Hazard Response and Recovery in Dutch Water Policy and Flood Management; A Case of a Paradigm Shift

Marija Bočkarjova,
Albert E. Steenge
University of Twente
The Netherlands

The 6th DRI-IIASA Forum on Integrated Disaster Risk Management
Istanbul, Turkey, 13-18 August 2006

Flood protection and water management policy in the Netherlands

- Permanent danger of flooding for the low-lying lands
  - From both the sea and the rivers (The Rhine, the Meuse and the Scheldt)
- A milestone in policy-making: the flood of **1953**
  - The Delta Plan as a response (*van Dantzig, 1956*)
  - Thinking based on flood frequency minimisation (**P**)

    → domination of engineering / structural solutions, which are reaching their limits

The Netherlands: a System of Dike Rings

57 major dike rings with differentiated safety standards

The vicious circle of guaranteed safety

- Emergence of a stable, yet false “absolute protection” feeling
- Accelerated accumulation of economic assets behind the dikes

- This has resulted in the current situation when…

  …an unlikely, though *possible* flooding can turn into a **disaster**, being a “low probability – high consequence” event

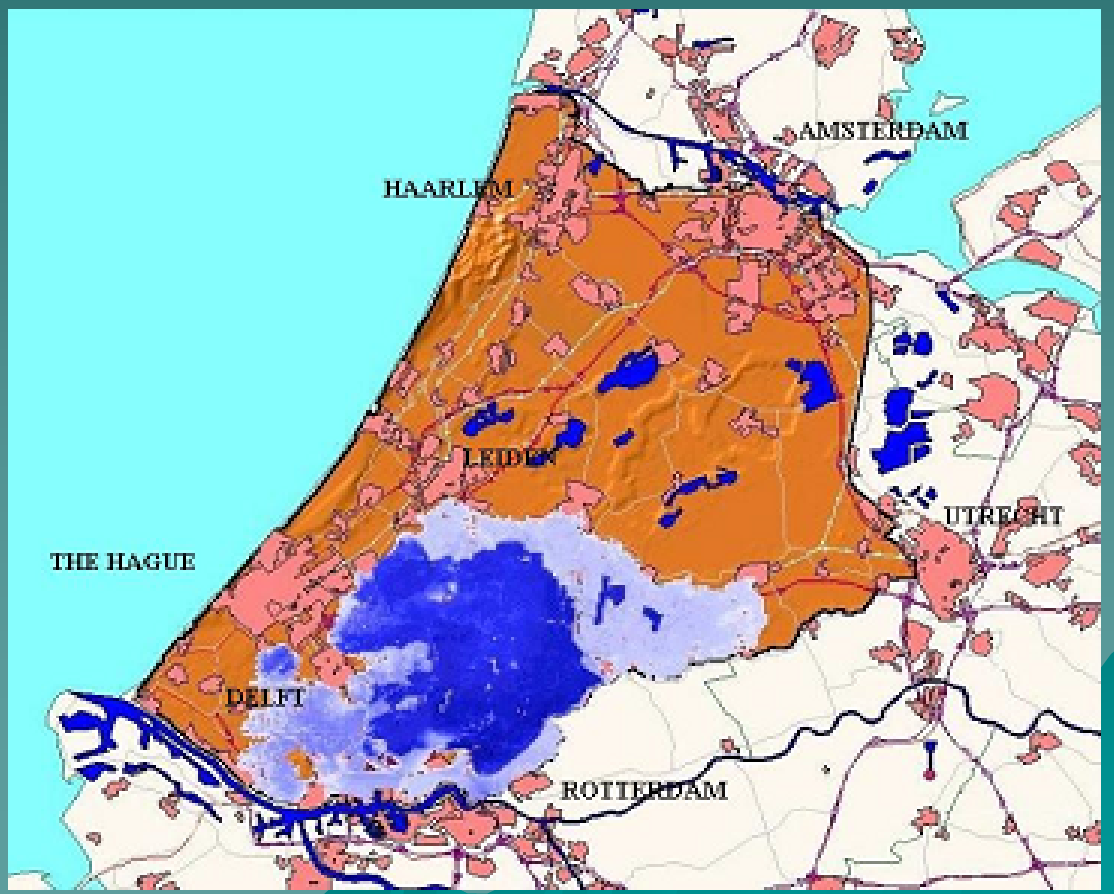
Specificity of Dutch situation

- Especially acute are systemic and group risks
- External factors:

  Climate change

  - rising sea level
  - expected increased precipitation and critical peak flows

  Subsiding ground
  in the West of the country



Shift to Risk approach to flooding I

- Current developments:
  emerging shift from probability to risk thinking

Risk = Probability x Effect

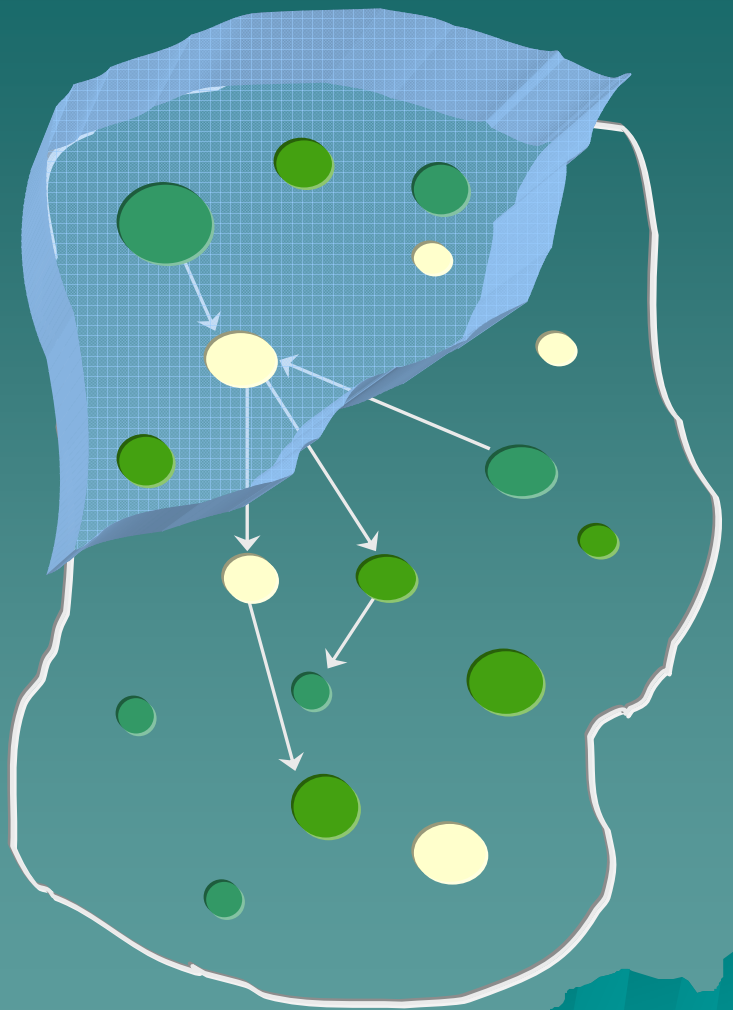
- Important to consider the interaction between the overlapping in space
  - water management system,
  - physical infrastructure **and**
  - economic network.

Shift to Risk approach to flooding II

- More attention to both **risk** components:
  - P (dike overtopping) → P (flooding)
    - Including dike failure mechanisms
  - Growing awareness of flood consequences
    - Need for economic damage appraisal
    - Economic consequence modelling
    - Economic justification for long-term solutions

Economy as a network

- Economy is a complex interconnected system
- A disaster imposes a major shock, disrupting established balances, with which an economy has to deal
- What now?



A Disaster in Economic Terms

- **Major disturbances** imply loss of connectivity in the network, and thus are *discontinuities*.
- Modelling of large-scale shocks is different from the usual pattern of (marginal) analysis
- Rather, a new way of modelling of economic effects of disasters, as well as of adaptations to the new thinking is required

Need for new concepts for disaster analysis

- Literature points out at room for new concepts:
  (*Green 2002; de Bruijn 2004; Messner and Meyer 2006; Rose 2006*)

  susceptibility
  vulnerability
  resistance
  resilience
  mitigation
  adaptation
  …

The New Concepts

There is no widely accepted agreement about these definitions in the literature yet

We shall present our interpretation of some of the concepts

Some definitions I

- *Susceptibility* – the degree to which an agent, premises or area are prone to hazard
- *Vulnerability* – the propensity of an object / system to incur damage
- *Resistance* (opposite of vulnerability) - the propensity of an object / system to withhold damage
- *Robustness* (rather applicable to marginal shocks) – the ability of an object / system to stay unaffected facing a disturbance
- *Resilience* – the ability of an (economic) system to cushion a shock, dynamically responding and adjusting in the face of a calamity, and to maintain its main characteristics, possessing learning capacity

Some definitions II

Policy-related concepts:

- *Mitigation* – aims at the reduction and control of a **hazard** (including the reduction of susceptibility)
- *Adaptation* – aims at the improvement of a **system's** response capacity (resilience), as well as at the reduction of its vulnerability

Economic modelling

- Questions asked to modellers in the light of new challenges, exploring the economic side of disasters:
  - What is potential **damage**?
    - How vulnerable are we?
  - What are the possibilities to **recover**?
    - Recovery policy to steer economic restructuring (also taking account of system's resilience)
  - What are the possibilities to **adjust** in advance?
    - Improve the protection as well as the capacity of an economy to absorb possible shocks (mitigation and adaptation)

The proposed model I

- We offer a modification of an Input-Output model: interconnectedness with geography component
- Model based on scenario analysis rather than prediction
- The model is suitable for inquiries on preventive policy options and their interpretation

The proposed model II

- A three-phase procedure (*Bockarjova et al, 2004*):

1. Accounting for the immediate post-disaster situation:
   disequilibrium
2. Design of recovery scenarios:
   new equilibria
3. Cost-benefit analysis (CBA) of various policy options:
   multiple preventive measures and recovery paths
   can be compared

The Model I

1. Derivation of the "Basic Equation" (*modelling disequilibrium*)

- [1] $\mathsf{x} = \mathsf{A}\mathsf{x} + \mathsf{f}$
- [2] $\mathsf{L} = \mathsf{I}\mathsf{x}$
- [3] $\mathsf{x} = \mathsf{A}\mathsf{x} + \left[\left(\frac{\mathsf{f}}{\mathsf{L}}\right)\mathsf{I}\right]\mathsf{x}$
- [4] $\mathsf{x} = \mathsf{M}_{\mathsf{c}}\mathsf{x}$
- [5] $M_c \equiv \left[A + \left(\frac{f}{L}\right)l\right]$

The Model II

- [6] $$M \equiv \left[A + \left(\frac{f}{L} \right) I \right] \hat{x}$$
- [7] $$= A\hat{x} + \left[\left(\frac{f}{L} \right) I \right] \hat{x}$$
- [8] $$= Z + F$$

where

- *Z* is the inter-industry deliveries of goods and services;
- *F* is for the workers' real wage bundles.

The Model III

Assumption: if sector *i* has lost 100γi percent of its capacity, also 100γi percent of its work force is lost. Introducing γi into [8], we now have:

- [9] $$M = \begin{bmatrix} \gamma_1(z_{11}+f_{11})+(1-\gamma_1)(z_{11}+f_{11}) & \cdots & \gamma_n(f_{1n}+f_{1n})+(1-\gamma_n)(z_{1n}+f_{1n}) \\ \vdots & \ddots & \vdots \\ \gamma_1(z_{n1}+f_{n1})+(1-\gamma_1)(z_{n1}+f_{n1}) & \cdots & \gamma_n(z_{nn}+f_{nn})+(1-\gamma_n)(z_{nn}+f_{nn}) \end{bmatrix}$$

or

- [10] $$M = \begin{bmatrix} \gamma_1(z_{11}+f_{11}) & \cdots & \gamma_n(z_{1n}+f_{1n}) \\ \vdots & \ddots & \vdots \\ \gamma_1(z_{n1}+f_{n1}) & \cdots & \gamma_n(z_{nn}+f_{nn}) \end{bmatrix} + \begin{bmatrix} (1-\gamma_1)(z_{11}+f_{11}) & \cdots & (1-\gamma_n)(z_{1n}+f_{1n}) \\ \vdots & \ddots & \vdots \\ (1-\gamma_1)(z_{n1}+f_{n1}) & \cdots & (1-\gamma_n)(z_{nn}+f_{nn}) \end{bmatrix}$$

- [11] $M = M_L + M_S$

The Model IV

Reminiscent of an I-O system:

- [12] $$M_s = \begin{bmatrix} (1-\gamma_1)z_{11} & \cdots & (1-\gamma_n)z_{1n} \\ \vdots & \ddots & \vdots \\ (1-\gamma_1)z_{n1} & \cdots & (1-\gamma_n)z_{nn} \end{bmatrix} + \begin{bmatrix} (1-\gamma_1)f_{11} & \cdots & (1-\gamma_n)f_{1n} \\ \vdots & \ddots & \vdots \\ (1-\gamma_1)f_{n1} & \cdots & (1-\gamma_n)f_{nn} \end{bmatrix}$$

Add elements row-wise:

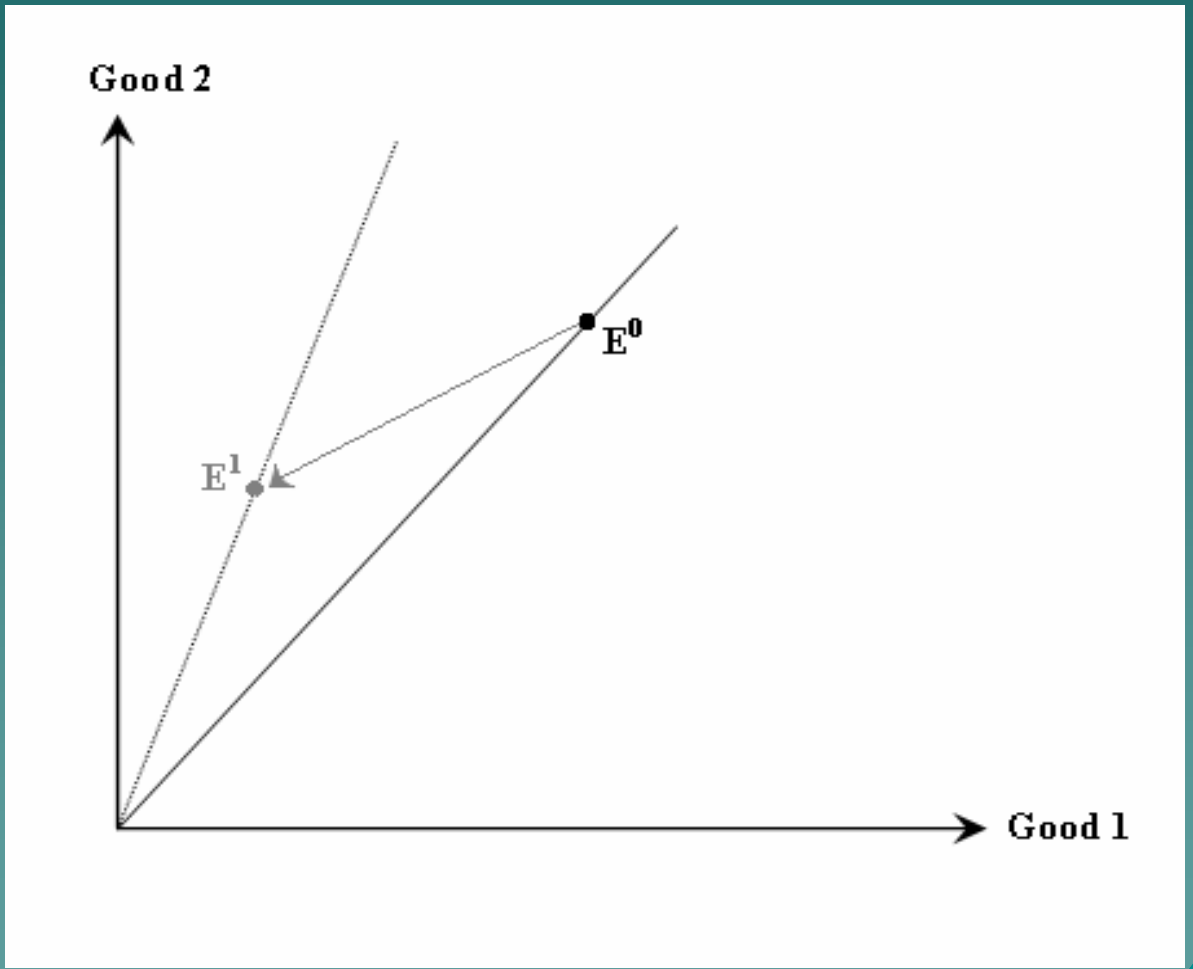
- [13] $$\begin{bmatrix} (1-\gamma_1)z_{11} & \cdots & (1-\gamma_n)z_{1n} \\ \vdots & \ddots & \vdots \\ \vdots & \ddots & \vdots \\ (1-\gamma_1)z_{n1} & \cdots & (1-\gamma_n)z_{nn} \end{bmatrix} \begin{bmatrix} 1 \\ \vdots \\ \vdots \\ 1 \end{bmatrix} + \begin{bmatrix} \sum_i (1-\gamma_i)f_{1i} \\ \vdots \\ \sum_i (1-\gamma_i)f_{ni} \end{bmatrix} = \begin{bmatrix} t_1 \\ \vdots \\ \vdots \\ t_n \end{bmatrix}$$

[13] looks like an I-O system in equilibrium, but *it is not*.
Strategy for the post-disaster recovery period modelling is required.

Modelling and Policy-making

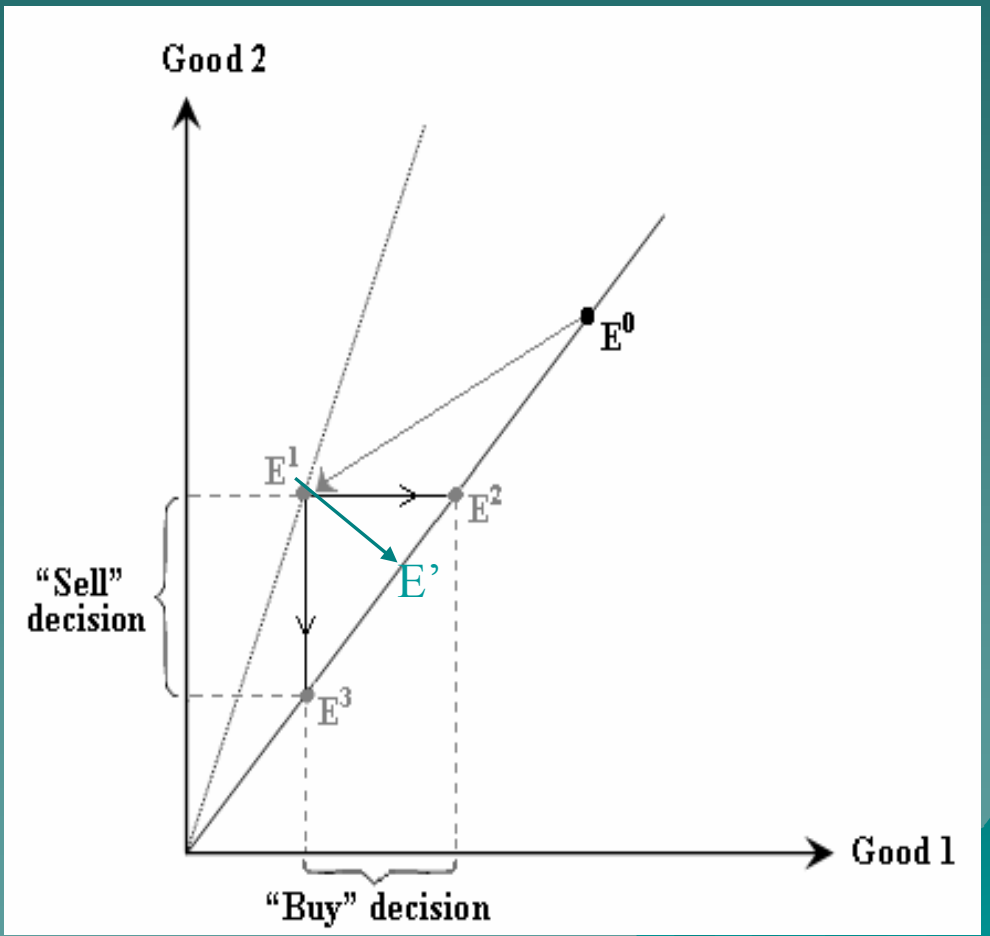
- The model is capable of analysing various options, both for recovery and for precautionary measures
- However, (political) priority setting is necessary for us as modellers to provide policy-suited scenarios
- For steering recovery, it is important to obtain a set of desirable and feasible scenarios in advance to be able to react efficiently in case a disaster strikes
- For precautionary policy-making, insight into the economic structure, vulnerability of an economy to a major shock and its resilience potential are necessary to be viewed in the longer run perspective

Post-disaster recovery spectrum



Recovery: a multiplicity of solutions

- Return to the pre-disaster situation is a threshold for damage estimation.
- This also fits in the definition of loss in terms of alternative costs:
  - where the economy could have been, has the disaster not happened.
  - gross measures of E(0) and E(1) can be compared, like total production or value added.



Adaptation and mitigation: spatial and intertemporal choices

Adaptation and mitigation: a CBA for precautionary policies I

- Government priorities in policy setting

- **Should everyone deserve the same level of protection?**

  This may imply a policy aiming at:

  - spatial redistribution of economic activities within a country to avoid damage in hazard-prone areas
  - improving country's overall resilience to respond to a shock (e.g., duplicating essential nodes in the economic network like lifelines)

Adaptation and mitigation: a CBA for precautionary policies II

- Government priorities in policy setting:

- **Should we stick to the same policy of differentiated safety standards?**

  This may imply the increase of RISK, unless strict protective measures are taken (e.g., strengthening and heightening the dikes around selected areas).

  Ultimately, this leaves us in the "vicious cycle" of guaranteed safety.

Conclusions I

- Understanding of hazard response and recovery are fundamental for systematic damage (vulnerability) assessment.
- Insights into the revival capacity of an economic system are essential for policy formation on disaster management.
- Vulnerability, resilience and adaptability lend themselves as helpful means to analyse disaster precautionary measures aiming at the reduction of potential damage in the face of potential calamity.

Conclusions II

- Our adjusted I-O model has good potential for the analysis of structural breaks and policy measures for disaster preparedness.
- The derived 'Basic Equation' brings structure into the disequilibrium modelling for the immediate disaster aftermath
- 'Basic Equation' approach also allows to incorporate new concepts emerging in disaster analysis and to carry out CBA of various pre- and post-disaster strategies