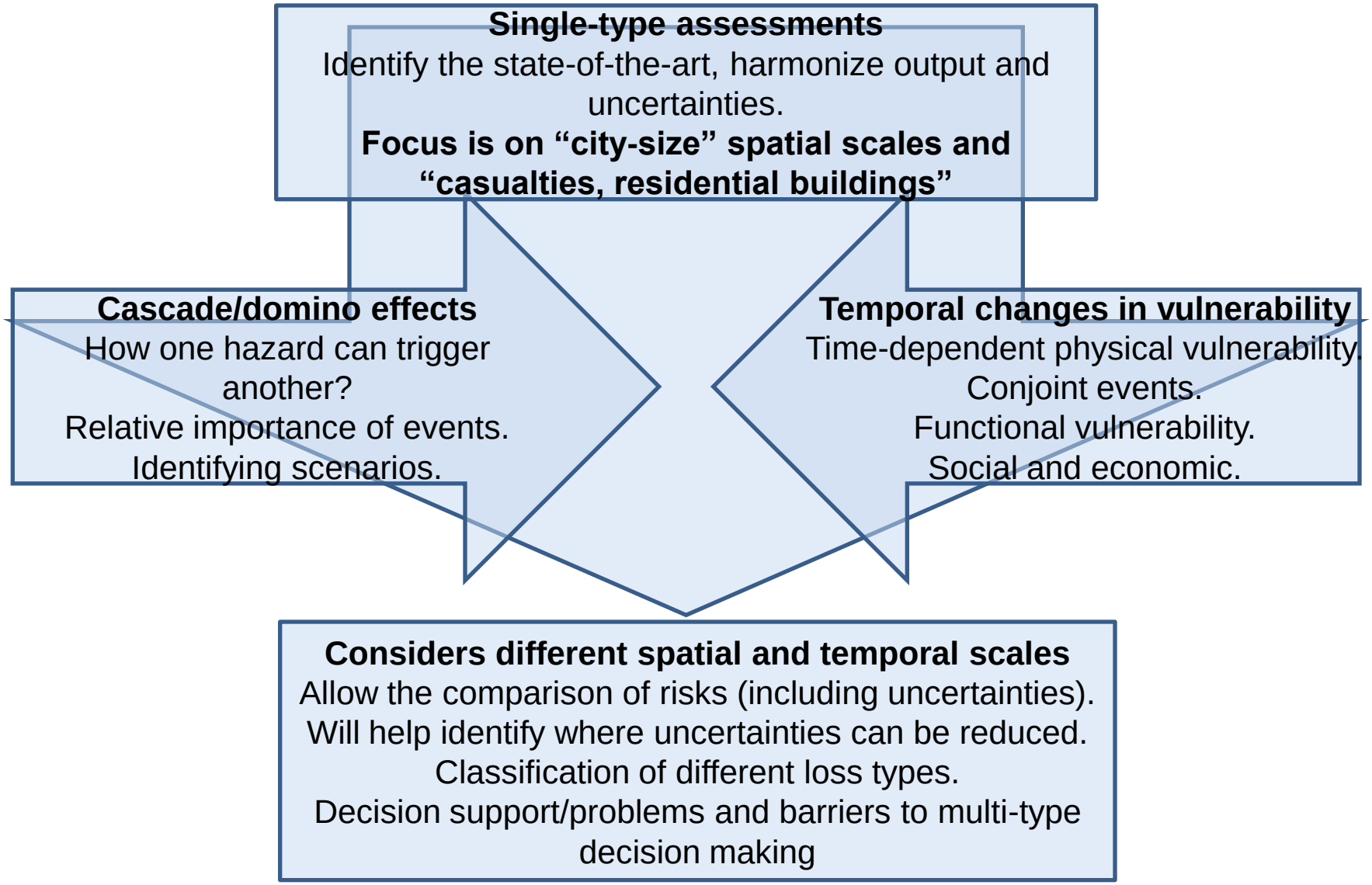
The “usual suspects” for Europe.

- Earthquakes
- Landslides
- Volcanic eruptions
- Tsunamis
- Wildfires
- Winter storms
- Cold and heat waves
- Fluvial and coastal flooding

Work package outline



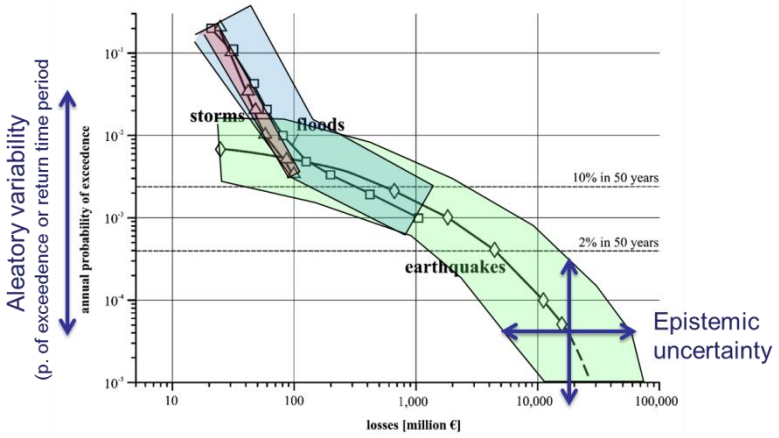
General work scheme



Uncertainties within a multi-type context (1)

- Random (aleatory (dice) uncertainty/variability)
  Represents “real” variability, intrinsic to the physical system.
  Cannot be reduced.
- Knowledge-based (epistemic uncertainty)
  “Artificial” ➔ from our imperfect knowledge, measurement and modelling limitations.
  Can be reduced. With infinite data, it would be zero.
- A point raised during one of the MATRIX meetings was:

“How do we present uncertainties to end-users?



Uncertainties within a multi-type context (2)

- First question to end-users . . .

  "Do you really care?"

  First question back (I imagine) . . .

  "How can this help my decision making?"

- Is a hierarchy of uncertainty required?
  Is there one now?
  How would this influence decision making?

- How willing are you to spend money to reduce uncertainty?
  (cost effectiveness of acquiring additional information)

- **Fundamental question** of how uncertainty can be communicated (not trivial)?

Socio-economic issues and multi-risk

A multi-risk approach/framework considers the temporal and interactive consequences of (even “single) hazards.

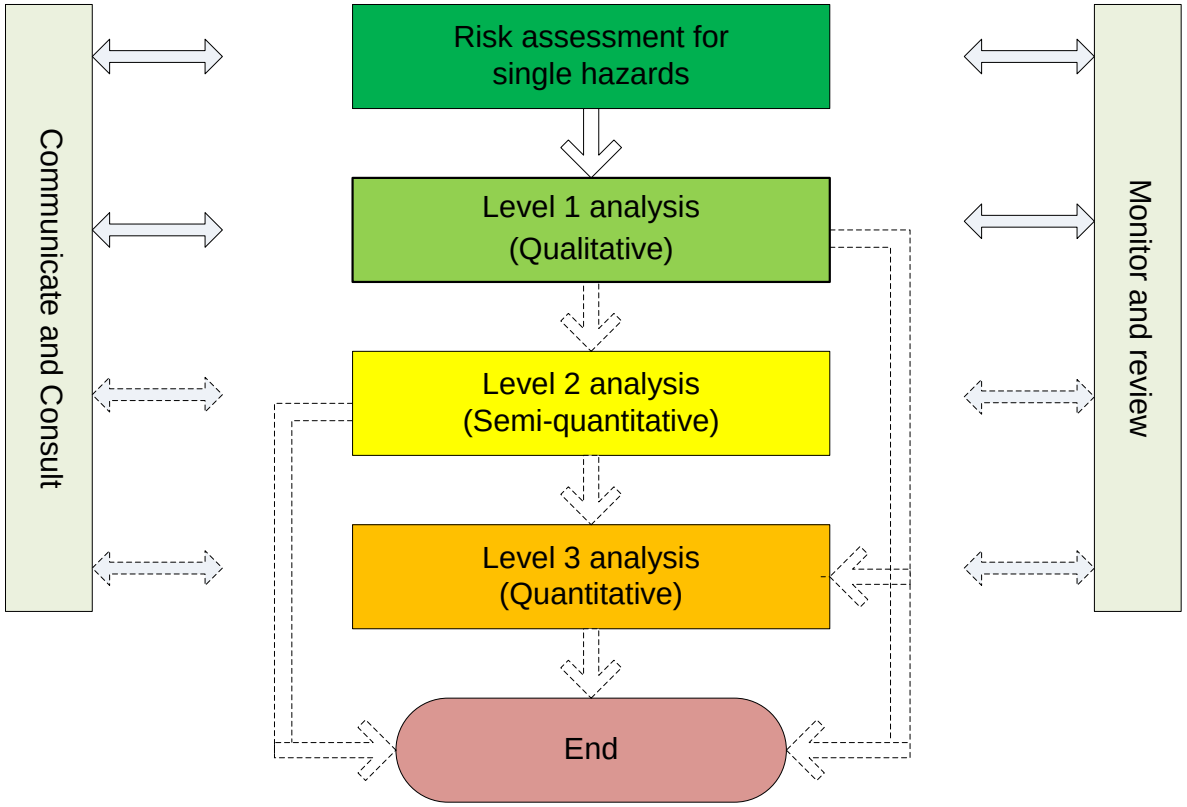
Example: Drought affected Iranian farmers

- Rich and moderate farmers (not surprisingly) cope better than poorer farmers.
- Some rich farmers even benefit (government loans allow improvement of infrastructure, denied to poor farmers).
- Poor farmers suffer income loss from their farms and loss of employment with richer (now better equipped) farmers.
- Effects on health (physical and mental), education, social cohesion. Long-term, “poverty trap”.
- Disproportionate affects on women and girls.

(Stefan Hochrainer, IIASA)

Multi-type risk assessment framework

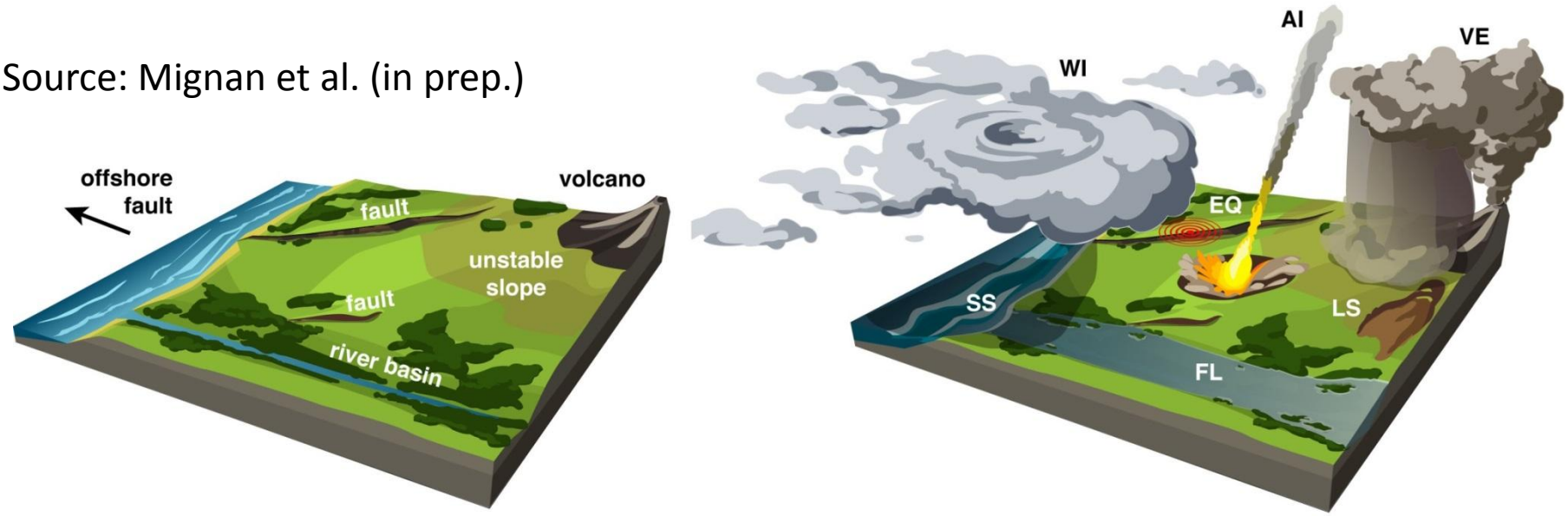
Development of a 3-level framework for multi-risk assessment, that accounts for possible interactions among threats, both qualitatively and quantitatively.



MATRIX-CITY and the Virtual City

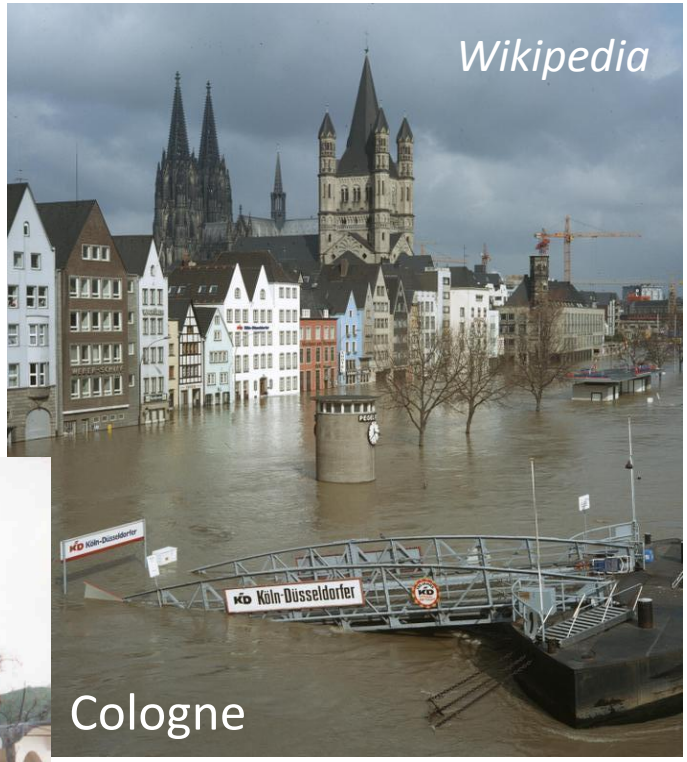
- A prototype multi-risk assessment tool, MATRIX-CITY (MATRIX-Common IT sYstem) and a “Virtual City” have been developed by ETH.
- The Virtual City is a generic tool that allows one to “play” with a range of events and consider their interactions. Includes NaTech (e.g., oil refinery explosion, levee failure).

Source: Mignan et al. (in prep.)



- The methodologies and process behind MATRIX-CITY is proposed to be imported into already existing decision making tools.

MATRIX Test Cases

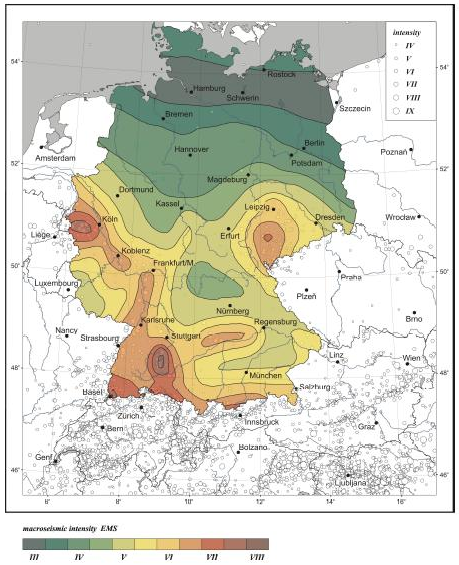


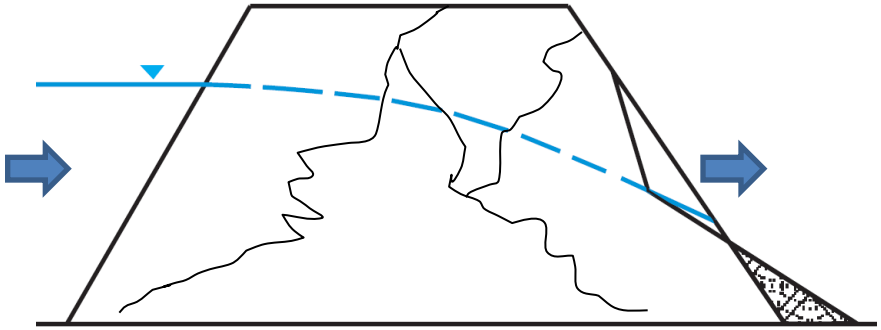
The City of Cologne (Köln)

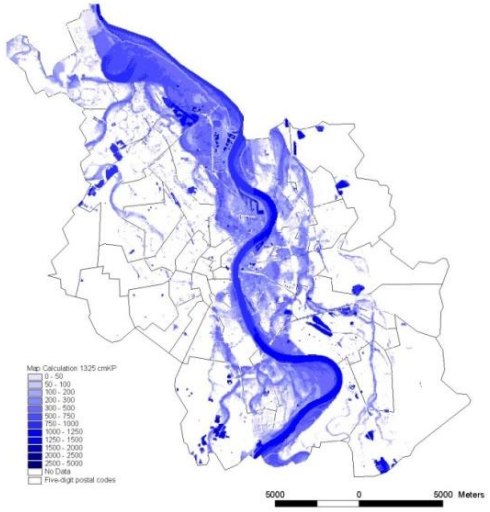
- Population 1,020,303 inhabitants
- Area 405.2 km^2
- Density 2518 inhabitants/km^2
- 4th largest city in Germany
- Largest in Rhine-Ruhr Metropolitan
- Area (ca. 10 million inhabitants).
- Important transport hub (train, river)

- Historically a major trade city.
- Major cultural, educational and media center.
- Corporate headquarters.
- Breweries and several car companies (Ford, Toyota).

Main interaction of concern in this study







Grünthal et al., (1998)

Research question:

How does flood risk change due to the simultaneous/near-simultaneous occurrence of an earthquake and flood?

Particular focus is on the performance of dikes under earthquake and flood loading.

Practitioners and multi-type assessment

- Practitioners rarely have an opportunity to discuss multi-type hazard and risk.
- Hence, a first step to develop multi-risk governance would be to create an environment where these issues can be discussed at the local level.
- However, still need to recognize the need for both single- and multi-type approaches.
- There is a strong need for territorial platforms for data and knowledge exchange for researchers and practitioners.
- While "technical capacity" may be well developed, main weakness is in institutional capacity (resources, planning integration). Need to improve integrating and using scientific knowledge for policy etc.
- End-users showed a great interest in actually being involved in the proposal creation stage.

(*Komentandova, Scolobig, IIASA*)

Some “long way to go” statements

- Terminology is still something of an issue.
  e.g., do all experts use the “same language”.

- Question of uncertainties are still unresolved.

  How to deal with them technically/scientifically?
  How to communicate them not only to professionals but to the broader community.
  e.g., the general population “do not really get” probabilities.

- A multi-hazard and risk perspective is very difficult.
  BUT . . I believe we have no choice, but to eventually adopt such a approach to properly deal with the complexities of hazards and risks.

THANK YOU for your attention and for the invitation

MATRIX website
http://matrix.gpi.kit.edu/

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