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Intersectoral vulnerability indices as tools for framing risk mitigation measures and spatial planning

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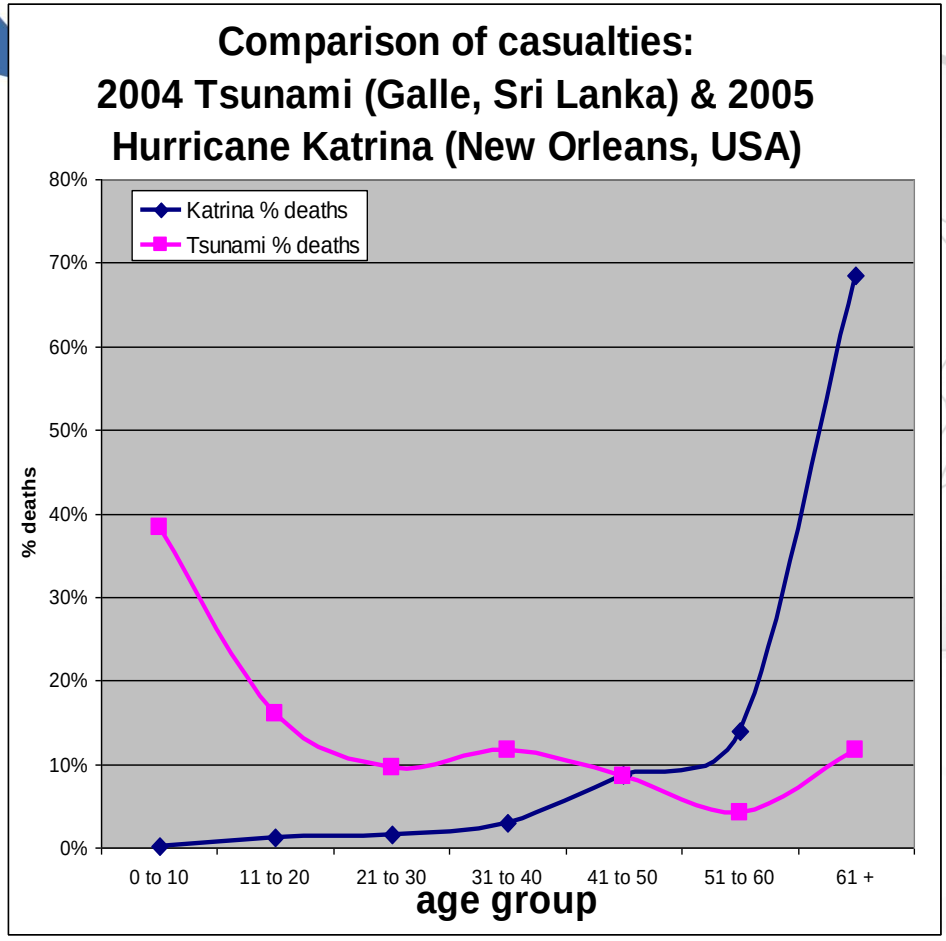
Vulnerability defines the losses



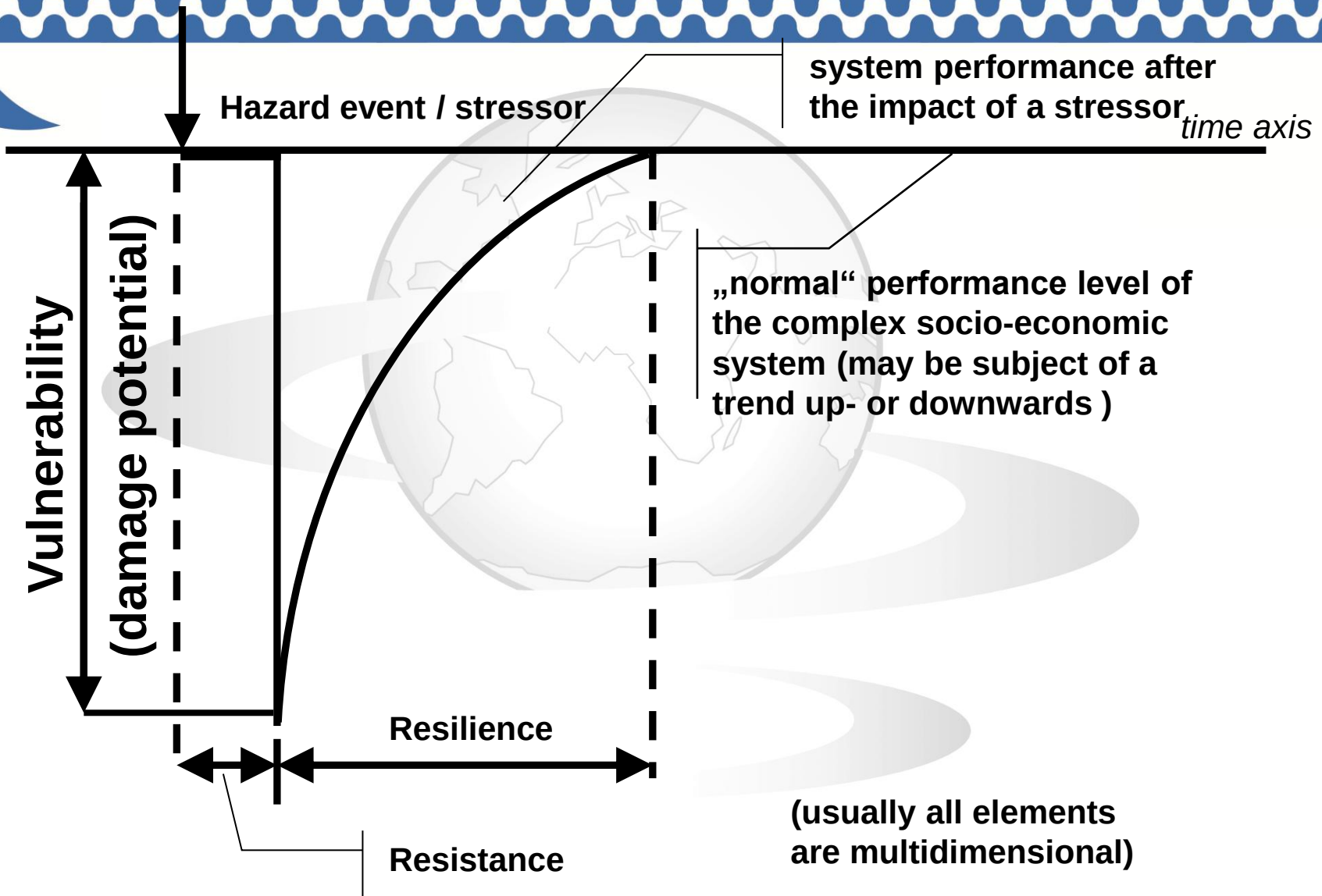
- Are our societies able to adapt to face unfamiliar environmental conditions?
- Do we account for the role of social networks when considering the impacts of disasters—e.g. differences in mortality distribution among age and ethnic groups, gender and class

When Urban Hazards Become Extreme Events

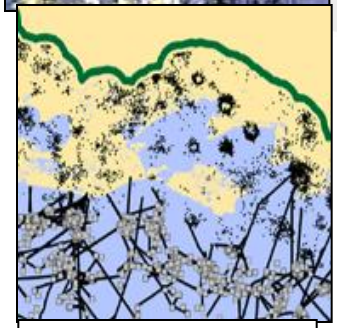
Seine Flood, Paris, January 1910
(the same flood would still affect 600.000 people but cause 6 times more damage)

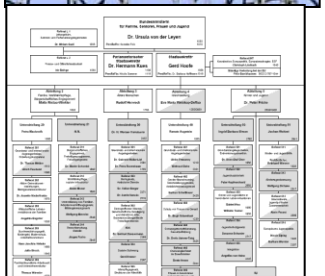
Hazard, Vulnerability and Risk

Visualization of the Concept of Vulnerability



Dimensions of Vulnerability





Social Dimension

Vulnerability of different social groups,

Role of social networks (coping)

Economic Dimension

Vulnerability of different economic sectors and critical infrastructure

Environmental Dimension

Environmental fragility (groundwater, land)

Dependency on environmental services

Institutional Dimension

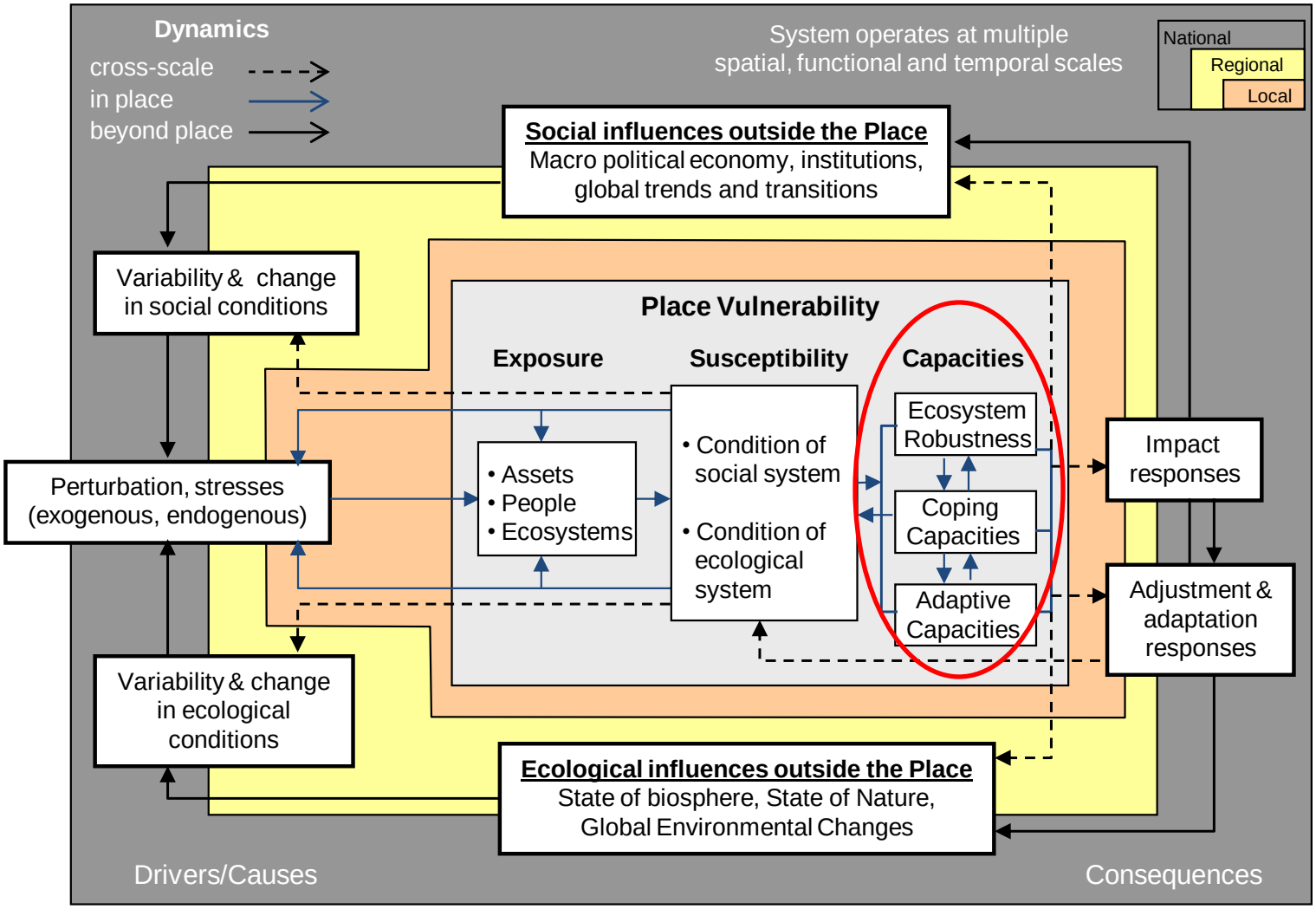
Effectiveness and failure of structures and institutions

Components of Vulnerability

- **Susceptibility (hazard independent)**
- **Exposure (to hazard/*s*/)**
- **Capacities (to mitigate susceptibility, exposure, vulnerability)**

- **Vulnerability(ies) TO HAZARD(S)**

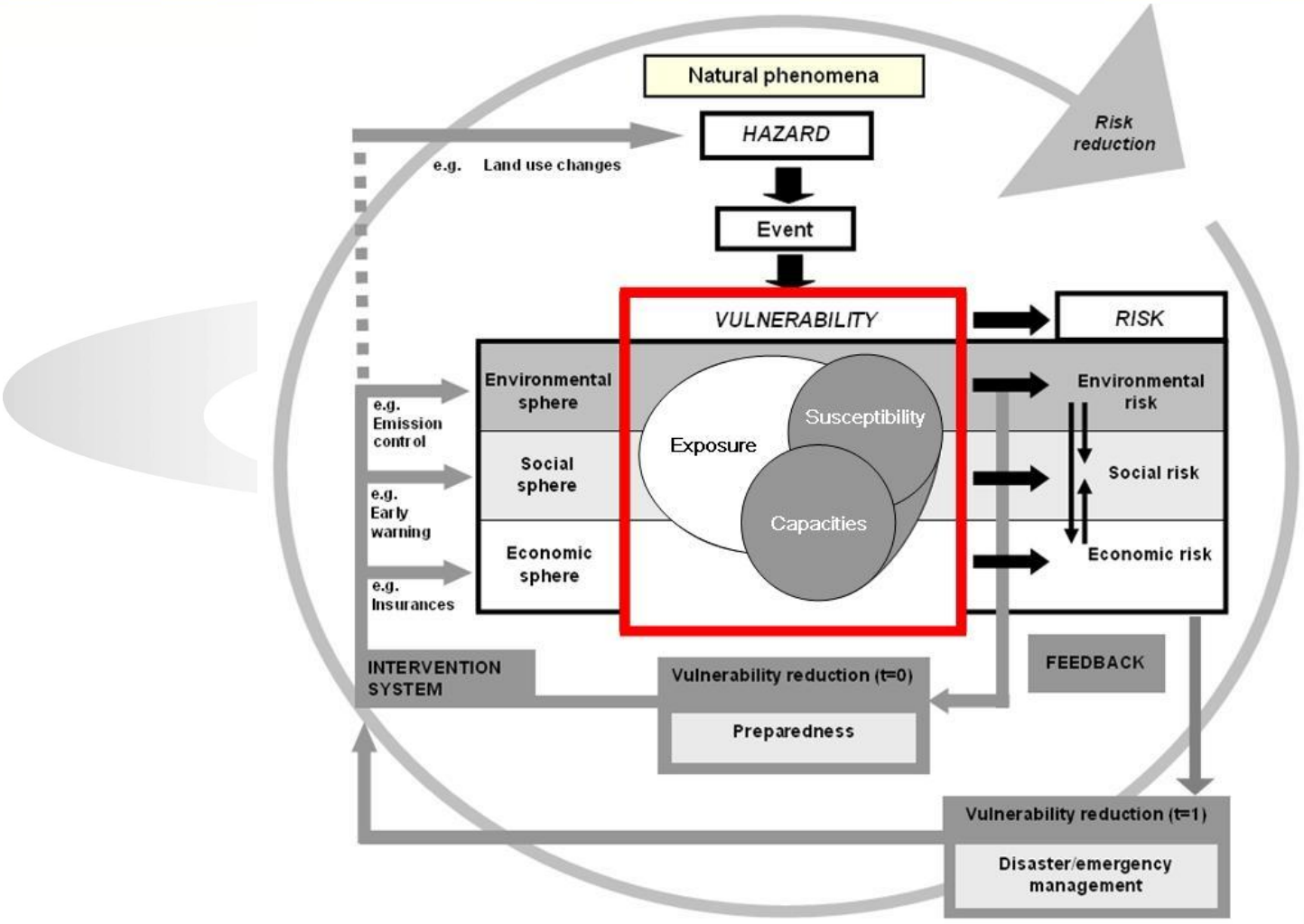
Conceptual Framework of the Modified "Turner Model"



modified from Turner et al. 2003

The BBC Vulnerability Concept

GWSP



Vulnerability Assessment: a Challenge with 3 Problems

Vulnerability assessment should be the basis to justify investments in disaster preparedness and risk reduction.

The dimension problem

- **social, economic, environmental, institutional, physical and critical infrastructure**

The scale problem

- **Household, social, group, community, region, nation, global**

Data non-homogeneity problem

- **Climate change, land use change, change in exposure (dynamic behavior), observation accuracy, method**

Methods of Vulnerability Assessment

- There are no unique prescribed tools yet
- What we currently use:
  - Sustainable livelihood approach:
    - Social, Natural, Human, Physical, Financial Capitals
  - Questionnaires
  - Remote Sensing
  - Survey of critical infrastructures
  - Census data
  - Specific, in-depth surveys
  - Proxies (indicators, indices) /deductive and inductive approaches/

Indicator Set – Forest

Forest Sector		
Component	**Sub-component**	**Indicator**
Exposure	Ecological system	% of forested area
	Social system	% of people employed in forest sector
Susceptibility	Condition of social system	Unemployment rate of district
	Condition of ecological system	% of damaged forest
		Water quality index
Capacities	Ecosystem robustness	Forest size
		Forest fragmentation
		Forest type
	Coping capacities	GDP per capita of Federal State
		GDP per capita of district
		Income of private households
	Adaptive capacities	Reforestation rate
		% of protected areas

- 13 Indicators selected
- Susceptibility is influenced by internal socio-economic and environmental stresses
- trend indicators included/ cross-scale influences
- not all categories could be covered

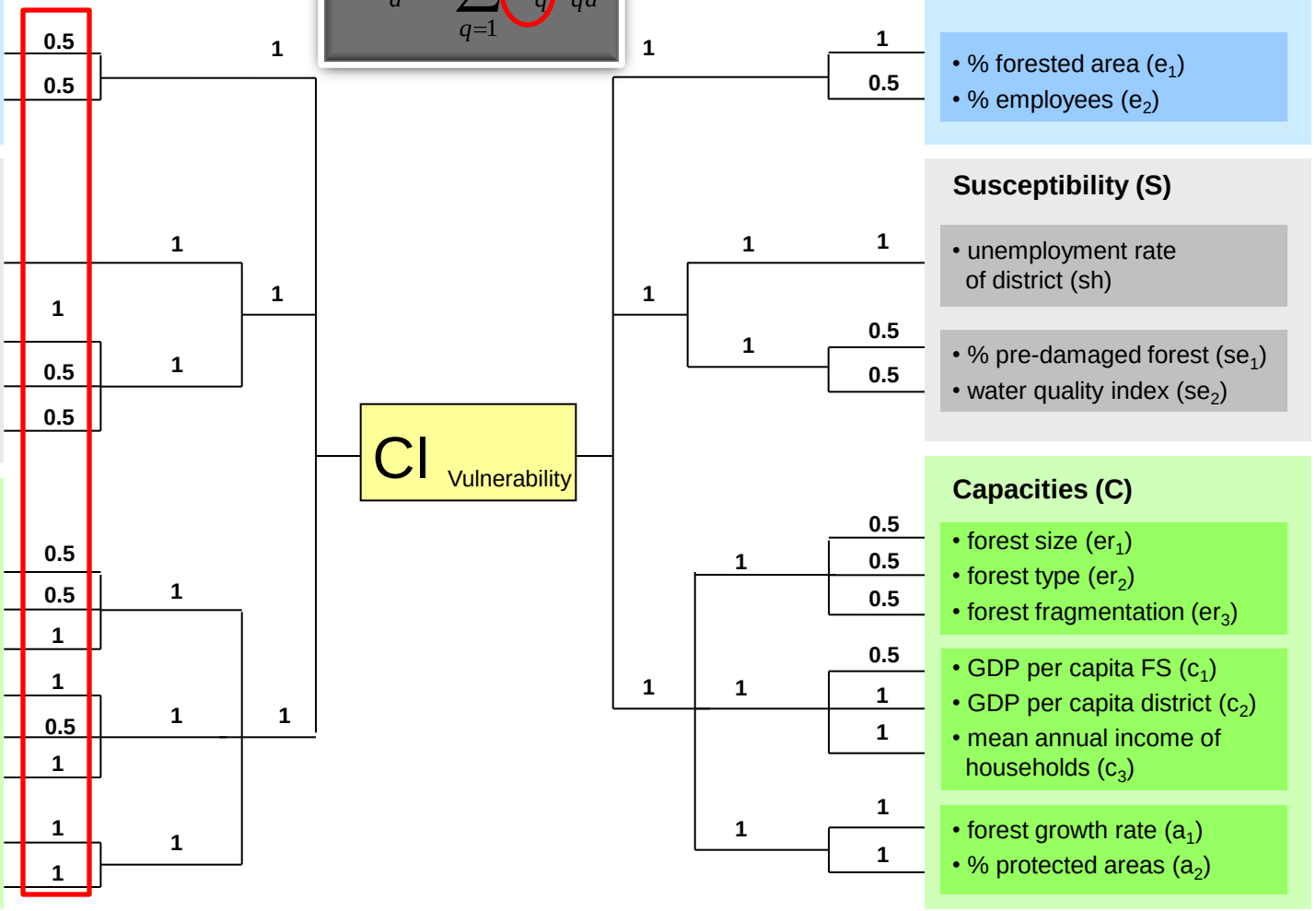
Indicator Set – Agriculture

Agricultural Sector		
Component	**Sub-component**	**Indicator**
Exposure	Ecological system	% of farmland
	Social system	% of people employed in agricultural sector
Susceptibility	Human condition	Unemployment rate district
	Ecological condition	Soil erosion potential
		Water quality index
		Potential contaminating sites
Capacities	Ecosystem robustness	Water retaining capacity
		Filter and buffer capacity
		Dominating land use
	Coping capacities	GDP per capita of Federal State
		GDP per capita of district
		% of farmers with side income
	Adaptive capacities	% of organic farming
		% of protected areas

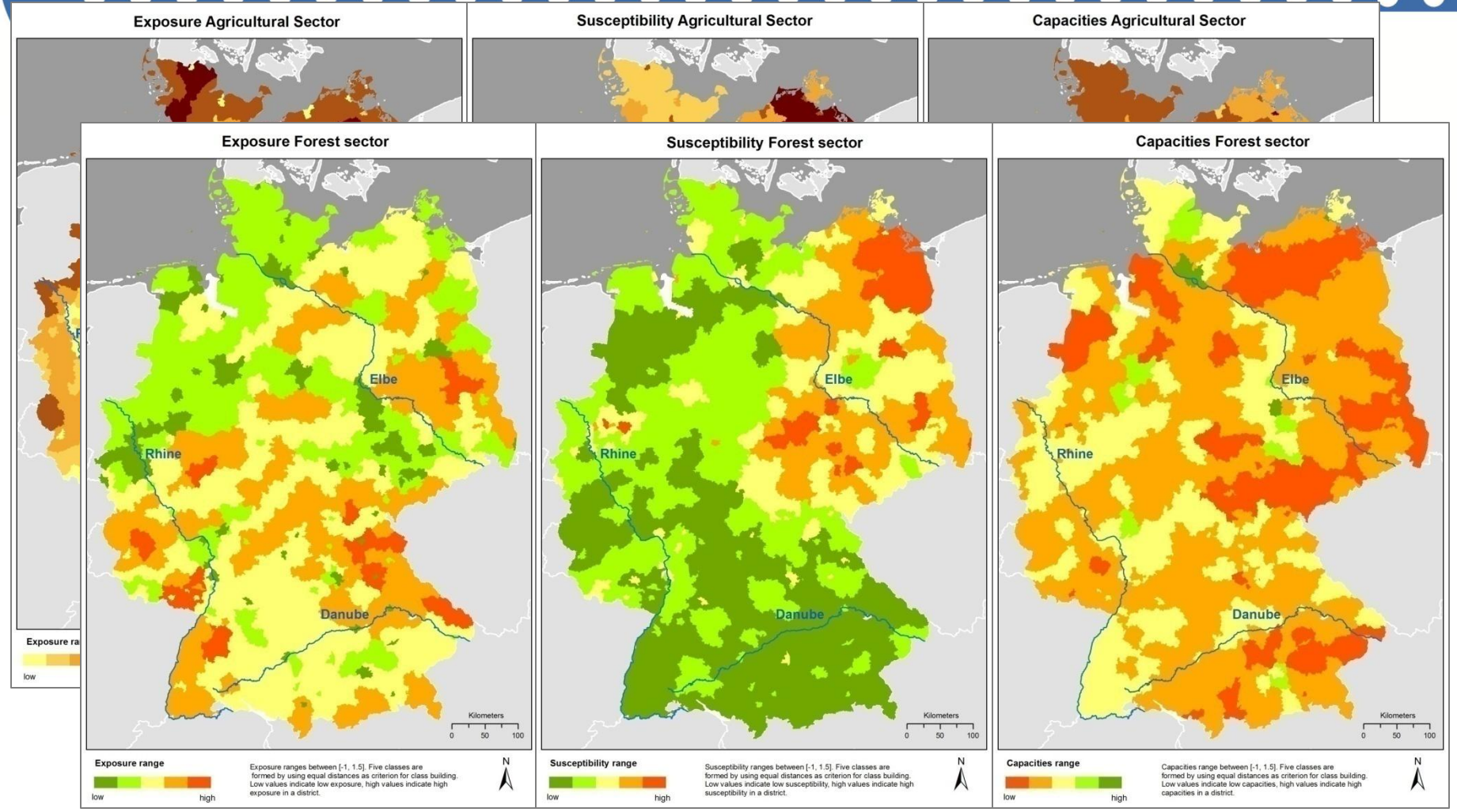
- 14 Indicators selected
- Susceptibility is influenced by internal socio-economic and environmental stresses
- trend indicators included/ cross-scale influences
- not all categories could be covered

Weighting and Aggregation

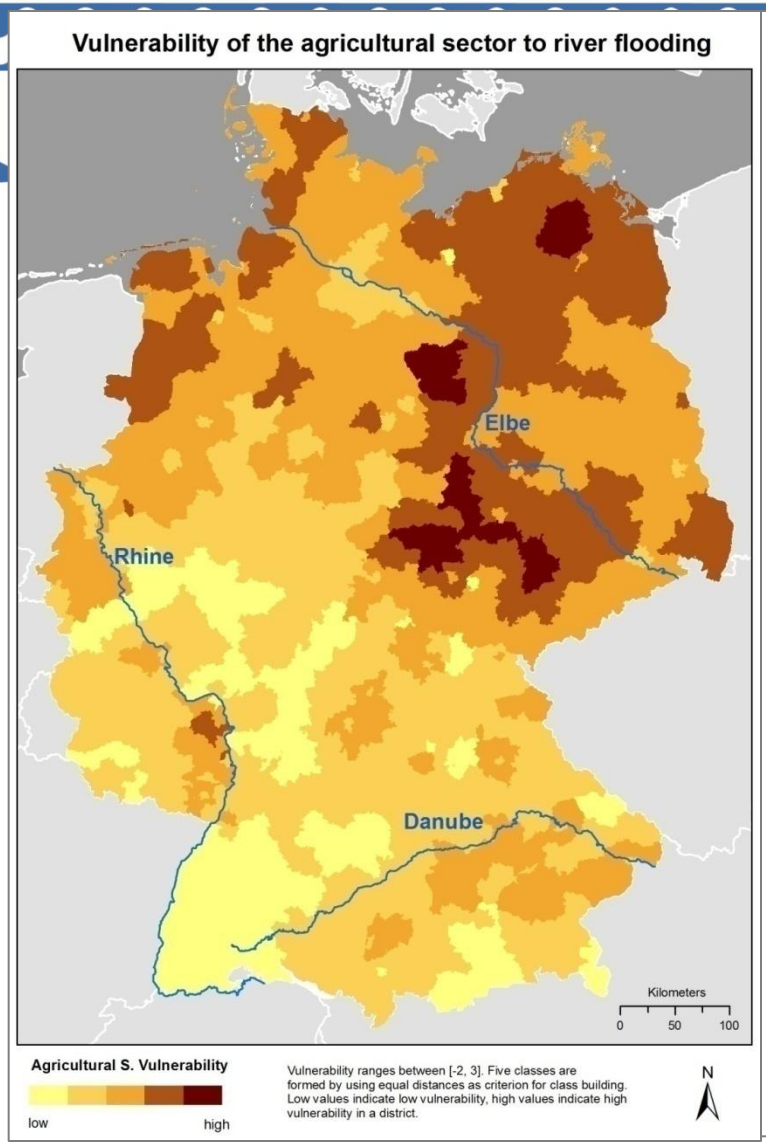
$$CI_d = \sum_{q=1}^{Q} w_q I_{qd}$$

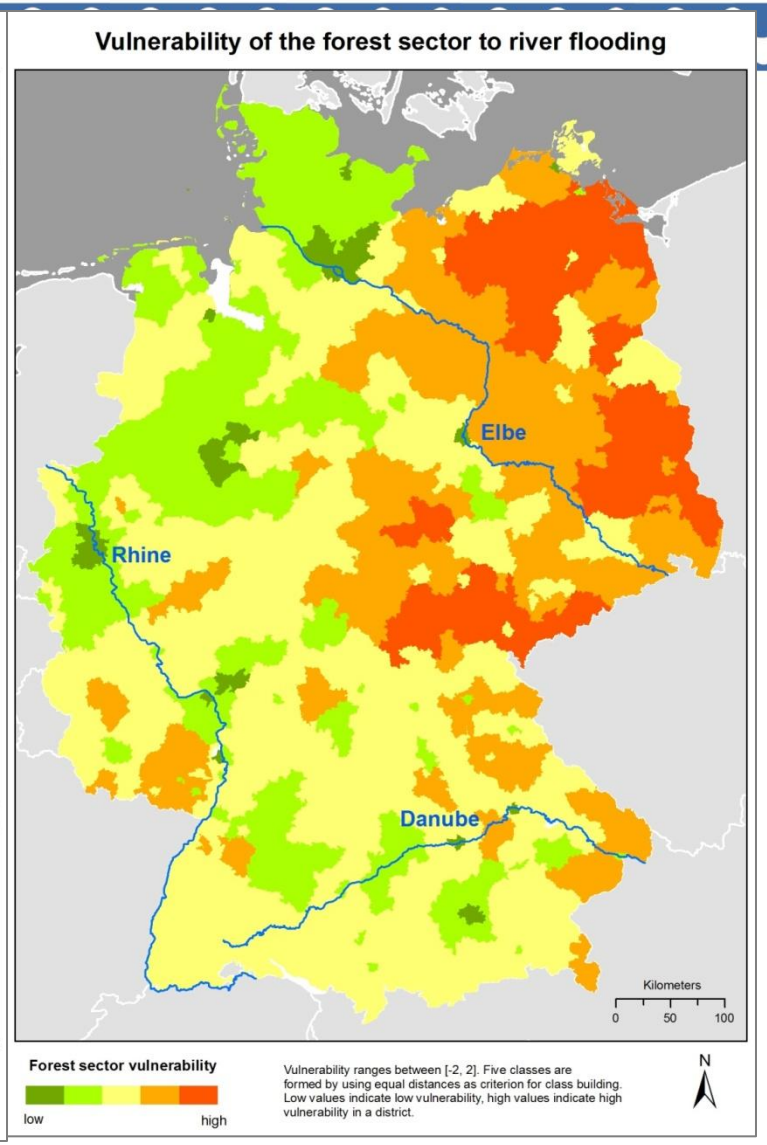


Vulnerability Components

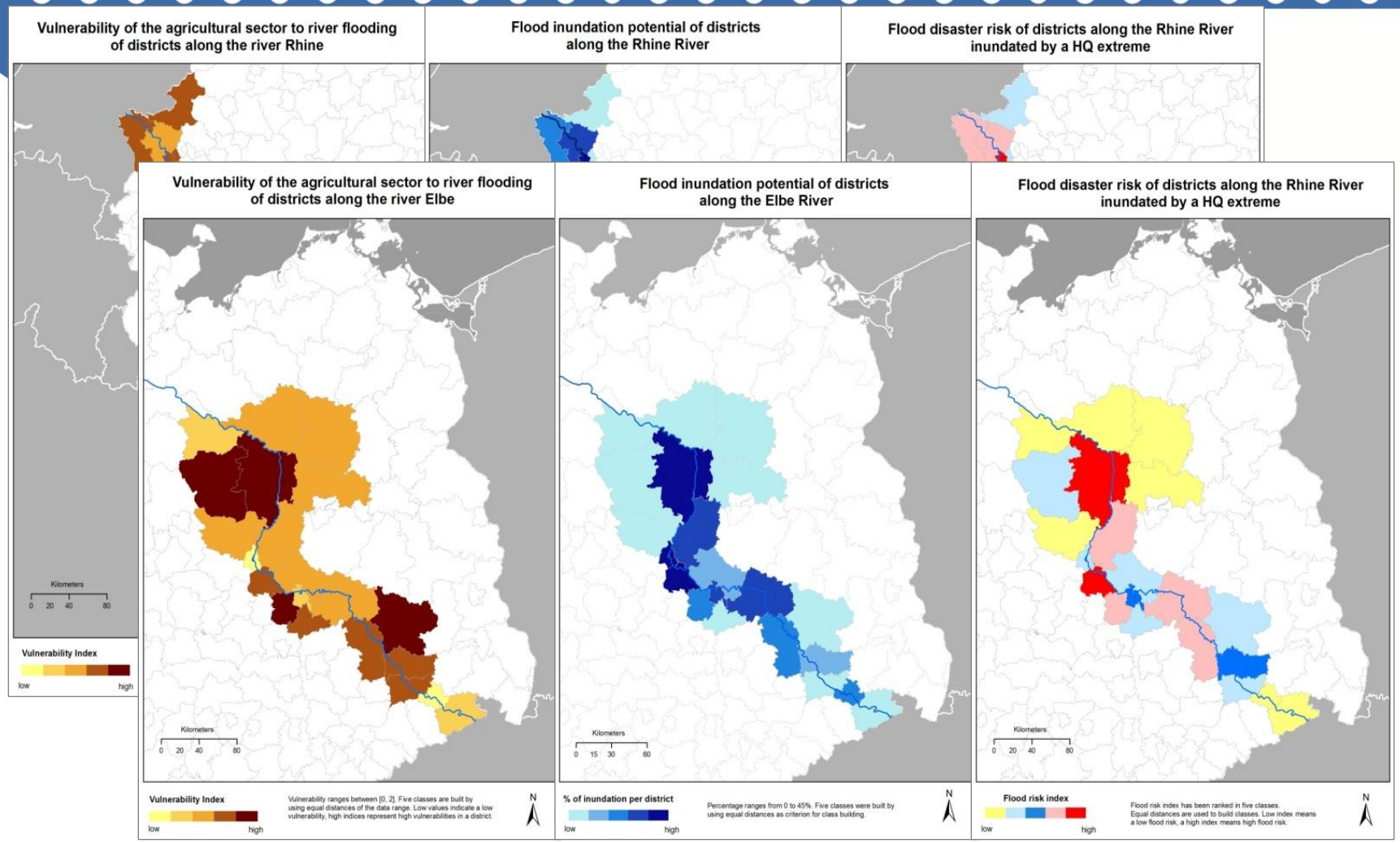


Vulnerability Maps





Risk Assessment and Mapping



Social Susceptibility Index for Germany

Fragility: %of citizens above 64

Socio-economic cond

Living space/person,

Unemployment ratio,

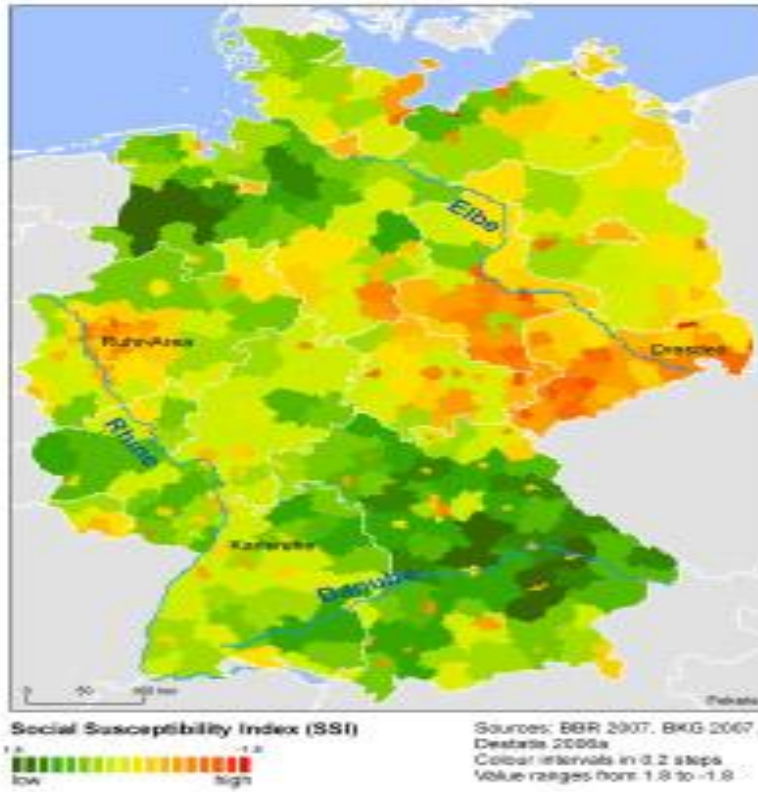
Education background

Regional conditions:

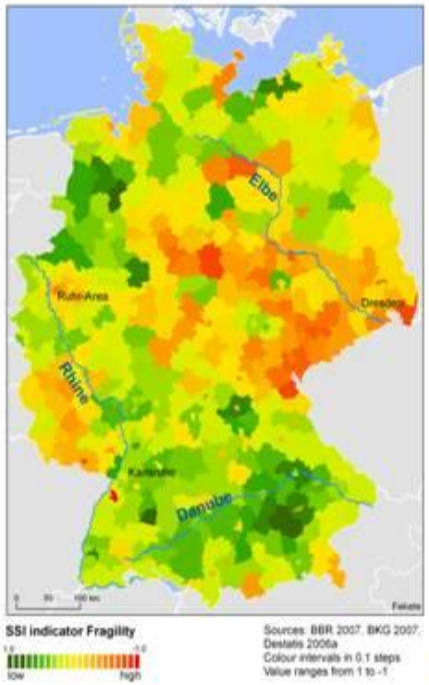
Population density,

Type of housing

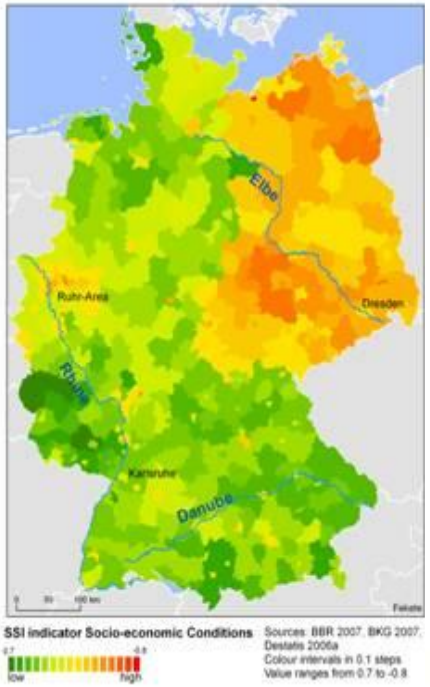
Social Susceptibility Index (SSI) per county in Germany
Objective: identifies demographic patterns of susceptibility and capacities towards stresses like river-floods
Aggregation: the simple sum of three indicators: - Fragility - Socio-economic conditions - Regional conditions
Indicator fragility: ratio of elderly residents (>64 years)
Indicator socio-economic conditions: living space per person; (un)employment ratio; education type
Indicator regional conditions: population density; housing type
Data: census data of the Federal Statistical Office in Germany
Standardisation: ratios per county; equal intervals from 1,8 to -1,8



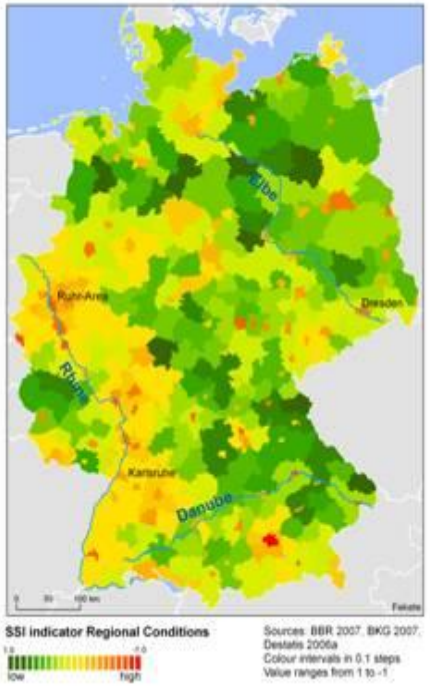
Indicators of Susceptibility / Capacities



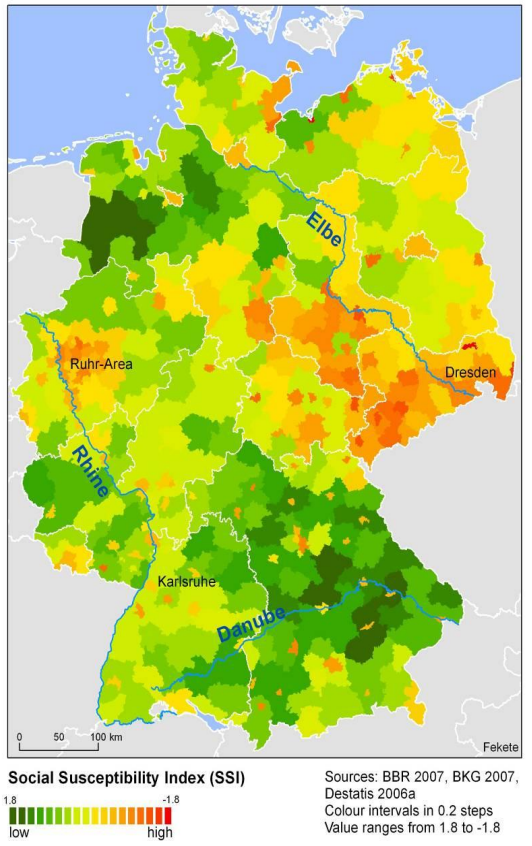
Fragility



Socio-econ. conditions



Regional conditions



Aggregated Index (equal weights)

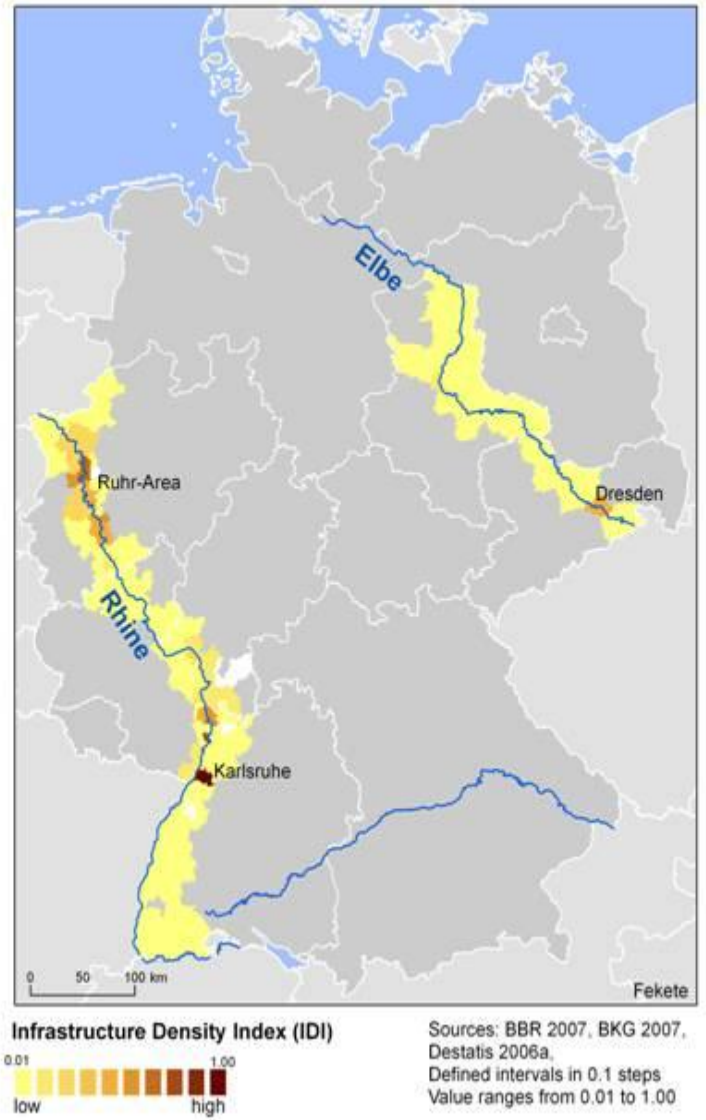
Infrastructure Density Index

Background:
Societal relevance very high Federal Office of Civil Protection and Disaster Assistance (BMI 2009)

Infrastructure:

- Supply infrastructure
- Pontentially contaminating infrastructure

Data: BKG 2007 Basis-DLM



Social and Infrastructure Flood Vulnerability Index

Social and Infrastructure Flood Vulnerability Index (SIFVI) per county in Germany

Objective: identifies the vulnerability towards river-floods by the social and infrastructure vulnerability considering the hazard exposure per county

Aggregation: multiplication of
- SSI
- IDI (Infrastructure)
- Exposure to floods

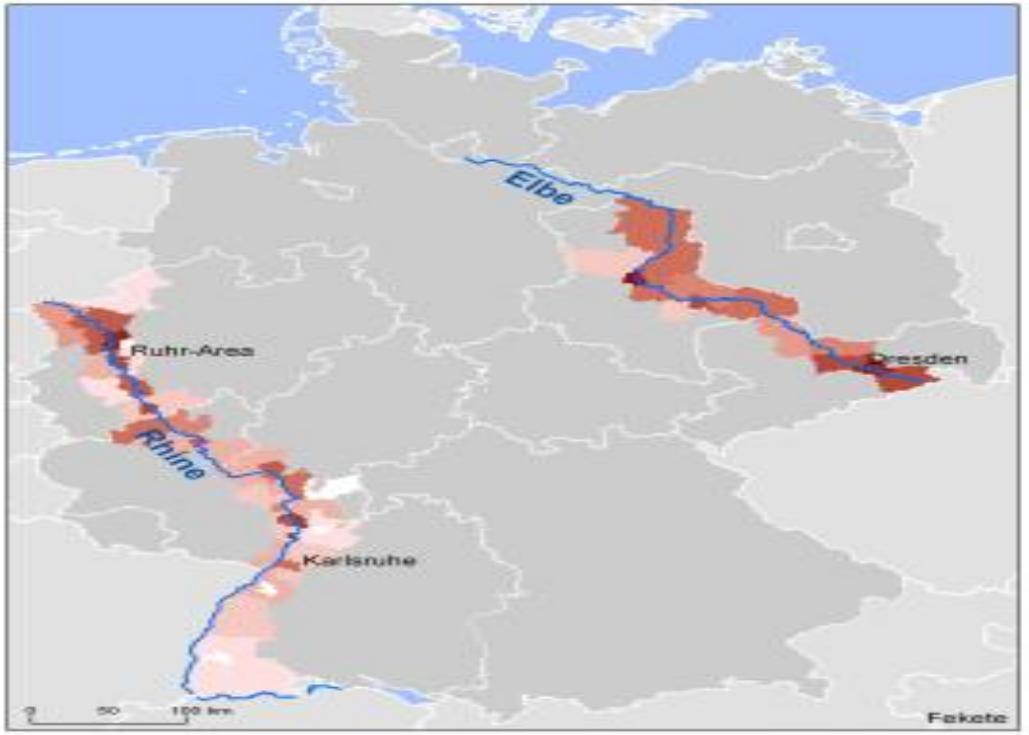
SSI: Social Susceptibility Index, measuring fragility, socio-economic conditions and regional conditions

IDI: Index for supply infrastructure, but also for potentially contaminating infrastructure

Actual exposure: settlement area per county inundated by a statistical extreme event scenario (200-500 years flood)

Data: census data of the Federal Statistical Office in Germany, land cover data, hazard maps

Standardisation: ratios per county; equal intervals from 0 to 1,1

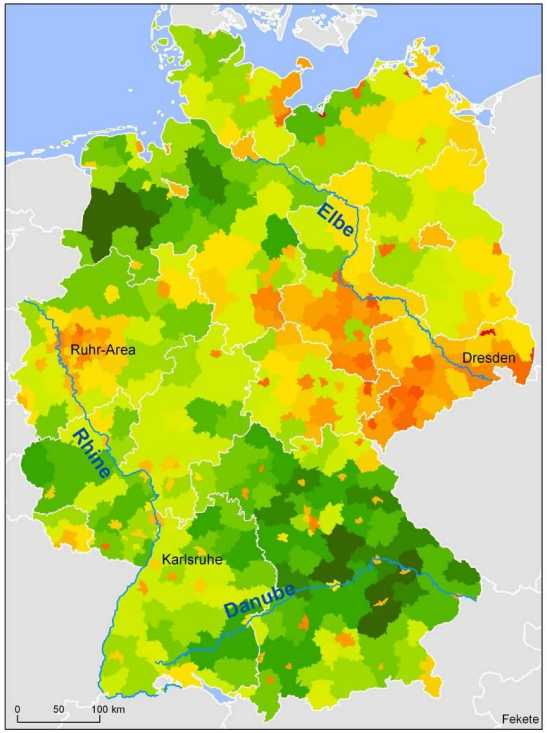


Social and Infrastructure Flood Vulnerability Index (SIFVI)

low — high

Sources: BBR 2007, BKG 2007, Destatis 2006a, DLR-DFD 2007, IKSR 2001, LfUG Saxony 2007, LHW Saxony-Anhalt 2007
Colour intervals in 0.1 steps
Value ranges from 0 to 1.1

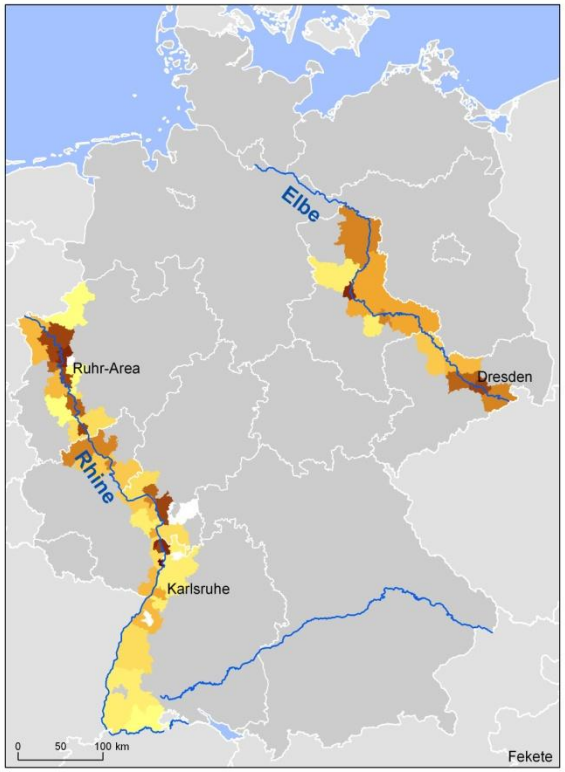
Combination of Vulnerability Components



Social Susceptibility Index (SSI)

1.8 -1.8
low high

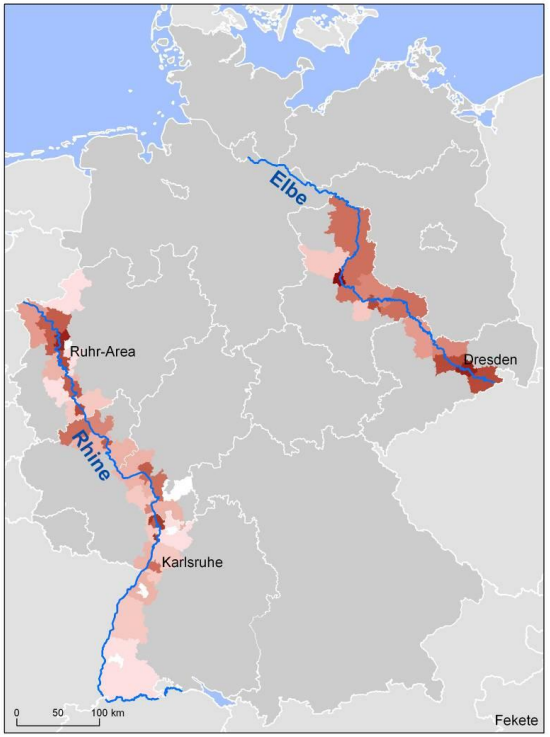
Sources: BBR 2007, BKG 2007, Destatis 2006a
Colour intervals in 0.2 steps
Value ranges from 1.8 to -1.8



Exposure degree to floods

0.01 1.10
low high

Sources: BBR 2007, BKG 2007, Destatis 2006a, DLR-DFD 2007, IKSR 2001, LfUG Saxony 2007, LHW Saxony-Anhalt 2007
Colour intervals in 0.1 steps
Value ranges from 0.01 to 1.1



Social and Infrastructure Flood Vulnerability Index (SIFVI)

0 1.1
low high

Sources: BBR 2007, BKG 2007, Destatis 2006a, DLR-DFD 2007, IKSR 2001, LfUG Saxony 2007, LHW Saxony-Anhalt 2007
Colour intervals in 0.1 steps
Value ranges from 0 to 1.1

Comparative Conclusions

- „Turner Model“ has no risk component
- Different approach to capture „exposure“
- Problems to distinguish between exposure and hazard and between susceptibility and capacity
- Different ways to assess risk
- Only comparative values of vulnerability on a cardinal scale