ADAPTATION OF COASTAL PROTECTION IN BELGIAN COASTAL TOWNS

Circle 2 – Conference on Climate Change Adaptation
Theme – Coastal areas, marine biodiversity and fisheries

Toon Verwaest, Renaat De Sutter
10/03/2014
Outline

• Policy framework
• The CLIMAR project
• New research ideas
Outline

• Policy framework
  • Master Plan Coastal Safety 2050
  • Vlaamse Baaien 2100
  • Parallel projects & relevant research
• The CLIMAR project
• New research ideas
Master Plan Coastal Safety

- Decision of 2011 – works from 2012 till 2015
- Protection of the complete Flemish coast
- Horizon 2050 including CC effects
- Tr = 1000 year storm
- Natural areas (dunes), coastal towns (dikes+beaches), harbours-economic activity
- No “large measures” but beach nourishment, local dike or quay wall heightening, stilling wave basins, etc...

www.afdelingkust.be
Masterplan Vlaamse Baaien (Flemish bays)

- Integrated coastal vision 2100
- 5 criteria: safety, sustainability, natural, attractiveness, development
- Coastal safety, economy, energy, nature
- Energy atols, extension of Zeebrugge harbour, new shipping lane Antwerp, sand motors, ....
- 2014 : decision on research projects

http://www.maritiemetoegang.be/vlaamse-baaien
Parallel policy projects & policy related scientific research

• Parallel policy projects
  • Dep. Spatial Planning : Metropolitan Coastal Landscape
    • Ongoing, research by design of landscape & spatial planning scenario’s
  • Federal government : Marine Spatial Plan

• Relevant research
  • Ccaspar
    • 2009-2013 www.ccaspar.ugent.be on future spatial visions versus CC
  • Quest 4D
  • Climar
Introduction – Flanders Hydraulics Research

- part of the Government of Flanders – Department of Mobility and Public Works
- research on the effects of water dynamics
  - optimization of hydraulic constructions (harbours, locks, dams, dikes, weirs...)
  - manoeuvrability of ships in harbours and inland waterways
  - management of navigable rivers and coast: to combat the consequences of water shortage or flooding
Outline

• Policy framework
• The CLIMAR project
  • Goal of the project
  • Primary and secondary CC effects
  • Measures and evaluation
• New research ideas
WP1 Definition and modelling of climate change induced primary impacts at North Sea scale

Climate change induced primary impacts: sea level rise, increased storminess, possible increased rainfall, salinity, temperature, etc.

- Definition and modelling

WP2 Deduction of climate change induced secondary impacts

Secondary impacts on the marine ecosystem in general and related socio-economic activities

- Identification and classifications

WP3 Identification of adaptation scenario’s/measure

Case study - Coastal flooding

- Modelling

Case study - Coastal flooding

- Identification/modelling of adaptation scenario’s/measure

Case study - Fisheries sector

- Impact assessment

Case study - Fisheries sector

- Identification/modelling of adaptation scenario’s/measure

Marine ecosystem in general and related socio-economic activities.

- Extrapolation of adaptation scenario’s/measure

WP4 Evaluation of adaptation scenario’s/measure

Case study - Coastal flooding

- Evaluation adaptation scenario/measure

Case study - Coastal flooding

- Evaluation adaptation scenario/measure

Case study - Fisheries sector

- Evaluation adaptation scenario/measure

Marine ecosystem in general and related socio-economic activities.

- Evaluation adaptation scenario/measure

Elaboration of an evaluation framework for adaptation scenario’s/measure as a response to climate induced impacts (North Sea)

Integrated sustainability assessment of adaptation scenario’s/measure

Evaluation of the effects of the proposed adaptive strategies (embedding in policy, practical integration, implementation)

Formulation of recommendations towards North Sea future policy and its different socio-economical activities.
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Indicator Approach

Eco logical impacts
Social impacts
Economic impacts
Vulnerability
Value
Risk without adaptation
Risk with adaptation

Secondary impact analysis

Modelling climate change induced primary impacts

Anthropogenic impacts (e.g. coastal infrastructure)

Physical/chemical modelling (temperature, salinity)
Hydraulic modelling (sea level, storminess, flooding)
Sedimentation modelling (erosion/deposition)

Climate change scenarios

Socio-economic scenarios (demography, GDP, fuel prices, market evolution, etc.)

Identification of adaptation measures

Non-structural measures
Structural measures

Adaptation scenarios

Comparing benefits & costs of adaptation measures

Evaluation framework

Evaluation of adaptation CBA - MCA

Policy & legislation

Policy advice

Public participation
Primary impacts

- Literature study (physical & chemical parameters)
- Statistical data analysis (SLR, t, waves & wind speed)
- Numerical models:
  - Hydrodynamic models
  - Wave models
  - Sediment transport models

Trend analysis
SLR Oostende (1927-2006)
## Primary impacts and CC scenario’s

### Scenario’s 2040

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Mean +</th>
<th>Warm</th>
<th>Warm +</th>
<th>Worst Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
<td>0%</td>
<td>+ 2%</td>
<td>- 1%</td>
<td>+ 4%</td>
<td>+ 4%</td>
</tr>
<tr>
<td>Average sea level</td>
<td>+ 30 cm</td>
<td>+ 30 cm</td>
<td>+ 40 cm</td>
<td>+ 40 cm</td>
<td>+ 100 cm</td>
</tr>
<tr>
<td>Storm surge level</td>
<td>+ 30 cm</td>
<td>+ 40 cm</td>
<td>+ 45 cm</td>
<td>+ 60 cm</td>
<td>+ 70 cm</td>
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### Scenario’s 2100

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Mean +</th>
<th>Warm</th>
<th>Warm +</th>
<th>Worst Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windsnelheid</td>
<td>0%</td>
<td>+ 4%</td>
<td>- 2%</td>
<td>+ 8%</td>
<td>+ 8%</td>
</tr>
<tr>
<td>Average sea level</td>
<td>+ 60 cm</td>
<td>+ 60 cm</td>
<td>+ 93 cm</td>
<td>+ 93 cm</td>
<td>+ 200 cm</td>
</tr>
<tr>
<td>Storm surge level</td>
<td>+ 60 cm</td>
<td>+ 80 cm</td>
<td>+ 80 cm</td>
<td>+ 130 cm</td>
<td>+ 240 cm</td>
</tr>
</tbody>
</table>

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[Logo of belspo]

[Logo of antea group]
Risk calculation

- Determination of representative superstorm: +8 m TAW anno 2000
- Selected climate scenario’s: (M+2040), M+2100, (WCS2040), WCS2100
- Translation of representative superstorm into the selected climate scenario’s:

<table>
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<tr>
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<th>2100</th>
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<tr>
<td>Current</td>
<td>~8 m</td>
<td>~8 m</td>
<td>~8,4 m</td>
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<tr>
<td>Mean +</td>
<td>~8,4 m</td>
<td>~8,8 m</td>
<td></td>
</tr>
<tr>
<td>Worst Case</td>
<td>~8,7 m</td>
<td>~10,4 m</td>
<td></td>
</tr>
</tbody>
</table>
Secondary effects - Indicators

• Should translate the impact of CC
• Quantifiable
• Ecological (?) – Social (?) – Economical
• Direct – Indirect (?) consequences

• Area of intertidal beach
  • Number of victims
  • Direct economical damage
Risk calculations

- Risc calculation:
  - Beach- and dune erosion
  - Initiation of breach
  - Breach growth and overtopping
  - Economical damage and victims

NB: different types of flood risk
- beaches, dunes,
- hinterland,
- harbours on the dike

Not treated in CLIMAR

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Impact of climate change: higher risk on damage and victims – flood map – breach locations current climate versus sea level rise + 2m
Impact of climate change: higher risk on damage and victims – flood map

Worst case scenario 2100
extreme surge + 2,4 m
+ 2 m MSL
+ 0,4 m setup (+8 % windspeed)
Impact of climate change: higher risk on damage and victims

<table>
<thead>
<tr>
<th>Climate</th>
<th>Economical damage [€]</th>
<th>Victims [#]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anno 2000</td>
<td>~ 3 M Euro (*)</td>
<td>~ 3000 victims (*)</td>
</tr>
<tr>
<td>M+ 2100</td>
<td>* 10 times</td>
<td></td>
</tr>
<tr>
<td>WCS 2100</td>
<td>* 100 times</td>
<td></td>
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</table>

(*) Data Masterplan Coastal Safety for superstorm with return period 17,000 year
Impact of climate change: loss of beach area
Impact of climate change: loss of beach area

<table>
<thead>
<tr>
<th>Municipality</th>
<th>M+ scenario (2100)</th>
<th>WCS scenario (2100)</th>
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</thead>
<tbody>
<tr>
<td>De Panne</td>
<td>- 19 %</td>
<td>- 51 %</td>
</tr>
<tr>
<td>Koksijde</td>
<td>- 18 %</td>
<td>- 49 %</td>
</tr>
<tr>
<td>Nieuwpoort</td>
<td>- 17 %</td>
<td>- 50 %</td>
</tr>
<tr>
<td>Middelkerke</td>
<td>- 16 %</td>
<td>- 55 %</td>
</tr>
<tr>
<td>Oostende</td>
<td>- 19 %</td>
<td>- 60 %</td>
</tr>
<tr>
<td>Bredene</td>
<td>- 17 %</td>
<td>- 47 %</td>
</tr>
<tr>
<td>De Haan</td>
<td>- 19 %</td>
<td>- 48 %</td>
</tr>
<tr>
<td>Blankenberge</td>
<td>- 17 %</td>
<td>- 47 %</td>
</tr>
<tr>
<td>Zeebrugge</td>
<td>- 13 %</td>
<td>- 35 %</td>
</tr>
<tr>
<td>Knokke-Heist</td>
<td>- 12%</td>
<td>- 40 %</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>- 17 %</strong></td>
<td><strong>- 48 %</strong></td>
</tr>
</tbody>
</table>
Adaptation measures

- Measures per sector (coastal defence)
- Taking into account other sectors (e.g. coastal tourism)
- No-regret measures
- Flexibility
- Sustainable (~ choice of indicators)
Adaptation measures

Structural measures
1 Superdikes
2 Beach nourishment
3 Multifunctional islands

Non-Structural measures
4 Managed retreat
5 Preparedness of coastal community
Example multifunctional islands as sea defence

ca. 240 Mm³

ca. 90 Mm³
Example multifunctional islands as sea defence

1) wave climate (M+ klimaatscenario 2040 ~ +8,4 m stormvloed)

Reduction in wave height:

Reduction in wave period:

2) Limited breach reduction => negligible risk reduction effect

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flanders HYDRAULICS RESEARCH

anteagroup
Non-structural measures

- Win-win if combined with structural measures, in order to reduce investment costs
- Problems with quantification of effect of non-structural measures → future research
Conclusions of the CLIMAR project – case coastal defence

• CC impact induces a strong storm risk increase at the Belgian coast
• Reinforcement of the first sea defence line avoids these CC risks but investment costs increase along with the CC effects – need for research on new approaches / non-structural measures
• Sand bank heightening (islands) is not an efficient measure in general,
• There is a need for quantification of non-tangible effects (health, ecology, social, ...) as well as the effect of non-structural measures
Outline

• Policy framework
• The CLIMAR project
• New research ideas
  • Protection against Superstorms
  • Flood protection within multi-functional seafronts
  • Innovative beach nourishment
  • Coastal flood risk calculation tools
Protection against Superstorms

- Physical scale testing + numerical scale modelling + new techniques
- Hydraulic modelling + overtopping + dike breaching detection tool
- Combination of testing of final designs and future conceptual ideas

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<th>Test #20</th>
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<th>PARAMETER</th>
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<td>2.54</td>
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<tr>
<td><em>A-VD93B</em></td>
<td>Hm0 (m)</td>
<td>4.75</td>
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<td>Tm-1.0, target (s)</td>
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<td></td>
<td>Hs, target (s)</td>
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<td></td>
<td>Hm, toe (m)</td>
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<td>q (l/s/m)</td>
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<th>Test #20</th>
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<table>
<thead>
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<th>Case</th>
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<th>Model Scale (1:25)</th>
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<tbody>
<tr>
<td>+8.00m “superstorm”</td>
<td>SWL (m TAW)</td>
<td>Hm0 (m)</td>
</tr>
<tr>
<td>7.94</td>
<td>4.97</td>
<td>9.00</td>
</tr>
<tr>
<td>+7.50m “superstorm”</td>
<td>7.44</td>
<td>4.75</td>
</tr>
<tr>
<td>1000 year “toetsing”</td>
<td>6.84</td>
<td>4.75</td>
</tr>
</tbody>
</table>

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**HYDRAULICS RESEARCH**
Flood protection within multi-functional seafronts

(Foto adapted by Xuexue Chen)
Coastal flood risk calculation tools

New developments: ecological impact / social impact / optimization of financial damage estimations (e.g. damage at dike, in harbours) / effect of non-structural measures

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Innovative beach nourishment

• Long term morphological balance
• Monitoring of beach nourishment
• Impact at harbour entrances, ...
• Sand motors

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[Logos of belspo and antea group]
Thanks for listening!