METHODOLOGY FOR FLOOD RESILIENCE INDEX

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Outline

• Introduction
• Resilience and vulnerability
• Adding resilience to flood risk management
• Methodology
• Conclusion
Introduction

- The shift from traditional flood risk management put a vulnerability in the focus
- Shift is done from typical technical solutions that is provided by pure engineering science to a concept of understanding the conditions associated with human actions, economic change and institutional capacity
Resilience and vulnerability

- System from an ecological point of view doesn’t need to define the conditions which will provide some functionality and structure
- Driving approach to improve sustainability of urban systems to flooding processes (resilience concept)
- Resilience of physical and social components of urban system
- How to describe and assess flood risk in urban systems (city)?

**carrying capacity** → **vulnerability** → **resilience**

Maximum tolerable damage

Measure and assess carrying capacity of a urban system
Resilience and vulnerability

- Resilience of urban systems – to what? Up to what level?
- It can be defined by identifying what system attributes are to be resilient, and to what kind of disturbances.

3 Directions for preventing an urban system to become unstable

- Adjusting the thresholds of a system in respect to changes in response to flood waves
- Defining the level to which system is capable of self-organizing
- Define the level to which system is able to build and increase capacity for learning and adaptation
Adding resilience to flood management – 5R

- **Relief** – A buffer element
- **Resist** – Prevention of flood risk if possible, threshold capacity
- **Response** – Measures taken during the flood
- **Recovery** – Providing support to recovery processes
- **Reflect** – Actions focus on increasing awareness and adaptive capacity, learning from past event and/or preparation for an uncertain future

Capacity of urban systems and communities is improved in each part of the flood risk management cycle

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Methodology

• Development of urban flood vulnerability and resilience assessment tools with indicators enables to provide a comprehensive overview of vulnerability and resilience of a city and community

• The relationship between the nature of interaction and the structure of an urban system is fundamental
Methodology – scales for analysis

New urban environments based on urban cells integrating services (specific scale)

Energy grid / smart grid → Convergence/ Resilience
Water grid / water cell → Convergence/ Resilience
Risk management → Convergence/ Resilience
Methodology – scales for analysis

- CITY
- District
- Block
- Parcel

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Methodology – mapping urban system

Urban Functions
- Housing
- Education
- Work
- Safety and governance
- Health
- Leisure and tourism
- Religion
- Food (storage)
- Transportation network
- Water networks
- Communication network
- Solid waste network
- Energy network

Components

Flux

CITY

City services

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Methodology – Flood Resilience Index (FRI)

• Index is represented as a level of flood resilience assessment in analyzed area and for certain flood characteristics

• Critical assumptions:
  – method is a simplification of reality
  – addressing the flooding processes in urban systems
Methodology – Flood Resilience Index (FRI)

- The urban system is considered through five dimensions: natural, physical, economical, social and institutional.
- The indicators are chosen according to the following criteria:
  - Sensitivity
  - Availability
  - Affordability and
  - Relevance
- The evaluation of the Flood Resilience Index (FRI) on parcel/building and the block scale focuses on urban function.
- The evaluation of FRI for the city and district scale is done through five dimensions: natural, physical, social, economic and institutional.
Methodology – FRI on parcel/building scale

• Physical components of urban system have a unique building topology. There are eight different building typologies for analysis that will filter requirements for urban functions and for city services
  – Services (related to external dependencies)
  – Safety of urban function (related to the safety for users)
Table 1: Availability levels of urban functions

<table>
<thead>
<tr>
<th>Availability level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not available</td>
</tr>
<tr>
<td>1</td>
<td>Poor availability – major interruptions</td>
</tr>
<tr>
<td>2</td>
<td>Low availability – interruptions provide minimum availability</td>
</tr>
<tr>
<td>3</td>
<td>Medium – small interruptions that are tolerable for small flood durations</td>
</tr>
<tr>
<td>4</td>
<td>Medium-high – interruptions that are tolerable for long flood durations</td>
</tr>
<tr>
<td>5</td>
<td>Requirement fully provided</td>
</tr>
</tbody>
</table>

Table 2: Evaluation of FRI for building scale

<table>
<thead>
<tr>
<th>Requirements for urban function</th>
<th>Availability level (0 – 5)</th>
<th>FRI (parcel/building scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTERNAL SERVICES</td>
<td></td>
<td>FRI(building) = Availability level 8</td>
</tr>
<tr>
<td>Energy</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>INTERNAL SERVICES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food availability</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>Occupation of urban function</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
<tr>
<td>Access to the urban function</td>
<td>1,2,3,4,5</td>
<td></td>
</tr>
</tbody>
</table>
Methodology – FRI for city/district scale

• Focusing on 5 dimensions
• Each dimension contributes to the evaluation of the flood resilience index for the particular urban system

Schematic presentation of FRI evaluation of city/district scale
Methodology – FRI for city/district scale

- Constructions of a rating scale with weights for all variables need to be done using weighted indexes

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low 0-2</td>
<td>The activities are not clear and coherent in an overall flood risk management (5R). Awareness is very low on the issues and motivation to address them. Interventions have a short-term character. Actions limited to crisis response.</td>
<td></td>
</tr>
<tr>
<td>Low 2-3</td>
<td>Awareness of the issues and motivation to address them exist. Capacity building of human resources remains limited. Capacity to act is improved and substantial. Interventions are more numerous and long-term. Development and implementation of solutions.</td>
<td></td>
</tr>
<tr>
<td>Medium 3-4</td>
<td>Integration and implementation of solutions is higher. Interventions are extensive, covering all main aspects of the ‘problem’, and they are linked within a coherent long-term strategy.</td>
<td></td>
</tr>
<tr>
<td>High 4-5</td>
<td>A “culture of safety” exists among all stakeholders, where the resilience concept is embedded in all relevant policies, planning, practice, attitudes and behaviour.</td>
<td></td>
</tr>
</tbody>
</table>
Limitations of the proposed index

• The outcome indicators were developed from actions in flood risk management cycle.
• The flood resilience index still depends on some assumptions.
• The proposed measurement of indicators relies on weights (assign for each indicator).
• Some limitations related to providing a quality measure of the process are possible since weights are used to intensify the scores in the assessment.
Conclusion

• The flood resilience concept brings a new philosophy to urban systems, ‘living with floods’
• The Flood Resilience Index (FRI) represents a tool for stakeholders and decision makers
• The imperative is to acknowledge the importance of social, institutional and economical component when managing flood risk
Theoretical presentation of flood resilience dynamics

- Agricultural and commercial period
- Commercial and industrial period
- Environmental crisis
- Sustainable development concept

Concentration of population and property:
- < 5000 inhab./km²
- < 10000 inhab./km²
- < 20000 inhab./km²

Developing city
- Developed city

Time

Resilience
Conclusion

• The importance is in the possibility to use experience from flood resilience urban systems and avoid huge flood damages and dysfunction.

• The developing urban systems can find a good practice and good paths towards flood resiliency without reaching a low level of functioning.
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