Climate Change and Floods:

Adaptation and Mitigation Options and Implementation in RBM plans

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EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

EurAqua Conference
How can climate change be incorporated in RBMP under the WFD?
Oslo, 23-24 October 2008

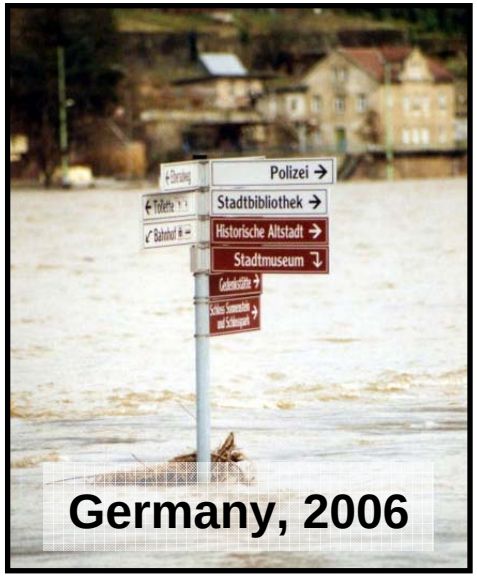
ies
LMNH Unit

Is climate change causing increased flooding?


Germany, 2002


Austria, 2005

Romania, 2005



Germany, 2006

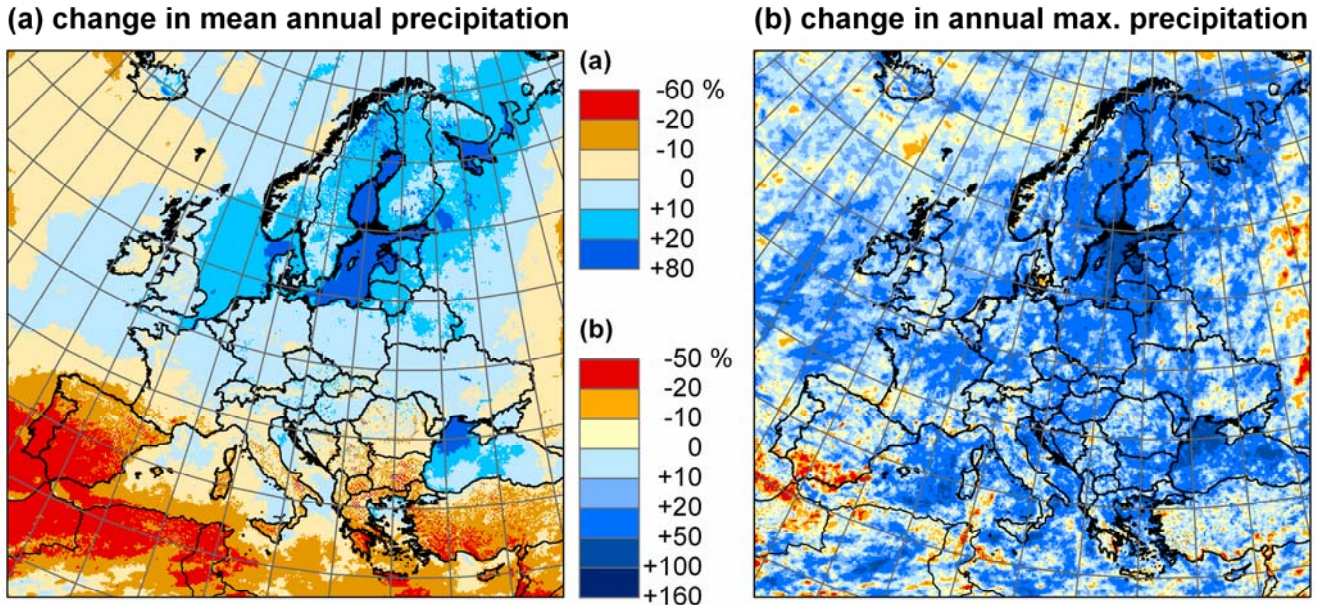

Hungary, 2006


UK, 2007

Will climate change causing increased flooding?

… based on the latest climate change predictions

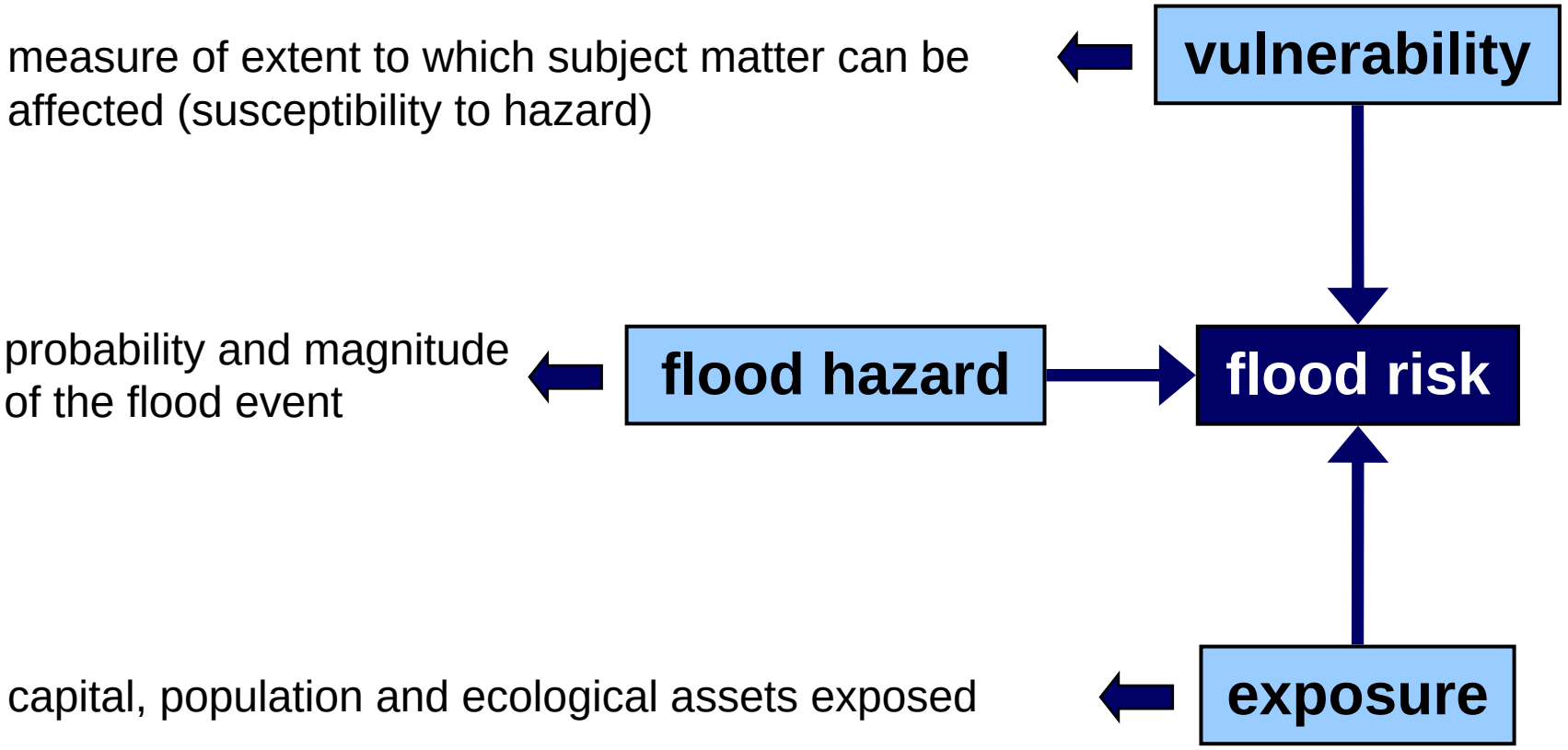
- **increase** in precipitation in N. Europe; **decrease** in the South
- **increase** in magnitude and frequency of **intense P** events in most of Europe (even in regions where mean P decreases)



Changes between control (1961-1990) and scenario (2070-2099) period, SRES A2 scenario. Data from RCM HIRHAM with boundary conditions from HadCM3.

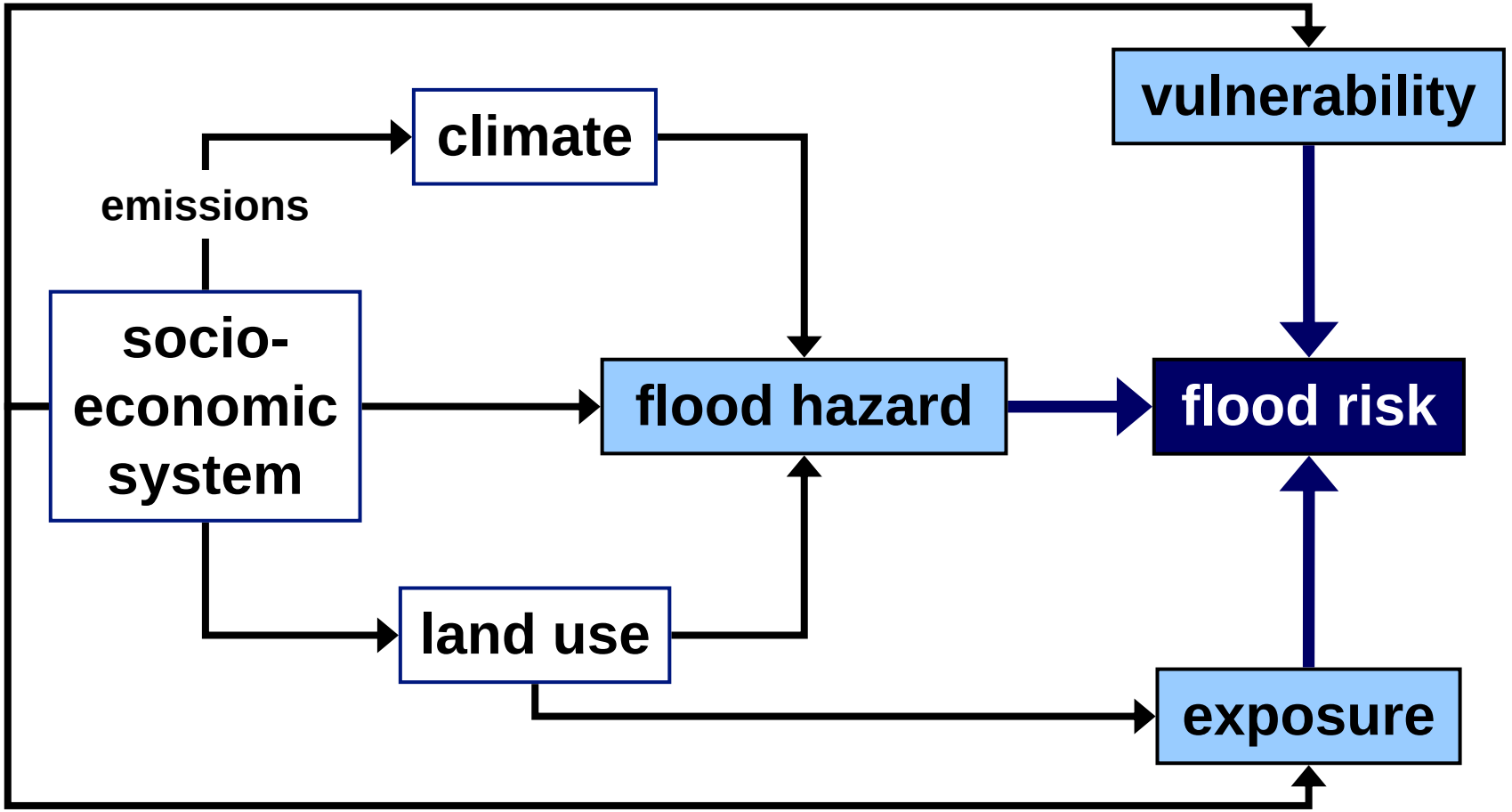
On the definition of flood risk

flood risk = potential loss caused by flooding



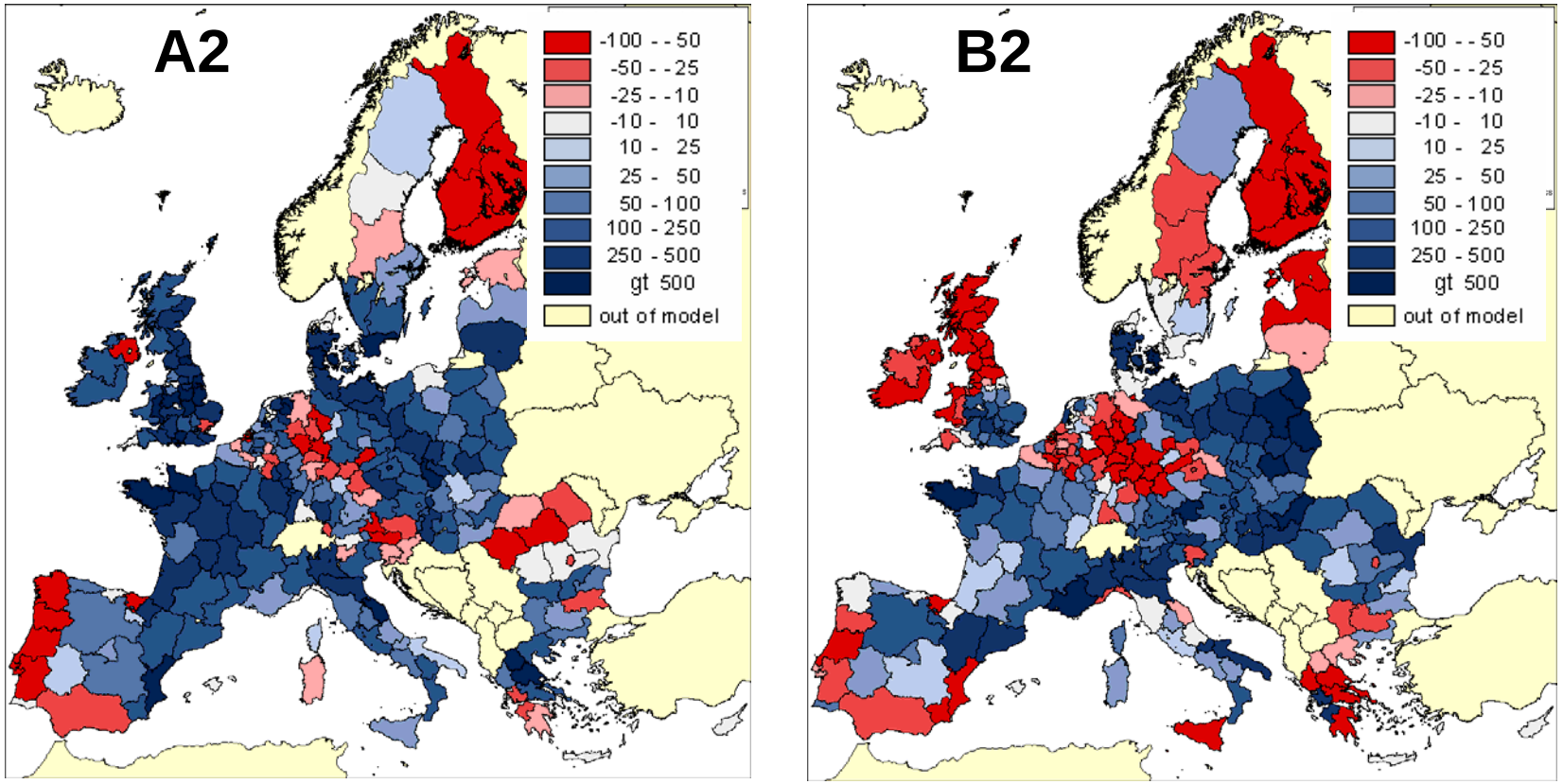
Major drivers of (future) flood risk

flood risk = potential loss caused by flooding



Change in flood risk by 2080s

➢ **change** in **Expected Annual Damage** (averaged over NUTS2)



EAD of EU27, currently €6.5 billion, is projected to rise to €18 billion (A2) and €14 billion (B2)

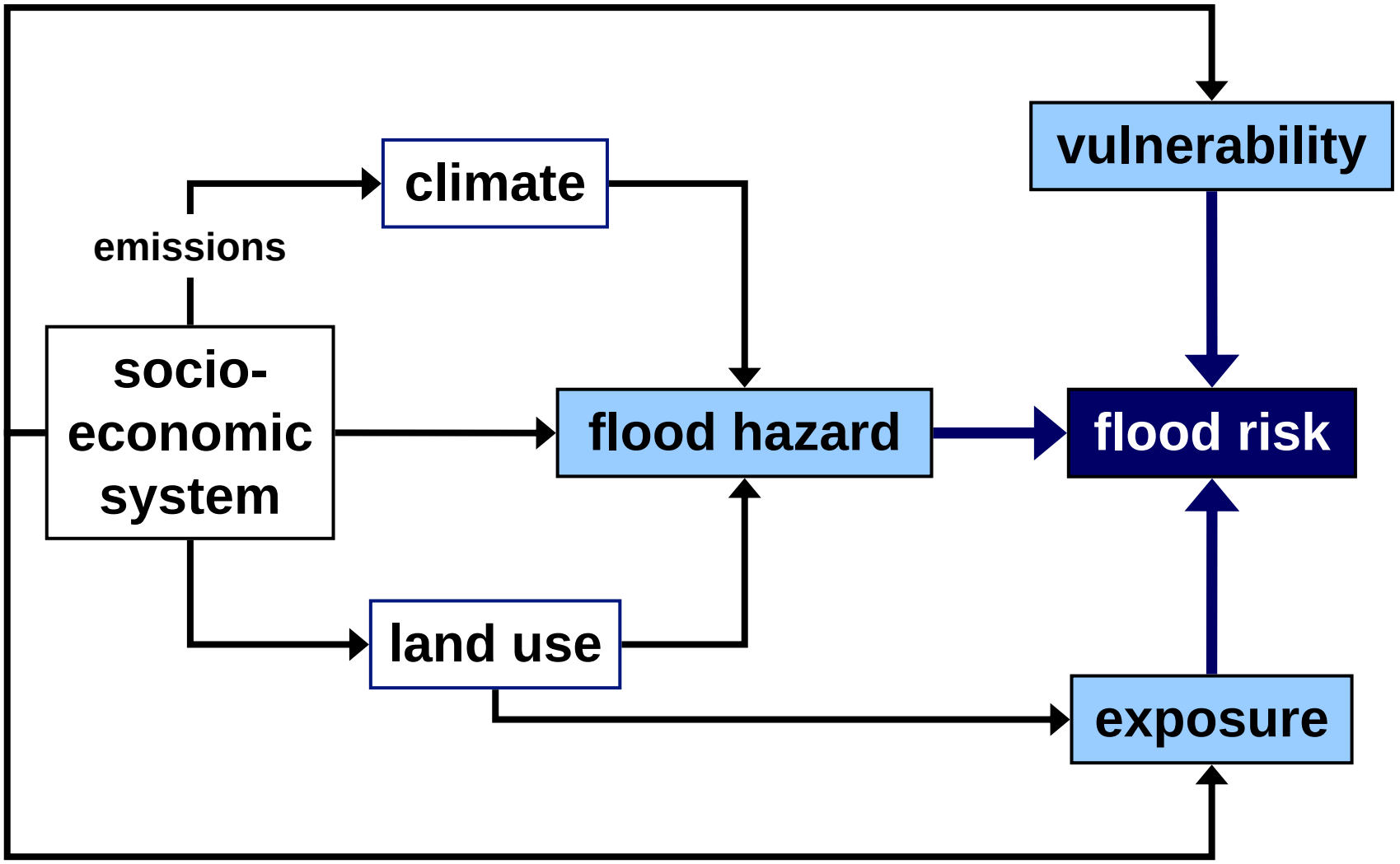
Feyen, L., R. Dankers, K. Bodis, P. Salamon and J.I. Barredo, 2008. Global warming and flood risk in Europe, Submitted for Special Issue in Climatic Change.

European dimension

1. **European Action Programme on flood risk management**
   - **exchange** of **information** and increase public awareness
   - optimal use of **EU funding tools** (e.g., Structural Funds, LIFE)
   - legal document: **Floods Directive** (2007/60/EC)
     - preliminary flood risk assessment (by 2011)
     - draw up flood risk maps (by 2013)
     - flood risk management plans (by 2015)
     - stipulates that possible effects of climate change have to be considered
     - coordination with WFD
2. **CIS activity on CC and water**
3. **European Climate Change Programme II: WG Impacts and Adaptation - White paper on adaptation**
4. **Direct other policies (e.g., agriculture, spatial planning, nature conservation) towards mitigating flood risk**
5. **Stimulate research (FP-programmes)**

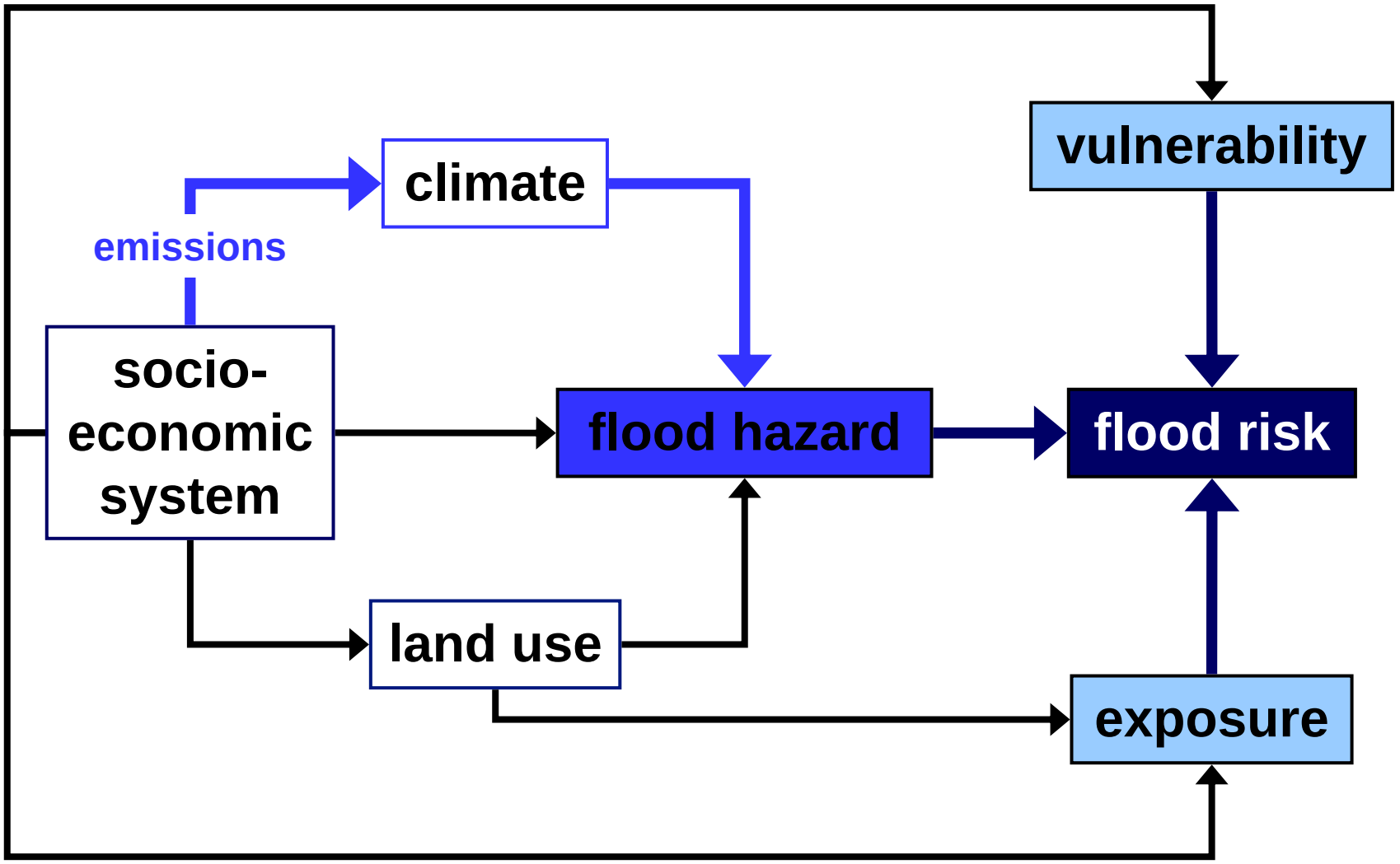
How can we mitigate future flood risk?

Combination of two pathways



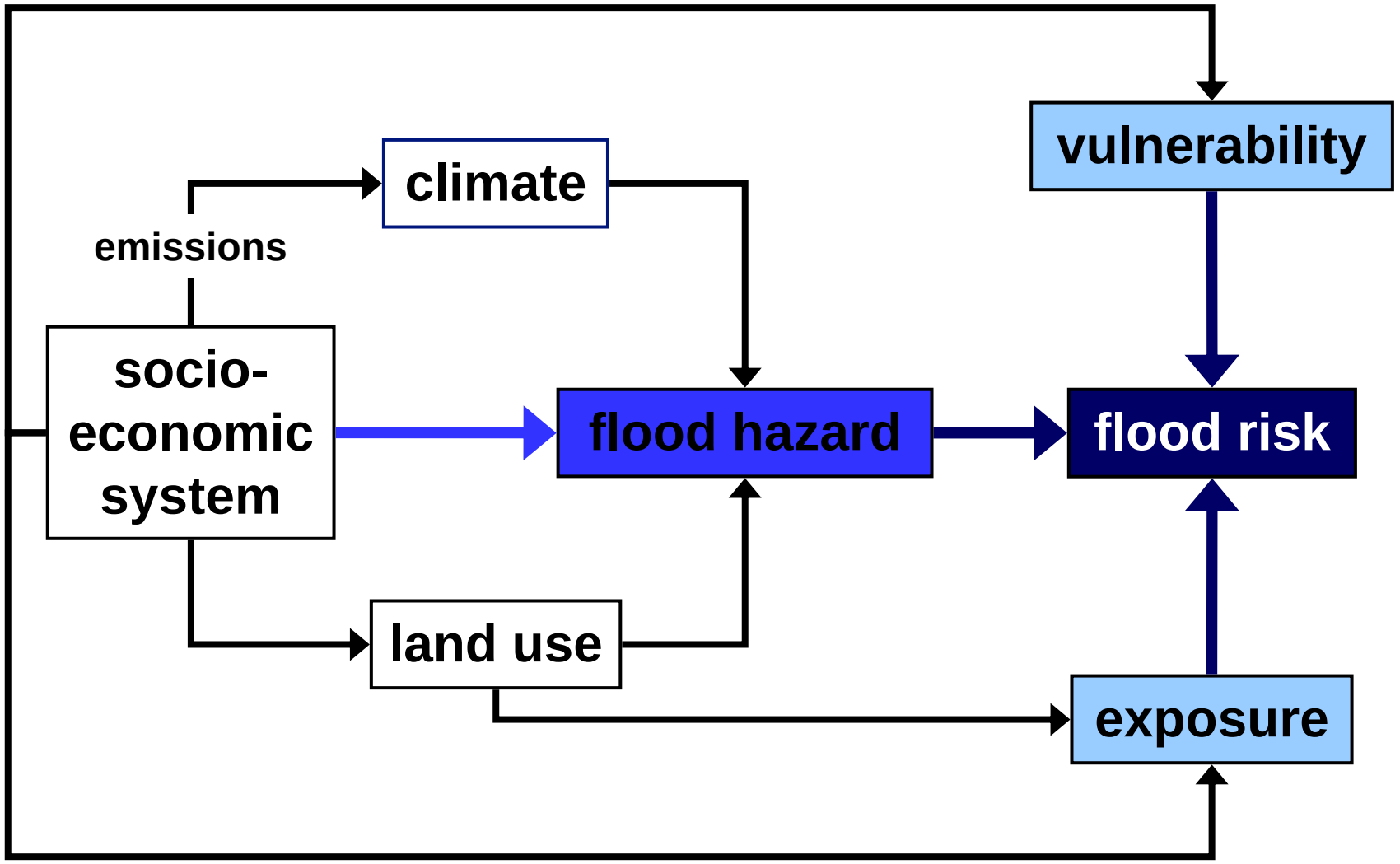
How can we mitigate future flood risk?

1. Cut greenhouse gas emissions (long term)



How can we mitigate future flood risk?

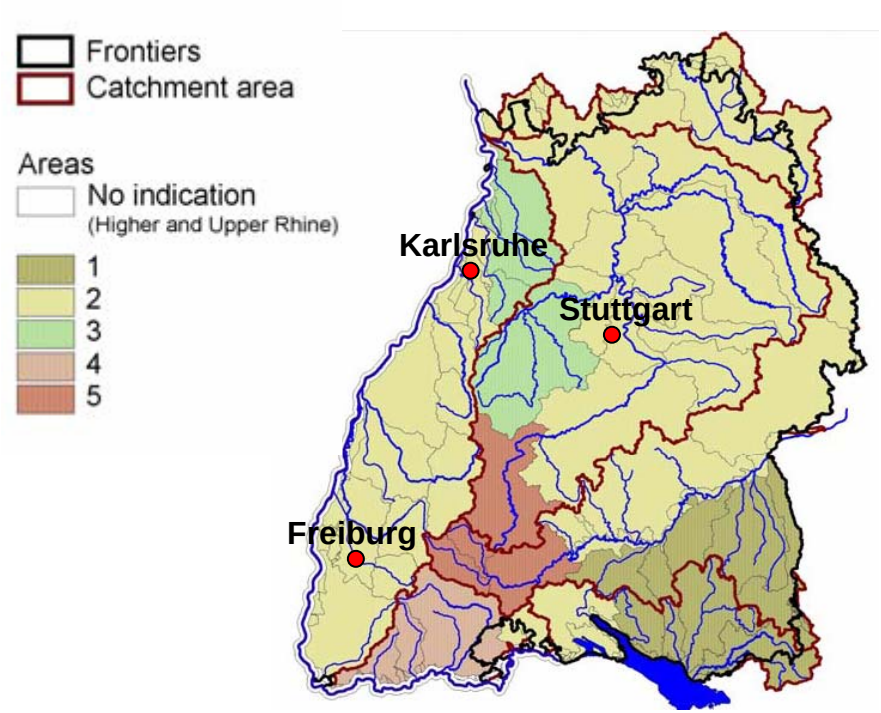
2. Adaptation: reduce flood hazard – structural measures



How can we mitigate future flood risk?

2. Adaptation: reduce flood hazard – structural measures

- **stationarity** principle is **no longer valid**
- **adjust design values** to projected changes and uncertainty



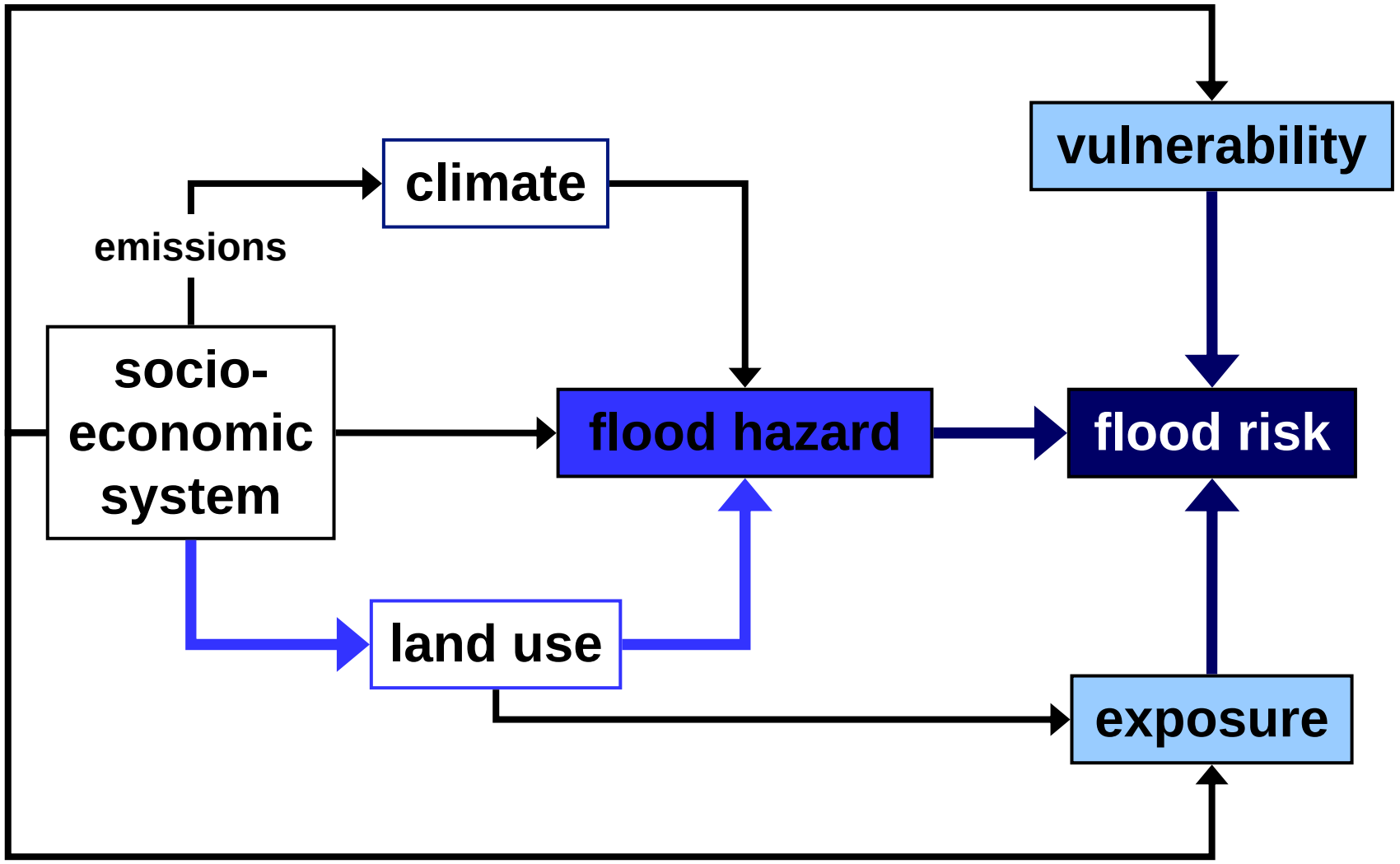
T [years]	Factors for climate change $f_{T,K}$				
	1	2	3	4	5
2	1,25	1,50	1,75	1,50	1,75
5	1,24	1,45	1,65	1,45	1,67
10	1,23	1,40	1,55	1,43	1,60
20	1,21	1,33	1,42	1,40	1,50
50	1,18	1,23	1,25	1,31	1,35
100	1,15	1,15	1,15	1,25	1,25
200	1,12	1,08	1,07	1,18	1,15
500	1,06	1,03	1,00	1,08	1,05
1000	1,00	1,00	1,00	1,00	1,00

Remark: Factor is equal 1.0 for annualities T>1000a

Climate change factors to determine the design flood for river catchments in Baden-Württemberg, Germany (Hennegriff et al., 2006)

How can we mitigate future flood risk?

2. Adaptation: reduce flood hazard – land management



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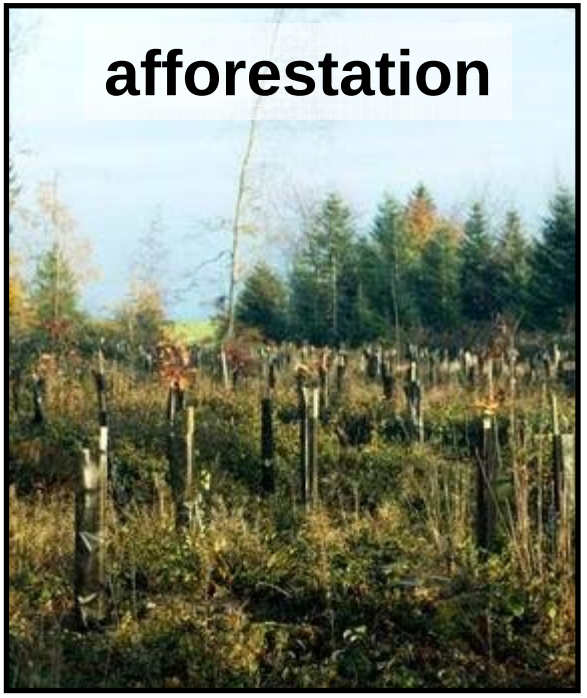
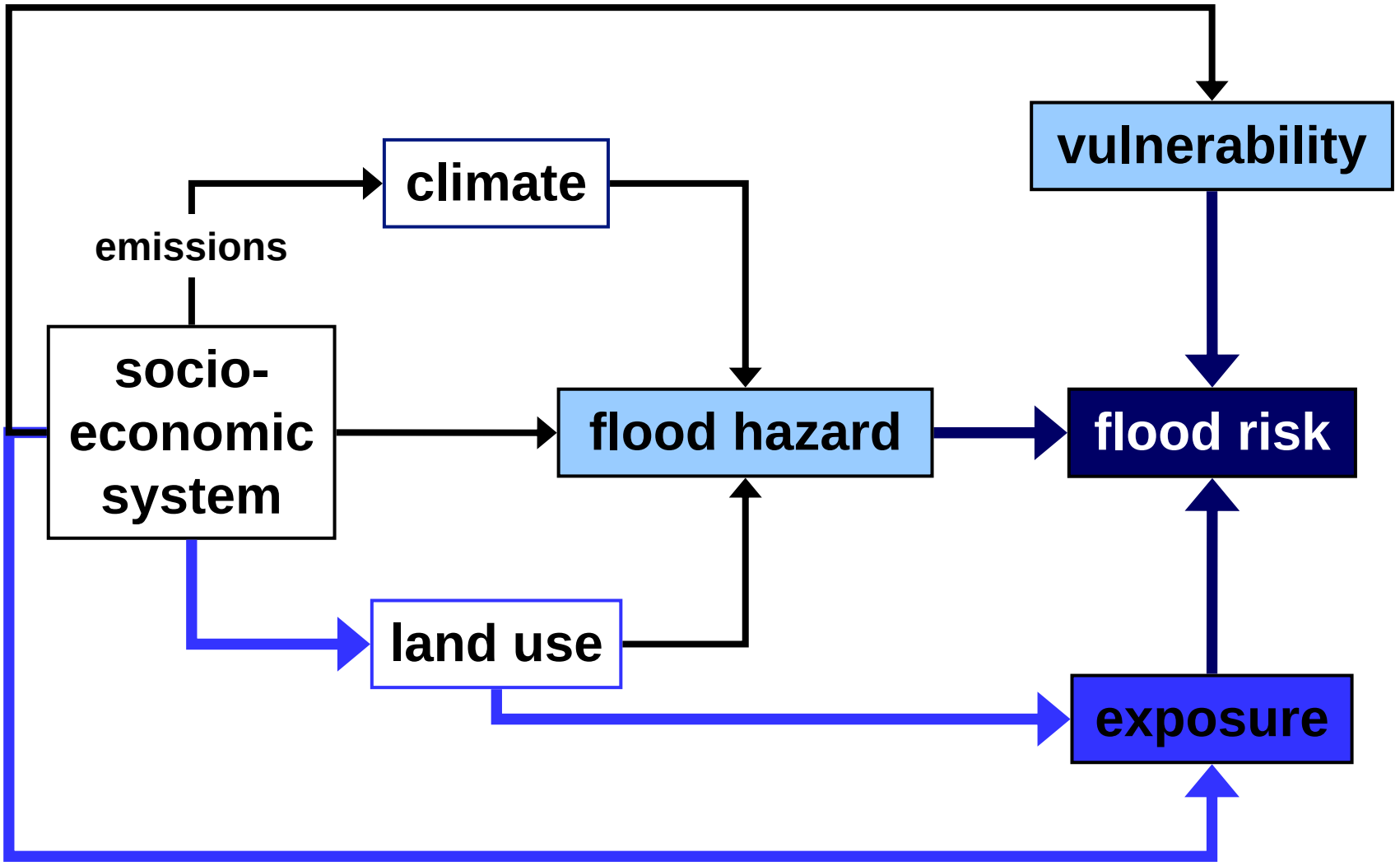


- wider environmental benefits, such as water quality, biodiversity

How can we mitigate future flood risk?

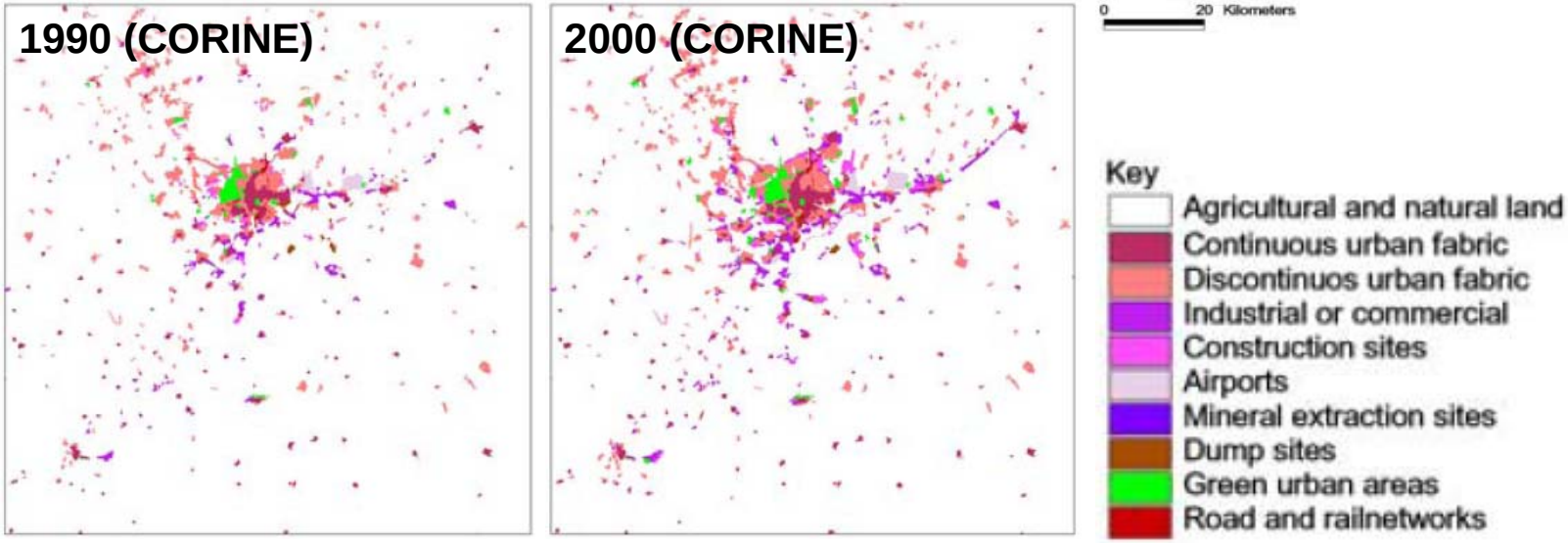
2. Adaptation: reduce exposure



How can we mitigate future flood risk?

2. Adaptation: reduce exposure – land development

- Madrid region: ~10,000 km^2 – 340 municipalities
- hot-spot in urban development in EU (EEA, 2005)
  - intense decentralisation of population and economic activity
  - urbanised land increased by 50% in the 90s
  - weak spatial planning framework



How can we mitigate future flood risk?

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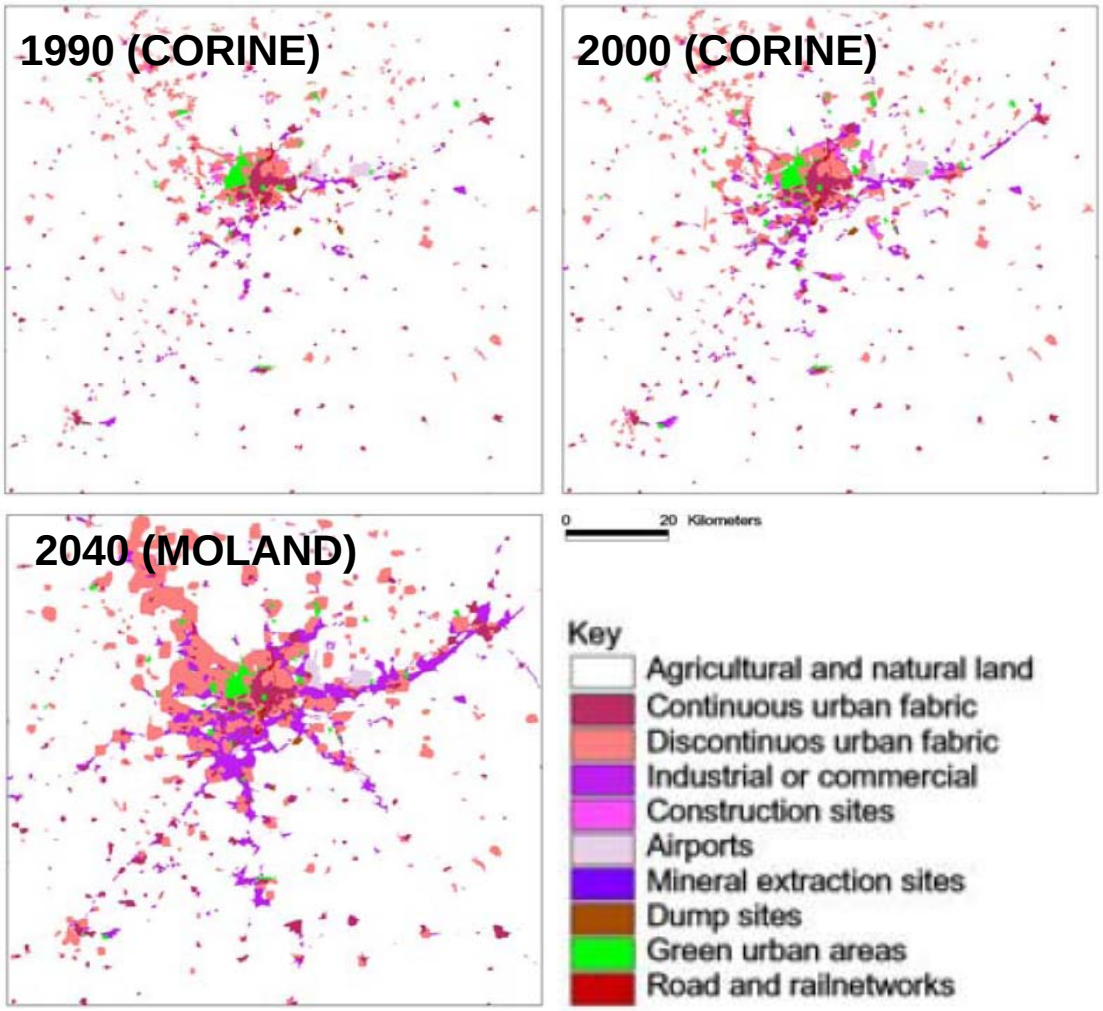


Based on SRES A2 scenario

How can we mitigate future flood risk?

2. Adaptation: reduce exposure – land development

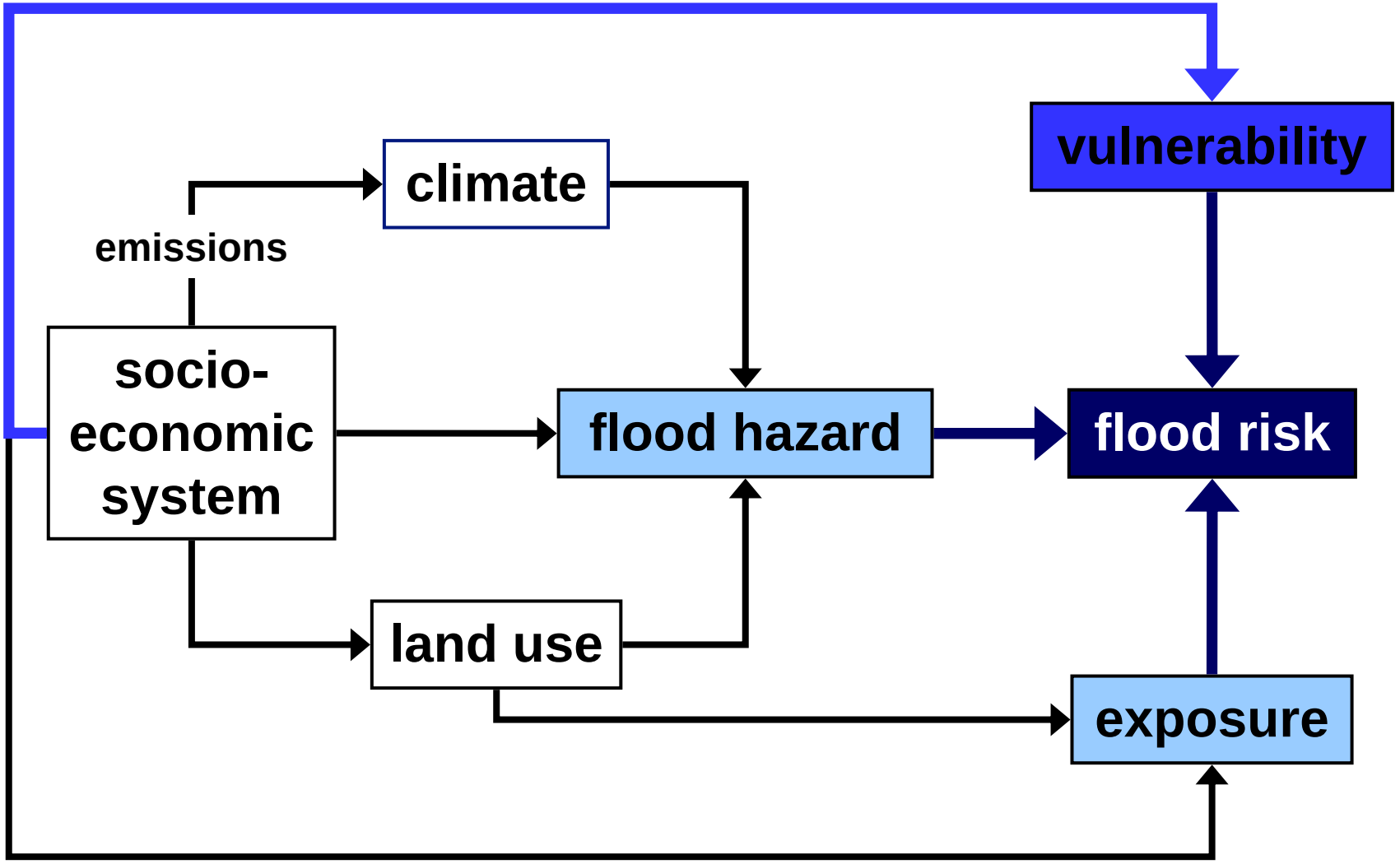
- EAD for greater Madrid region (in constant prices of 2006)
  - flood protection level assumed at 75 year return level of control period

Period	EAD	change in %
Control	€13 million	
Scenario A2 **static land use**	€23 million	**+75%**
Scenario A2 **land use change**	€110 million	**+750%**

➡ **discourage land development in flood prone areas**

How can we mitigate future flood risk?

2. Adaptation: reduce vulnerability



How can we mitigate future flood risk?

2. Adaptation: reduce vulnerability – flood proofing

Property-level flood protection and resilience

How can we mitigate future flood risk?

2. Adaptation: reduce vulnerability – preparedness

- Forecasting and early warning
- Awareness
- Information
- Education
- Insurance
- Post-recovery

From January 2008 onwards EFAS warnings are accessed directly by the partners through the EFAS-IS interface. This interface is password protected and only accessible to EFAS partners.

In addition EFAS issues brief alert emails.

Activated EFAS Alert

issued on – for - confirmed

July	Rivers	Countries	Flooding Confirmed
20	all rivers in RO	RO	yes
21	Tisza	HU, RO	high levels, flood protection effective
22	Bodrog	SK	yes

Informal EFAS Alert

issued on – for - confirmed

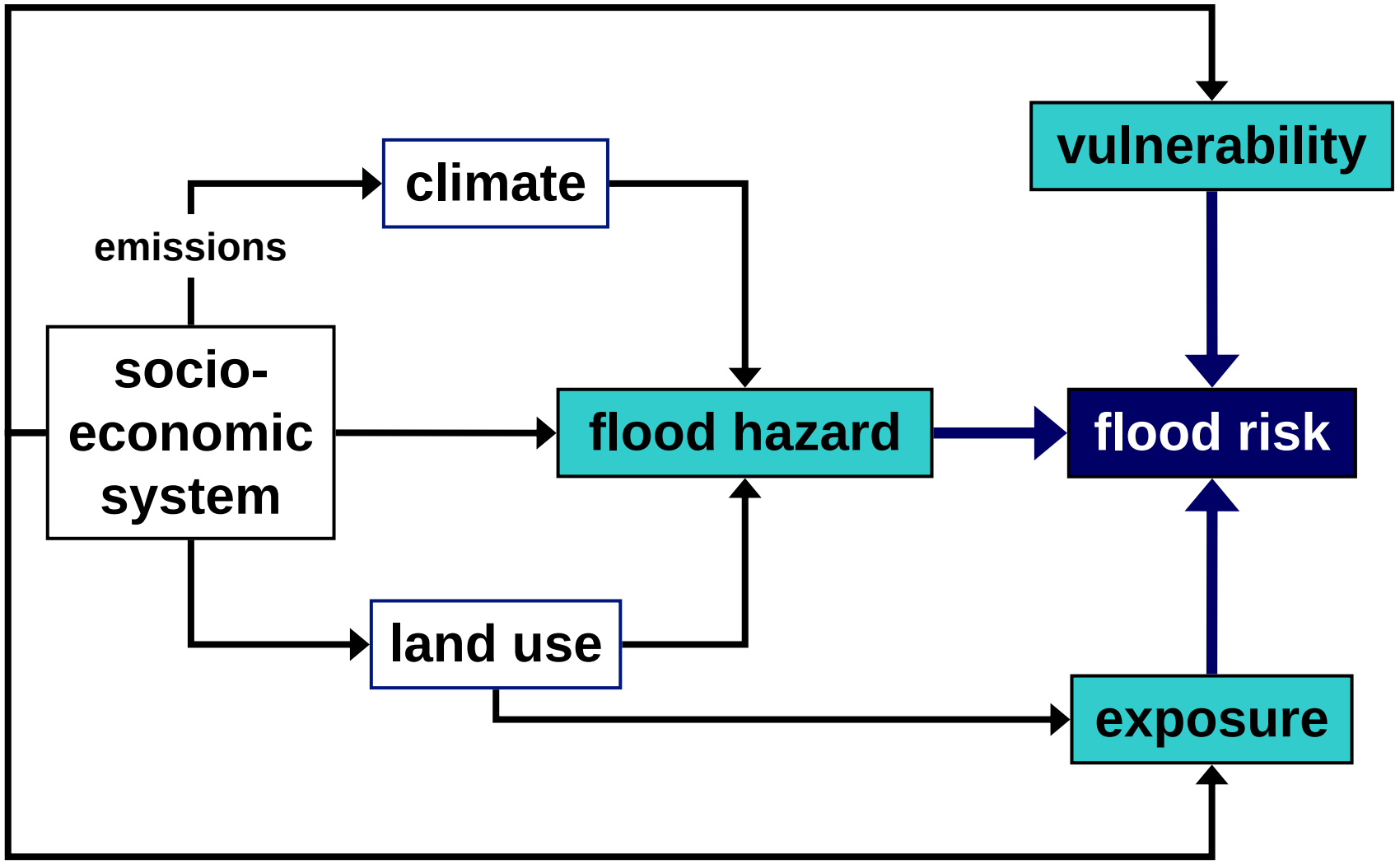
July	Rivers	Countries	Flooding Confirmed
10	Inn	AT	yes

Active alert email send to MoU partners

Informal alert email send because catchment area too small, not part of MoU agreement (but partner has signed an MoU for another river)

How can we mitigate future flood risk?

➡ site-specific mix of measures, adaptable or robust to changes



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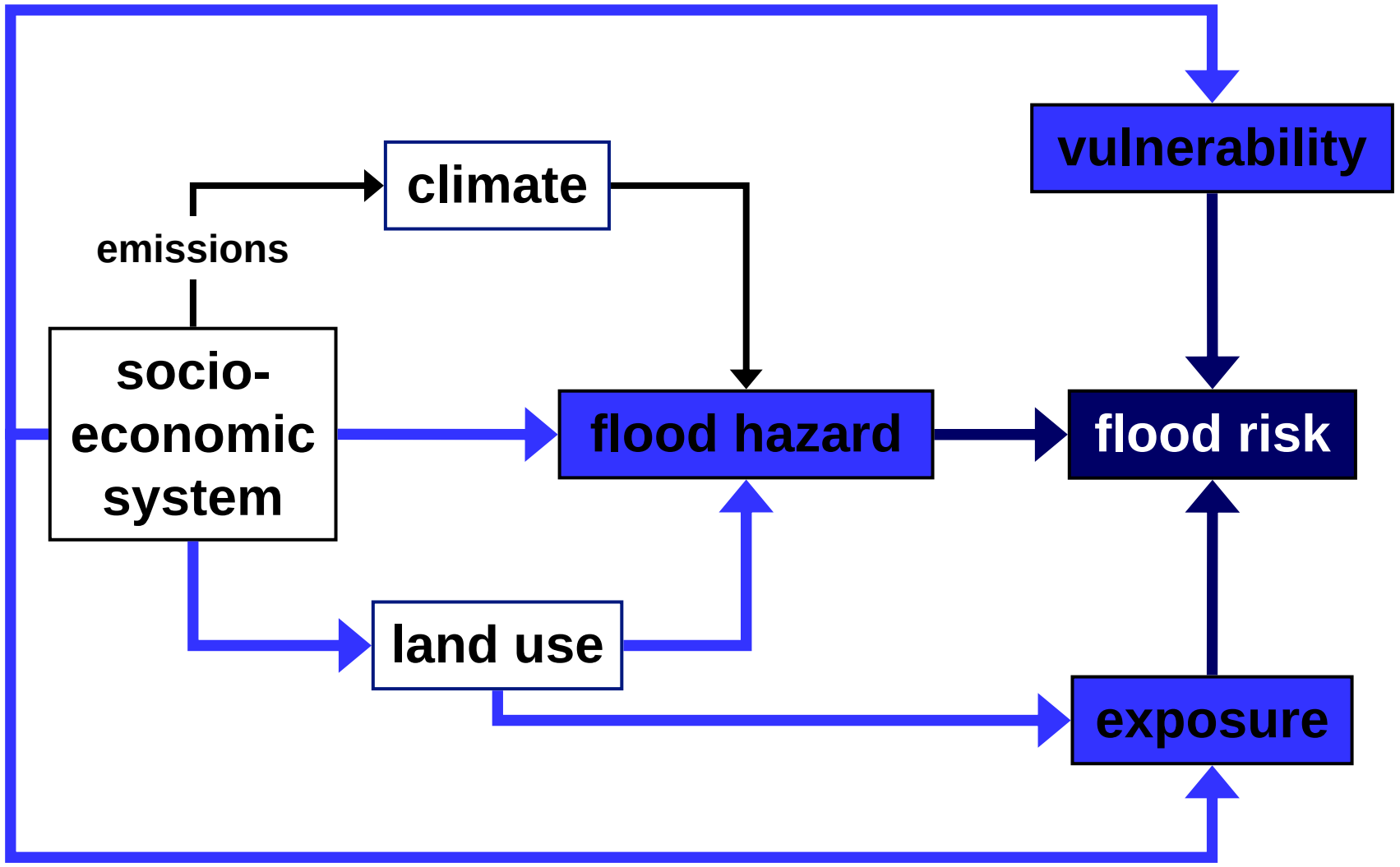


How can we improve future flood risk assessment?

Key research challenges

- in climatology, hydrology, land-use planning, socio-economic sciences and multi-objective decision-making under uncertainty
- need for sustained, high-quality observations & **data sets**
- **advance scientific understanding** of the
  - mechanisms that trigger, and alter the probabilities of, extreme events
  - interaction/feedback between land-use and climate change and variability
  - interaction/feedback between hydrological cycle and climate
- **improve capabilities** of **regional climate models** to represent and predict variability and extremes at regional and local scale

How can we improve future flood risk assessment?

Key research challenges (continued)

- improve **early warning** systems, in particular for flashfloods
- better **quantification** of **damages** and of **cost/benefits** of **adaptation measures**
- better **quantification** of current and future **vulnerability** and of the reliability of protection measures
- formal treatment of **uncertainty** in the chain "emissions – climate – extreme flows – inundation – damage"
- flood risk mapping and management in the face of these uncertainties

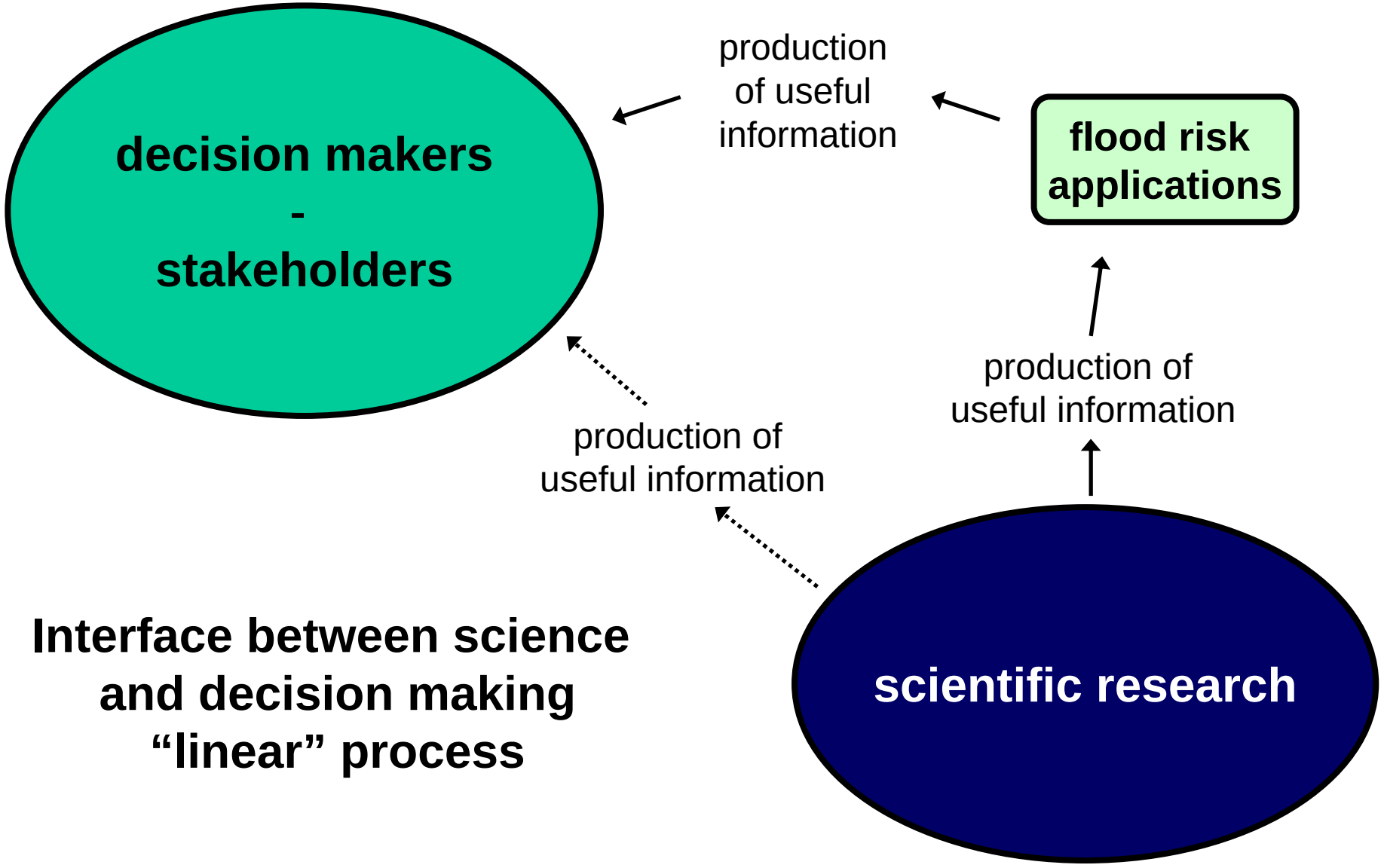
How can we improve future flood risk assessment?

Key research challenges (continued)

➡ several of these issues are addressed in ongoing or planned FP6 and FP7 projects such as ENSEMBLES, FLOODsite, PREVIEW, ADAM, CECILIA, ARMONIA, ClimateCost and WATCH

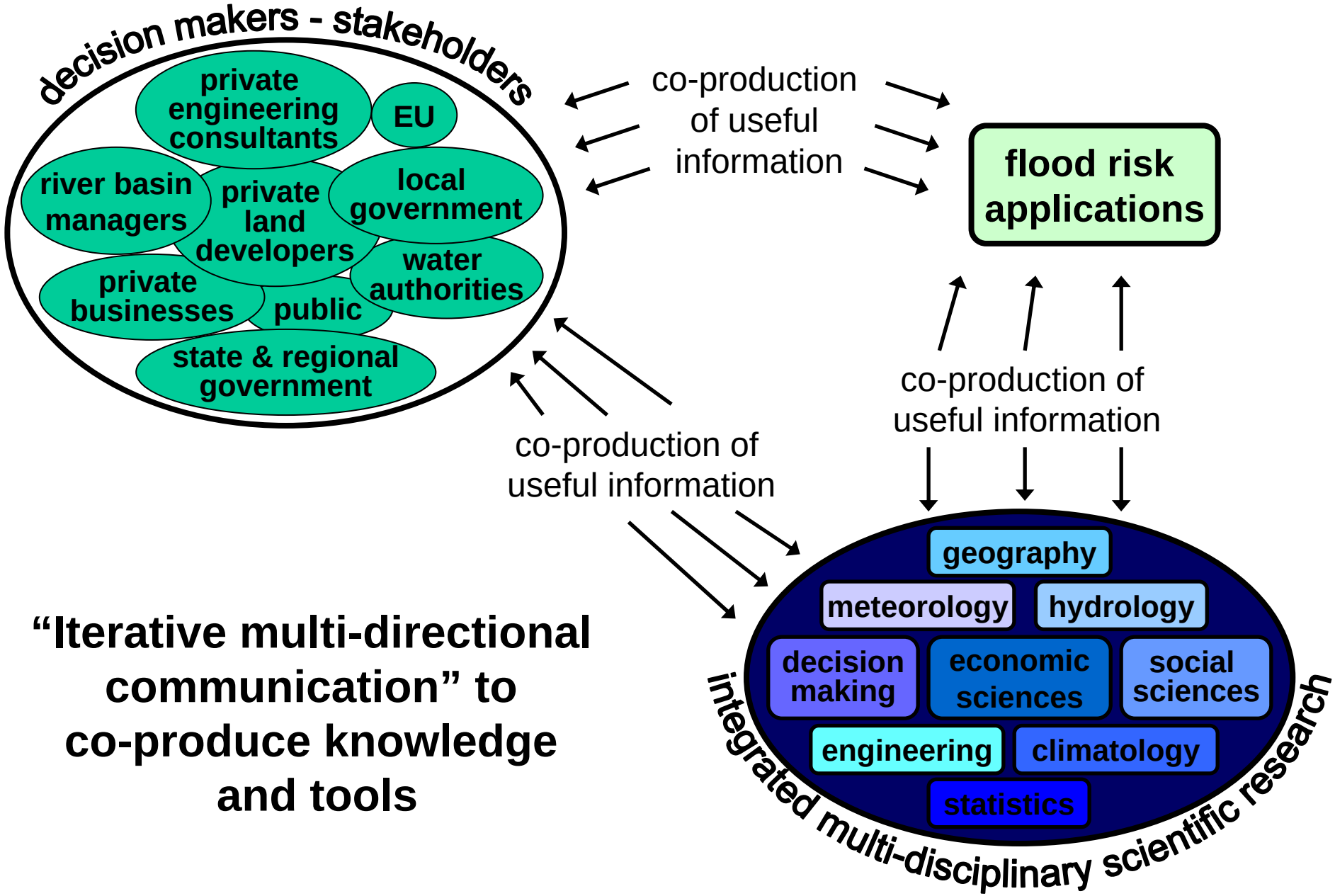
… but **many challenges** remain

Science to Policy



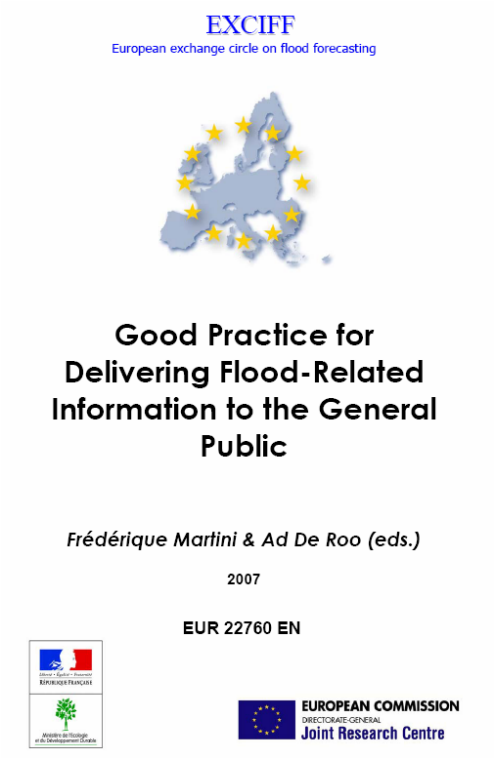
Interface between science and decision making
“linear” process

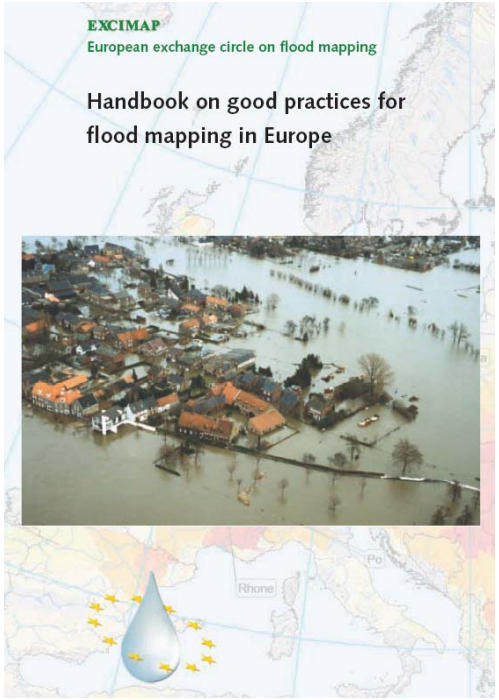
Science to Policy

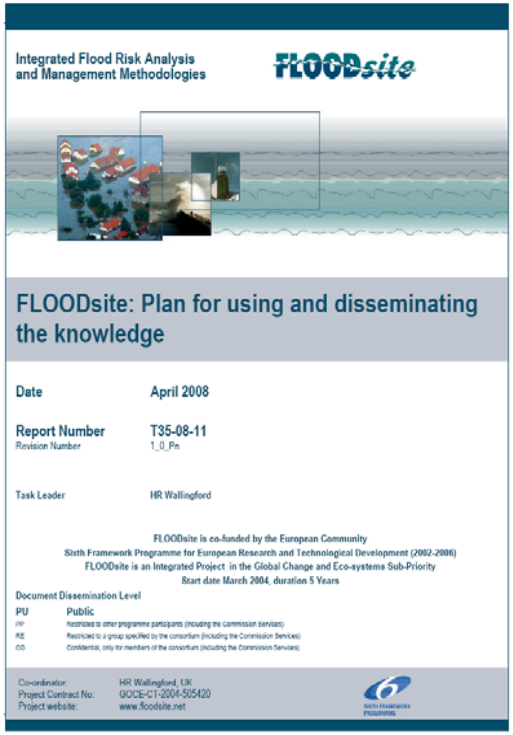


"Iterative multi-directional communication" to co-produce knowledge and tools

Science to Policy







Conclusions

- climate and socio-economic changes will likely increase flood risk in large parts of Europe
- entails iteratively integrating knowledge, data and methods across scientific disciplines, socio-economic sectors, decision makers and stakeholder groups
- that consider possible climate, land use and socio-economic changes, as well as water management strategies, in a coherent and consistent way
- to design flood risk management strategies that are robust or adaptable to changes

THANK YOU FOR YOUR ATTENTION

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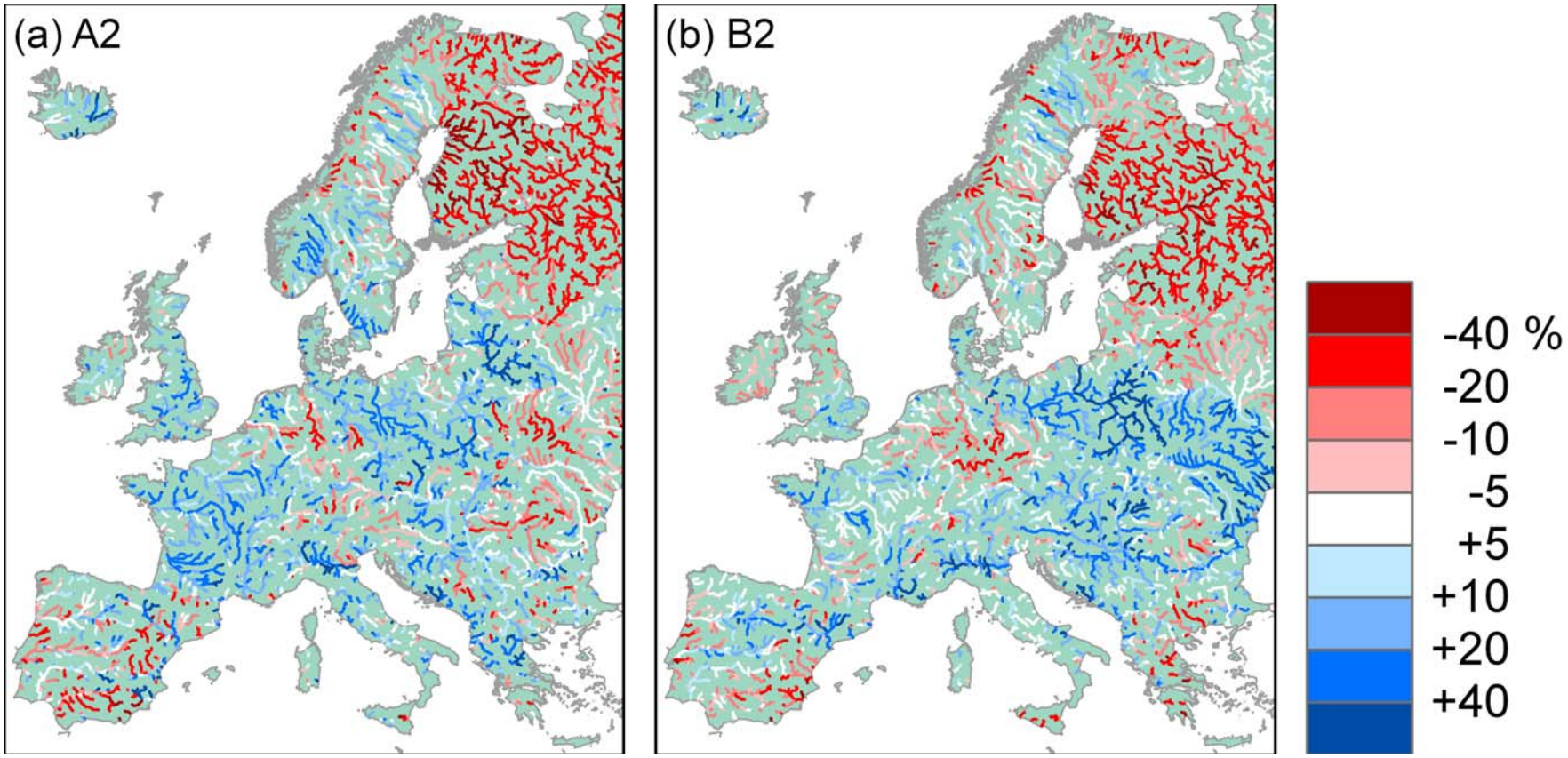
Change in flood hazard by 2080s

➢ **change** in **magnitude** 100-year return discharge level



Dankers, R. and L. Feyen, 2008. Climate change impact on flood hazard in Europe: An assessment based on high resolution climate simulations, J. Geophys. Res., doi:10.1029/2007JD009719.