Flood security strategies

An assessment of the strategies of compartmentalization and flood shelters

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Overview

• Introduction
  – Context
  – Objective
  – Case study area

• Scenarios

• Strategies
  – Compartmentalization
  – Flood shelters in self prepared cells

• Results

• Conclusions and recommendations
Context

• The development towards actual flooding probability not only overtopping can result in dike failure

• Consider dike ring area as a whole

• Focus shift from probability to consequences

• Is it wise to invest in a lower probability by investing in dike heightening or do we need to invest in reduction of consequences?
Objective

Research objective:

To design, analyze and compare flood security strategies that aim to decrease the consequences of a flood.

I do not discuss:

- Probability of failure
- Cost benefit analysis of the strategies
The case study location

Dike ring area 6, the Northern Provinces of the Netherlands (i.e. Fryslân and Groningen)
Old (secondary) dikes are subject of discussion
Artificial hills, ‘terpen’, are part of this landscape
Scenarios

- Hydraulic boundary conditions (lake and sea differentiation)
- Breach locations are defined (15 breaches)
- Future scenario, by adding up sea level rise increased storm surges and bottom inclination
- These scenarios are used as input for 1D2D hydraulic modelling
Strategies: compartmentalization

- Secondary Dike
- Partitioning
- Value Protection Large
- Value Protection Small
Strategies: Flood shelters

- Support self-preparedness
- Safe havens
  - High grounds
  - Water resistant buildings
  - Artificial hills ‘Terpen’
- Division in hazard zones
  - Determining distance

<table>
<thead>
<tr>
<th>Flood hazard (u*d)</th>
<th>Time to respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>High &gt;7</td>
<td>Short &lt; 5h</td>
</tr>
<tr>
<td></td>
<td>Sufficient &gt;5h</td>
</tr>
<tr>
<td>Low &lt;7</td>
<td>Zone 1</td>
</tr>
<tr>
<td></td>
<td>Zone 2</td>
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<td></td>
<td>Zone 3</td>
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<td>Zone 4</td>
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</tbody>
</table>

Overview | Introduction | Scenarios | Strategies | Results | Conclusions
Planning of flood shelters
Neighbourhood scale implementation

Assessment of strategies: Hydraulic, damage and casualty modelling

- Detailed 1D2D hydraulic modeling (Sobek)
- Damage estimation (HISSSM) containing damage functions:
  - Land use types
  - Maximum waterdepth
  - Rise rate
- Extensive database of GIS maps of results for publication on our website:
  - www.vluchtplaats.nl
Flood pattern maps
Damage density maps

Overview
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Casualty density maps

<table>
<thead>
<tr>
<th>Klasse</th>
<th>Slachtoffers [km²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 - 5</td>
</tr>
<tr>
<td>2</td>
<td>5 - 10</td>
</tr>
<tr>
<td>3</td>
<td>10 - 50</td>
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<tr>
<td>4</td>
<td>50 - 100</td>
</tr>
<tr>
<td>5</td>
<td>100 - 500</td>
</tr>
<tr>
<td>6</td>
<td>&gt; 500</td>
</tr>
</tbody>
</table>

Overview | Introduction | Scenarios | Strategies | Results | Conclusions
Summary of damage, affected inhabitants and casualties

<table>
<thead>
<tr>
<th></th>
<th>Laissez-faire</th>
<th>Secondary dike</th>
<th>Partitioning</th>
<th>Value prot. Large</th>
<th>Value prot. Small</th>
<th>Flood shelters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>15 Breaks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Damage (Billion €)</td>
<td>4.5</td>
<td>2.8</td>
<td>-39</td>
<td>5.2</td>
<td>15</td>
<td>4.2</td>
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<tr>
<td>Inhabitants (*1000)</td>
<td>120</td>
<td>59</td>
<td>-51</td>
<td>116</td>
<td>3</td>
<td>94</td>
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<tr>
<td>Casualties (*1000)</td>
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<td>0.3</td>
<td>4</td>
<td>0.8</td>
<td>193</td>
<td>0.3</td>
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<tr>
<td><strong>Worst case</strong></td>
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<td></td>
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<tr>
<td>Damage (Billion €)</td>
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<td>-77</td>
<td>12</td>
<td>-50</td>
<td>12</td>
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<tr>
<td>Inhabitants (*1000)</td>
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<td>96.0</td>
<td>-73</td>
<td>218</td>
<td>-51</td>
<td>239</td>
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<tr>
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<td>1.4</td>
<td>-85</td>
<td>3.3</td>
<td>-62</td>
<td>0.6</td>
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<tr>
<td><strong>15 Breaks + Climate</strong></td>
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<td></td>
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<tr>
<td>Damage (Billion €)</td>
<td>27</td>
<td>5.7</td>
<td>-79</td>
<td>16</td>
<td>-41</td>
<td>17</td>
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<td>215</td>
<td>-65</td>
<td>345</td>
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<tr>
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<td>3.5</td>
<td>3.3</td>
<td>-5</td>
<td>13</td>
<td>279</td>
<td>2.1</td>
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<tr>
<td><strong>Worse case + Climate</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damage (Billion €)</td>
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<td>11</td>
<td>-83</td>
<td>33</td>
<td>-52</td>
<td>49</td>
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<tr>
<td>Inhabitants (*1000)</td>
<td>1006</td>
<td>195</td>
<td>-81</td>
<td>333</td>
<td>-67</td>
<td>682</td>
</tr>
</tbody>
</table>
Damage estimation for compartmentalization

Scaling 1.0 = 4.5 billion euros
Casualty estimation for compartmentalization

![Graph showing casualty estimates for different scenarios: No Comp., Secondary Dike, Partitioning, Value Protection. The graph indicates that scaling 1.0 = 289 persons.](image_url)

Scaling 1.0 = 289 persons
## Preliminary conclusions

Given future scenarios the estimated damage for this region increases approximately with a factor 4 and the estimated casualties with a factor 10.

The secondary dike strategy is promising, given the assumption that the secondary dike fails independent of the primary dike.

Partitioning can be very dangerous, depending on the flood scenario and can lead to an increased hazard.

Self prepared cells using flood shelters are very promising, but need administrative arrangements and a proactive attitude of the inhabitants, which will be the greatest challenge.

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Recommendations

The probability of the scenarios has to be calculated in order to compare the risk to conventional strategies such as dike strengthening and dike heightening.

Cost benefit analysis has to be performed to give insight in the feasibility of these strategies.

Combination of strategies has not yet been assessed and would be interesting for areas close to the sea.

Do not (yet) destroy the old existing secondary dikes as they might turn out to be life saving by slowing down the flood.

Further development of the administrative arrangements for self preparedness and awareness.
Questions
Additional slides
Dike failure mechanisms

Fig. 2. Failure modes of a dike.

(Vrijling 2001)
Dependent vs independent failure

Dikes fail when overtopping occurs

\[ P_{\text{fail}}|\left(H>H_{\text{dike}}\right) = 1 \]

All other mechanisms depend on the water level:

\[ P_{\text{fail}}|\left(H<H_{\text{dike}}\right) \ll 1 \]

- Independent
- Dependent
Method

Water level (H) [m]

Probability of failure

$P(H) [-]$

$P_{\text{fail}} | H = H_{\text{dike}}$

$P = F(H)$

Water level (H) [m]

Probability

$X$

Water level (H) [m]
Water levels at two breach locations