The development of a library of coastal vulnerability indicators

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Flood loss assessment: why?

To understand the risk:

“'flood risk’ means the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event.” Article 2 Directive 2007/60/EC

To support decision:

Tax money - budget allocation
Project appraisal evaluation
(CBA, CEA, MCA)
Ex-post assessment
Insurance Companies
Private purpose

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Flood loss assessment: how?

Source-Pathway-Receptor-Consequence approach

Three step approach:
– Classification of the element at risk
  land use, first order
– Exposure analysis
  flood/water characteristics
– Vulnerability analysis
  loss depending of $n$ factors
## Flood loss assessment: what?

<table>
<thead>
<tr>
<th></th>
<th>Tangibles</th>
<th>Intangibles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct</strong></td>
<td>Damages to assets and contents</td>
<td>Life and injuries Ecosystems</td>
</tr>
<tr>
<td><strong>Indirect</strong></td>
<td>Business, transport, utilities services</td>
<td>Long-term health (physical and mental) Community disruption</td>
</tr>
<tr>
<td></td>
<td>disruption and higher order</td>
<td></td>
</tr>
</tbody>
</table>
Flood loss assessment in Europe

UK Multi-Coloured Manual suite of products Flood Hazard Research Centre, Middlesex University

Germany FLEMO/FLEMOps – HOWAS 21 GFZ Helmholtz-Zentrum Potsdam

Netherlands HIS-SSM Deltasres / Standard Method 2004

Belgium LATIS Flanders Hydraulics Research and Ghent University

France L’ACB CEPRI / PAPI/ MEDDTL

EU JRC Model Joint Research Centre - Institute for Environment and Sustainability/HKV Consultants
Flood and Coastal Defence Project Appraisal Guidance: Economic Appraisal

5.2 million properties at risk
DEFRA funding
Cost-Benefits Analysis
Project Appraisal Report
Spreadsheet

<table>
<thead>
<tr>
<th>Costs and benefits (£k)</th>
<th>Op 1 - No Project</th>
<th>Op 2</th>
<th>Op 3</th>
<th>Op 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV costs from estimates</td>
<td>9</td>
<td>321</td>
<td>338</td>
<td>343</td>
</tr>
<tr>
<td>Optimism bias adjustment</td>
<td>14</td>
<td>90</td>
<td>89</td>
<td>108</td>
</tr>
<tr>
<td>Total PV Costs for appraisal (PVC)</td>
<td>22</td>
<td>411</td>
<td>427</td>
<td>451</td>
</tr>
<tr>
<td>PV damages</td>
<td>3,485</td>
<td>317</td>
<td>317</td>
<td>317</td>
</tr>
<tr>
<td>Total PV damages (PVD)</td>
<td>3,485</td>
<td>317</td>
<td>317</td>
<td>317</td>
</tr>
<tr>
<td>PV damage avoided (benefits)</td>
<td>3,169</td>
<td>3,169</td>
<td>3,169</td>
<td>3,169</td>
</tr>
<tr>
<td>Total PV benefits (PVB)</td>
<td>3,169</td>
<td>3,169</td>
<td>3,169</td>
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</tr>
<tr>
<td>Net Present Value NPV</td>
<td>2,757</td>
<td>2,742</td>
<td>2,717</td>
<td></td>
</tr>
<tr>
<td>Average benefit/cost ratio</td>
<td></td>
<td>7.71</td>
<td>7.42</td>
<td>7.02</td>
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<td>Incremental benefit/cost ratio</td>
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5.2 million properties at risk

DEFRA

Cost-B

Project

Spread

Confidence that the project is desirable

Benefit-cost ratio

Net Present Value NPV

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The Loss - Probability Curve

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Residual Damages  Benefits

- without reservoir
- with reservoir
The Middlesex FHRC* Manuals:

- **1970**: Centre founded
- **1977**: Direct damages
- **1987**: Indirect losses
- **1990**: FLAIR
- **1992**: Coastal added
- **2005**: Multi-Coloured Manual
- **2005**: All Update topics

* Flood Hazard Research Centre, Middlesex University

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The Middlesex FHRC* Manuals:

http://www.mcm-online.co.uk/

* Flood Hazard Research Centre, Middlesex University

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Chapters: techniques and data

1. Introduction
2. Using Appraisals to Make Better Choices
3. Flood Risk Management Benefits: Theory and Practice
4. Residential Properties
5. Non-Residential Properties
6. Other Flood Losses
7. Coastal Erosion: Potential Losses and Benefits
8. Recreational Gains and Losses
9. Appraisal of Flood Risk Management for Agriculture
10. Assessing Environmental Benefits and Costs
1. Different type of appraisal to assess flood losses to residential properties
2. Direct losses
   Damages to residential property (building fabric, inventory items, cleaning costs (Property type, Flood type, Flood warning, Property-level Protection))
   Vehicle damages
3. Indirect losses and intangibles
   Evacuation, Health Risk to life, social vulnerability
4. Economic losses!

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Progress in the development of methodologies for flood loss assessment in Europe BUT issues on data qualities and availability

Towards a Coherent Framework?

User community of stakeholders
Land use data and classification
Critical installations
Major network
Hotspots area
Appropriate Depth/Damages curves
Flood hazard model
Intervention options: costs, fragility curves
Loss Probability Curve
Robustness and Uncertainty
Assessing the losses – research challenges

Limits

• Higher order of losses are often neglected (spatial and temporal - systemic)
• Intangibles are underestimated (economic loss – CBA)
• Resilience and recovery: ability for a system to return to its initial state

Necessary changes

• Better recognize systemic vulnerability
• Considering flows rather than stocks
• Change metrics

From Menoni et al., 2010
Assessing the recovery

Time?

Final State?

Scale of the Shock – Recovery Pattern?

RISC-KIT

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The **open-source and free-ware RISC-KIT tool kit** will consist of

- a **Coastal Risk Assessment Framework (CRAF)** for assessing hot spot areas: Hazard model, Vulnerability library, Impact model, MCA

- a quantitative, high-resolution **Early Warning and Decision Support System (EWS/DSS)** for use on these hot spots

- a web-based management guide offering innovative, cost-effective, ecosystem-based **DRR measures**;

- and a **Coastal Risk Database of present and historic socio-economic and physical data**.

- all designed for **Europe’s coastal managers, decision-makers and stakeholders** to **evaluate the effect** of climate-related, socio-economic and cultural changes on coastal risk and **choose the best** prevention, mitigation and preparedness measures for their coast.

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http://www.risckit.eu

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Overview of CRAF

Coastal Hazard

Coastal Strip Exposure

Vulnerability Indicators

Impact Assessment

MCA – Visualisation Hotspots Identification

Up to 100 km

Probability of erosion and inundation (water level and water discharge HAZARD)

Geomorphic Vulnerability

Transfer Function (EXPOSURE)

Coastline

Limits of potential flooding

1km

HINTERLAND

LAND USE UNIT VULNERABILITY AND IMPACTS
Development of CVLI

Click on your country of interest:

- Bangladesh
- Belgium
- Bulgaria
- France
- Germany
- Italy
- Portugal
- Spain
- Sweden
- United Kingdom

Click on a category below:

- **Physical vulnerability**
  - **Built Environment**
    - Damage to residential and commercial property
    - Damage to infrastructure and public assets
    - Building collapse
  - **Population**
    - Demographics
    - Social Flood Vulnerability
  - **Ecosystems**
    - Dunes
    - Saltmarshes
    - Pine woods
    - Berths
    - Biogenic reefs
    - Grasslands
    - Seagrass Meadows
    - Forests
    - Livestock
    - Crops

Return to Country Index

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Built Environment

• Depth damages curves
  • Fluvial flooding (depth)
  • Availability varies from one country to another
  • Harmonization / transfert remain difficult
  • Limited information on specific assets
  • Time to repair?

• Building collapse
  • Very few studies
  • Risk matrix

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Population

- **Impacts**
  - Risk to life, health impact, financial recovery

- **Social Vulnerability Indicators**
  - Factors?
  - Weight?
  - Double counting?
  - Availability and scale of data (e.g. census data)
  - Comparative descriptor than quantitative assessment
Ecosystems

- Different types more or less adapted
- Recovery time / change in ecosystem
- Loss of ecosystem services

![Ecosystems Diagram]

<table>
<thead>
<tr>
<th>Crop group</th>
<th>Sensitivity to saline flooding</th>
<th>Yield Penalty (extra penalty as a % of normal yield relative to fluvial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley and oil seed rape</td>
<td>Tolerant</td>
<td>10%</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>Tolerant</td>
<td>10% (including preplanting)</td>
</tr>
<tr>
<td>Winter cereals</td>
<td>Moderately tolerant</td>
<td>15%</td>
</tr>
<tr>
<td>Spring cereals</td>
<td>Moderately sensitive</td>
<td>10% before planting, 20% after</td>
</tr>
<tr>
<td>Spring peas</td>
<td>Moderately sensitive</td>
<td>15% before planting, 20% after</td>
</tr>
<tr>
<td>Horticulture and potatoes</td>
<td>Sensitive</td>
<td>30% before planting, 100% after</td>
</tr>
</tbody>
</table>

From THESEUS EU project Zanuttig et al., 2014
Systemic vulnerability

Propagation of the direct impact through different systems beyond the hazard area (spatial and temporal dimension)

Interruption / disruption and their impacts

Systemic approach:

- Nodes and networks: flow and capacity
- Dependencies and interdependency
- Degrees of uniqueness / redundancy
- Substitution
- Prioritisation / relative importance
- Boundaries
- Scale effect
A 5 step approach

Template for assessing systemic vulnerabilities
Use this template for all systems

The 5 step approach

1. Approach stakeholders: ascertain the importance of the system; collect data
2. Produce a table listing the key components
3. Produce a schematic of the system
4. Map the schematic diagram
5. Develop a narrative to describe the vulnerability of the selected system and its potential consequences for the overall system

<table>
<thead>
<tr>
<th>Asset ID (assign a unique code)</th>
<th>Asset Description</th>
<th>Input</th>
<th>Output</th>
<th>Capacity</th>
<th>Likelihood of Exposure? (High, Med, Low, None)</th>
<th>Sensitivity (High, Med, Low, None)</th>
<th>Is the asset unique? (Yes/No)</th>
<th>Surrogate measures</th>
<th>Dependency (list factors)</th>
<th>Estimated repair time (hours)</th>
<th>Prioritisation (1-5)</th>
</tr>
</thead>
</table>

- Critical services: electricity, water, gas
- Transport network: road, train, port/harbour
- Others: business supply chain, financial

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Conclucion

• Holistic analysis of vulnerability is required
  Better data collection – appropriate information
• Model propagation of losses – complex system
  Innovative modelling approach
• Quantitative assessment remains limited
  Descriptive approach and discussion with decisions makers are key
Next Steps

• Completion of the coastal vulnerability indicators library
• Development of the Agent-Based Modelling for impact assessment
• CRAF from hazard model to MCA Visualisation
• Testing on pilot case studies
• Application on all case studies
Thank you very much

For more information,

MCM http://www.mcm-online.co.uk/

ConHaz http://conhaz.org/

Guidance for assessing flood losses - WP6 deliverable
Prof. Colin Green, Dr. Christophe Viavattene, Dr Paul Thompson

Risc-kit http://www.risckit.eu


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