VU University Amsterdam



Flood risk developments in the Rhine Basin and its Delta

Philip Bubeck, Aline te Linde, Jasper Dekkers, Hans de Moel and Philip Ward

IVM Institute for Environmental Studies

Content

- Study Area
- Problem description and research goals
- Current flood damage potential and risk
  - Method and results
- Future drivers of flood risk in the Rhine Basin
  - Methods and results
- Evaluation of current adaptation strategies
  - Flood Action Plan of the International Commission for the protection of the Rhine (ICPR)

Study Area









Problem description

- Rhine is a very important traffic route and economically important
- ~10 million people live in areas at risk from extreme flooding (ICPR)
- Flood events in 1993 and 1995 caused considerable damage / evacuation
- Increase in flood risk is expected
  - Socio-economic development / Global warming



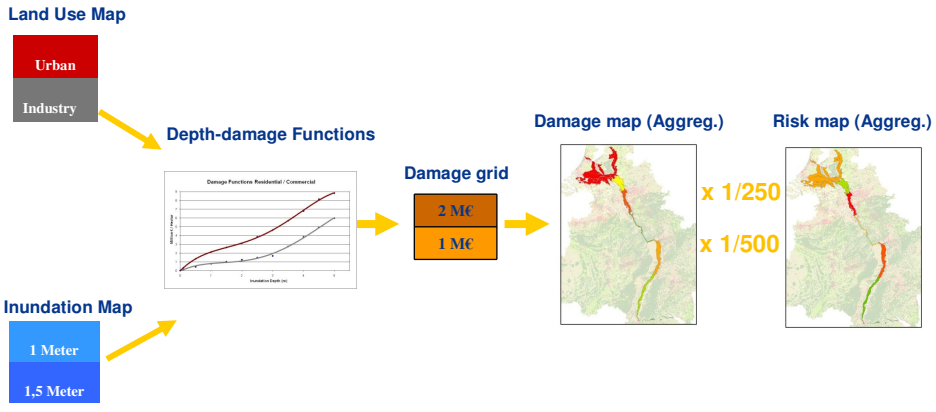
→Requires better understanding of potential flood risk developments

→Need to evaluate effectiveness of adaptation strategies

Research Goals

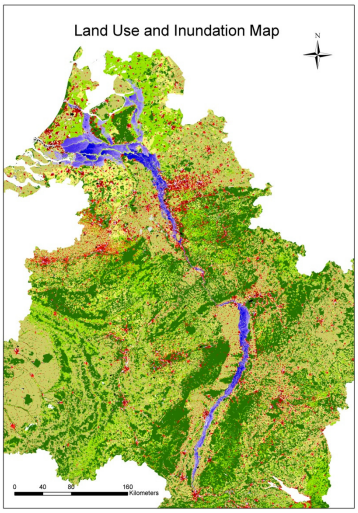
- Develop a flood risk model for the entire Rhine channel
  - Estimate potential flood damage
  - Estimate flood risk
    - > Probability x damage
- Estimate the developments in future flood risk
  - What is the main driving factor
- Assess different adaptation strategies (Flood Action Plan, ICPR)

Current flood risk - Method



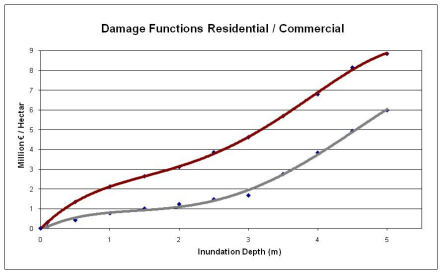
Current flood risk - Method

- Land Use
  - CORINE
  - Switzerland 1990
  - Population density
- Inundation
  - Rhine Atlas (ICPR, 2001)
  - NL: Provincial „Risikokaart“



Current flood risk - Method

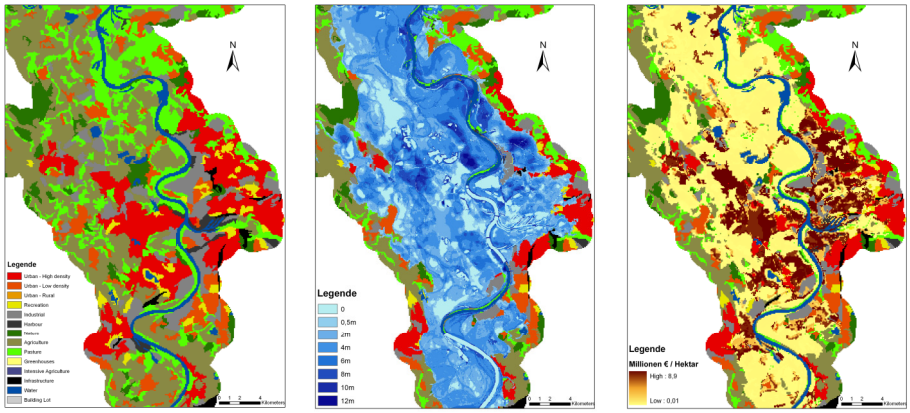
- Damage Functions (Klijn et al., 2007)
  - High uncertainty of DF in terms of absolute values
  - Relative changes are of interest
    - > Results more robust
    - > Factor 1.3 (Bubeck et al. (in prep.) / De Moel and Aerts, 2009)
- Return periods
  - ICPR
  - Report No. 153d (Hval)



Current probabilities

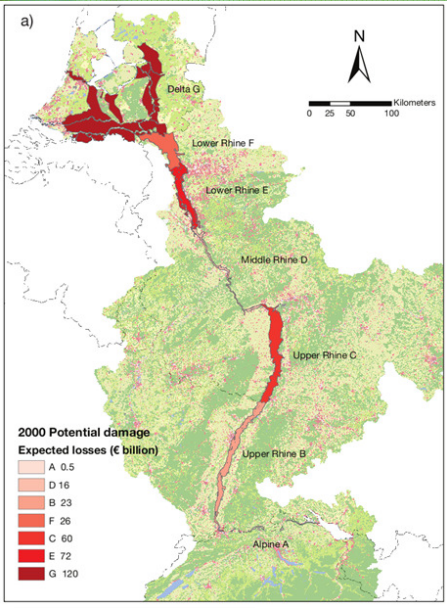
	Return periods
Alpine	1/200
Upper Rhine(st)	1/1000
Upper Rhine (d)	1/200
Middle Rhine	1/200
Lower Rhine	1/200
Lower Rhine	1/500
Rhine delta	1/1250

Current flood risk - Results

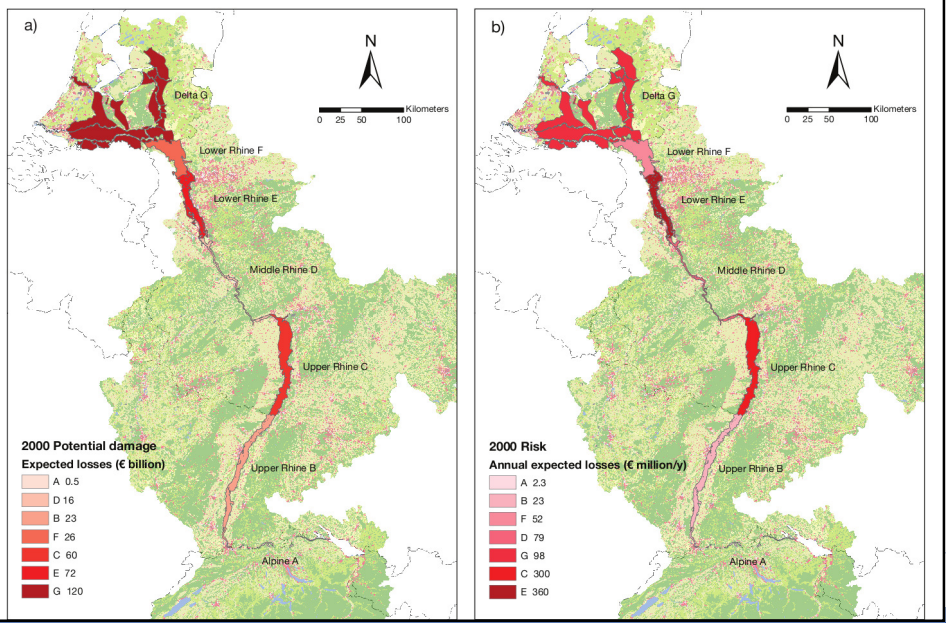


Rhine at Duisburg

Current flood damage potential and risk - Results



Current flood damage potential and risk - Results



Current flood risk - Results

Country	**Risk** (Mill. Euro / year)
Switzerland	1
France	9
Netherlands	99
Germany	810

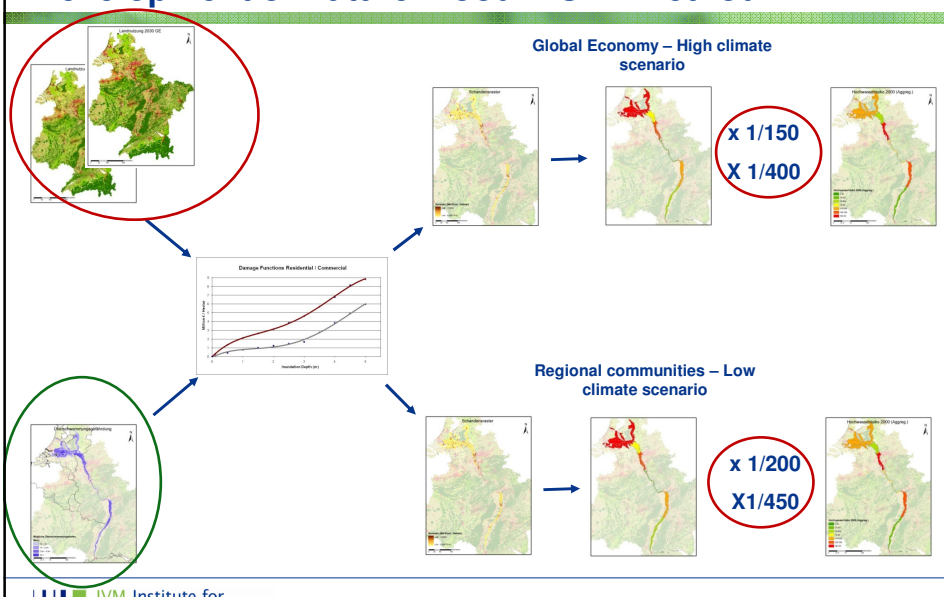
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Development of Future Flood Risk

"It is difficult to make predictions, especially about the future"

Development of Future Flood Risk – Method



Development of Future Flood Risk – Method

Global Economy
- Strong population and economic growth
- International economic integration
- Weak role of the government
  - Little environmental regulations
- Strong role of the individual
  - Private interests

Regional Communities
- Low economic and population growth
- National / regional focus
- Strong role of governments
  - Environmental regulations

"claims GE - EURURALIS"

EURURALIS

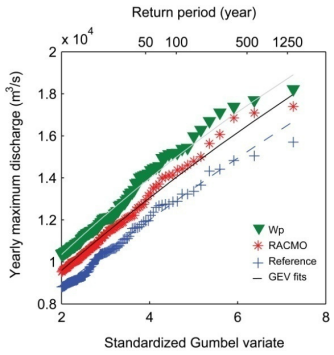
"claims RC - EURURALIS"

(Verburg et al., 2008)

„Land Use Scanner"
- Suitability Maps
  - Flood zones (100 years)
  - Nature areas
  - Retention areas
  - Distance Maps
  - DEM

(Rietveld & Hilferink, 1999; Loonen and Koomen, 2008)

Development of Future Flood Risk – Method

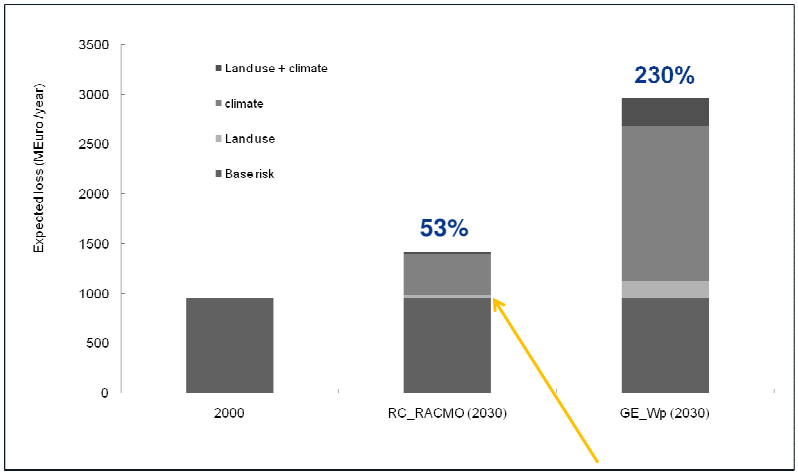


Assumption: No flood control measures

	RACMO	Wp
Region	*p* incr.	*p* incr.
Alpine A	1.4	3.1
Upper Rhine B	1.5	3.9
Upper Rhine C	1.3	2.6
Middle Rhine D	1.3	2.5
Lower Rhine E	1.5	2.5
Lower Rhine F	1.5	3.1
Delta G	1.9	2.9

- Taken from Te Linde et al. (2010)
- Long time series (weather generator)
- 'low' and 'high' scenario

Development of future flood risk - Results



2000 – 2030: 30 Mill. € = 1 Mill. € / year
1990 – 2000: 19,2 Mill. € = 1,92 Mill. € / year

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Evaluation Flood Action Plan (ICPR)

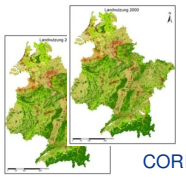


Source: ICPR

Flood Action Plan
- Adopted 22nd January 1998 by the ICPR

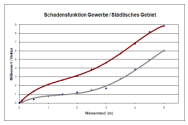
Goals
- **Reduce flood risk by 10% in 2005 and 25% in 2025**
- **Reduce peak water level**
- Improve flood awareness
- Improve early warning system

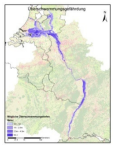
Evaluation Flood Action Plan (ICPR) - Method



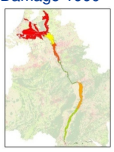
CORINE 2000

CORINE 1990



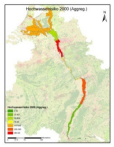


Damage 1990

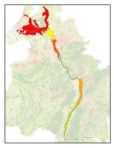


x Current probabilities

Base risk 1990

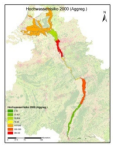


Damage 2000

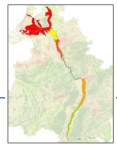


x Current probabilities

Risk 2000 + Effect Land Use

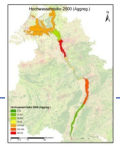


Damage 2000



x Current Probabilities + Max. Effect Measures

Risk 2000 + Effectiveness



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Evaluation Flood Action Plan (ICPR) - Results

Change in flood risk 1990 – 2000 (in %)

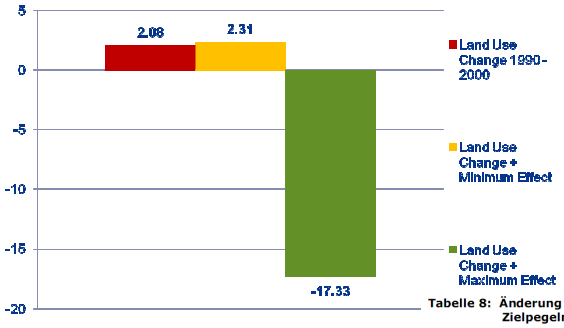


Tabelle 8: Änderung der Jährlichkeit, gegliedert nach HW-Bereiche an den Zielpegeln (scheitelwertbezogen)

Pegel		Q/T-Änderungen (Zustand 2005 - 1995) nach HW-Bereich			
		HQ 10	HQ 100	HQ 200	HQ 1000 / HQ 1250
Maxau	Minima	+/- 0	+ 15	+/- 0	-
	Maxima	+ 2	+ 45	+ 130	-
Worms	Minima	+/- 0	+ 10	+ 20	-
	Maxima	+ 5	+ 30	+ 80	-
Kaub	Minima	+/- 0	+/- 0	- 5	-
	Maxima	+/- 0	+ 15	+ 15	-
Köln	Minima	+/- 0	+/- 0	+/- 0	+/- 0
	Maxima	+/- 0	+ 10	+ 20	+ 35
Lobith	Minima	+/- 0	+/- 0	+/- 0	+/- 0
	Maxima	+/- 0	+ 10	+ 20	+ 120

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IKSR (Hval) Bericht Nr. 153d

Conclusions and recommendations

- 2000-2030: 53-230% increase in basin-wide flood risk
  - About three quarters can be attributed to climate change
- Probabilities of extremes are very uncertain, impact of climate change even more

  → damage reduction seems robust adaptation measure

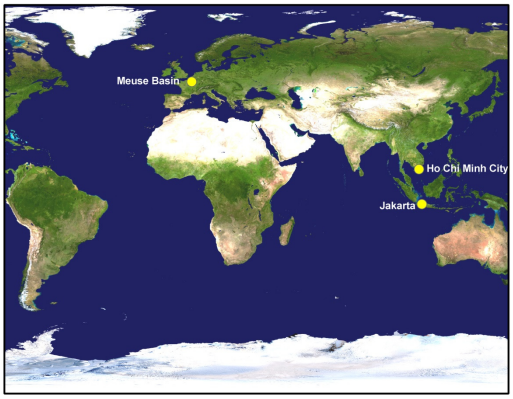
Method needs improvement:

- Inundation simulation
- Estimates of safety levels
- Damage estimates

Thank you!

For more questions:
philip.bubeck@ivm.vu.nl

For more information:
http://www.ivm.vu.nl
http://www.adaptation.nl



Developments of future flood risk - Results

		Socio-economic scenario		
		Reference	RC	GE
Climate scenario	Reference	**920**	980 (6.5%)	1200 (25%)
	RACMO	1300 (43%)	**1400 (53%)**	1600 (79%)
	Wp	2400 (160%)	2600 (180%)	**3000 (230%)**

Development of Future Flood Risk – Method

