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Dutch water management

- West Netherlands: Rhine and Meuse confluence delta
- 2/3 of the Netherlands' land area lies below sea level. Economic core (Randstad Holland) completely below sea level. Estimated value below sea level amounts to € 1.800 bln
- Dutch history features many floods. Most important: flood in Zeeland province 1953 and previous flood in 1916; near floods in 1993 and 1995

Dutch water management

- 1960: Delta commission: uniform set of flood probability norms and comprehensive Deltawerken plan (finished 1997) to protect the southwest of the country
- Safety standards per dike ring based on flood probability, not on flood risk (risk = probability * damage); implying much reliance on ex ante safety standards
- 2008: second Delta Commission. Proposed new safety norms
- Delta programma: to design new safety norms and needed investments for the 21st century

Flood damage assessment

- Based on Dutch guidelines for cost-benefit analysis
- Three components: direct damage to economic objects, production loss and indirect damage. Differences in time span of occurrence
- Difference in ex ante and ex post damage estimates might be considerable. Hurricane Katrina: ex ante 16 billion $, ex post 80 billion $

Flood damage: short term effects

- Short term effects: physical (direct) damage
- Current practice in NL: HIS-SSM. Detailed GIS-based information system based on land use by function (housing, transport, factories, offices) and industry (agriculture, manufacturing, services) per hectare
- Important indicators for damage function include water flow speed, maximum water depth in inundated area and time span of flood
- Direct damage dominant: 95% of total. Fixed coefficients for long-term damage

Flood damage: long-term effects

- Long term effects: production loss (medium term) and indirect effects (long term)
- Spatial Computable General Equilibrium (SCGE) modeling with RAEM: based on New Economic Geography developed for estimating indirect impact of transport infrastructure investment
- Netherlands divided in 40 regions (NUTS3+exterior) and 15 industries

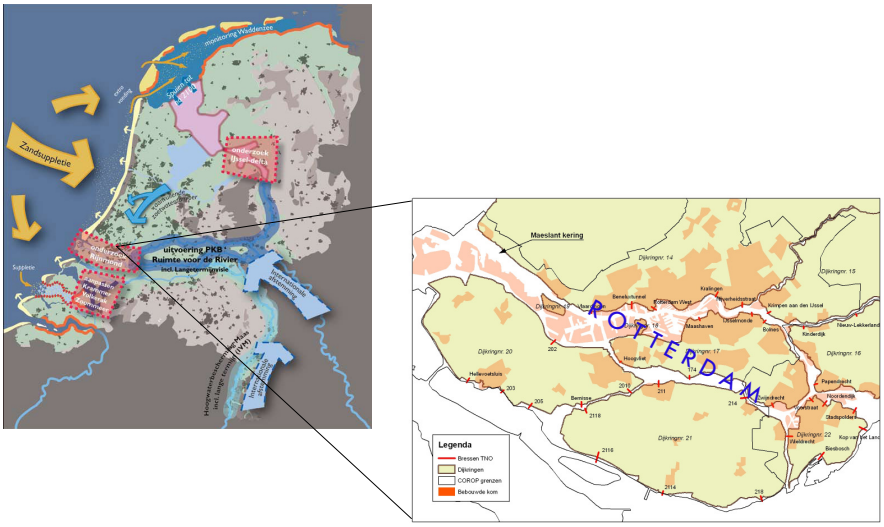
Flood damage: long term effects

- RAEM: economy represented as a circuit comprising production, labour, housing, consumption, transport, domestic trade and foreign trade
- Flood modeled as a spatial disinvestment
- Types of effects calculated for:
  - demanding and supplying firms outside inundated area
  - interruption of transport connections
  - interruption of communication connections
  - feedback effects on housing, labour and product markets in short, intermediate and long run

Case: greater Rotterdam

- 8 dike rings
- HIS-SSM input for RAEM
- HIS-SSM results based on sample of 5-8 flood locations per dike ring: average output per dike ring in HIS-SSM is input for RAEM
- Four types of input:
  - Loss of capital, based on damage to business areas
  - Loss of land, based on flood characteristics
  - Loss of labour, based on casualties
  - Loss of housing supply, based on damage to dwellings

Greater Rotterdam

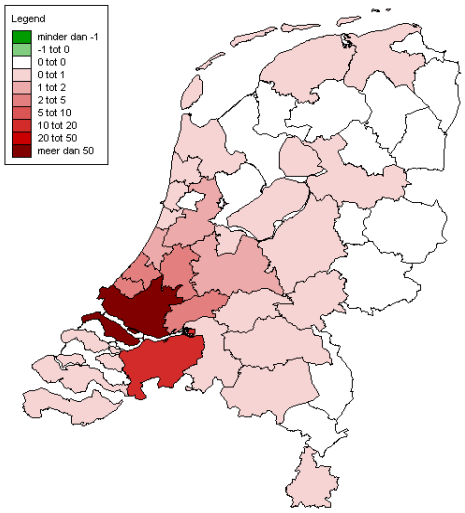


Comparison: HIS-SSM and RAEM

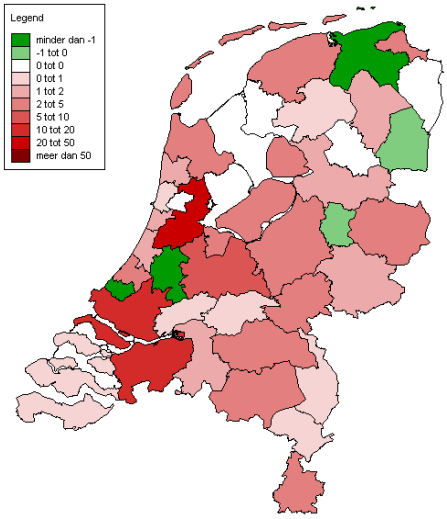
Average of several flood scenarios in dike ring 15, in million €

Damage category	HIS-SSM	RAEM	Total (HIS-SSM+RAEM)
Physical damage	3.074	x	3.074
* housing	1.833	x	1.833
* infrastructure and public works	590	x	590
* business sites	652	x	652
Economic damage during flood period	133	163	163
Economic damage on intermediate and long run (years 2009-2100)	x	1.670	1670
Total damage	3.207	1.833	4.907

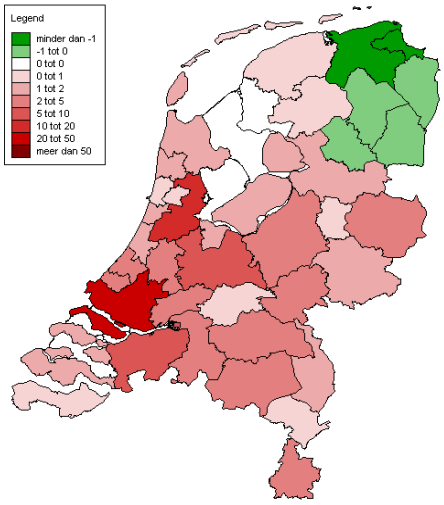
Regional distribution of flood damage of a flood in dike ring 15 in the short run (Netherlands = 100%)



Regional distribution of flood damage of a flood in dike ring 15 in the intermediate run (Netherlands = 100%)



Regional distribution of the flood damage of a flood in dike ring 15 in the long run (Netherlands = 100%).



Results

- Total damage estimate increased by 15 to 55 percent indirect effects, depending on location and time span of flood, based on a discount rate of 5,5%
- In the short run over 60 percent of the damage is allocated in the flooded region, only ca. 25 percent in the long run: regional dispersion of damage over time
- In the intermediate run and long run other regions can (modestly) benefit from a flood depending on sector likeness
- In the intermediate run: demand shift to nearby regions

Conclusions

- Long-term effects matter, especially on the regional level
- Inclusion of long-term effects in ex ante flood damage assessment can contribute to improved water safety policy, spatial planning and insurance
- SCGE models are useful to estimate intermediate and long run economic effects of a flood because they incorporate changed behaviour of economic agents after flooding
- SCGE models apply equilibrium approach but account for market imperfections

KVK research

- IVM-VU and TNO will combine SCGE modeling and multi agent modeling. Departing form the standard equilibrium approach should shed light on
  - the impact of floods on real estate values
  - adjusted (migratory) behavior of individual households and firms
  - the effect of public recovery plans
- Accounting for bounded rationality of economic agents to answer:
  - Do households and firms change their attitude towards flood risks after a flood?
  - How will firms deal with long term investments in vulnerable flood areas? What is the additional damage when government recovery investments do not take place or are delayed?