Smart Control of the Climate Resilience in European Coastal Cities

Quantitative risk models and their importance in the design of financial resilience strategies

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Work Package 6: Strategies to increase the financial resilience of coastal cities

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Importance of disaster risk management

- There is growing worldwide attention towards the management and reduction of catastrophe risk
- Examples of recent international initiatives:

Sendai Framework for Disaster Risk Reduction

European Directive on the assessment and management of flood risks

Importance of disaster risk management

UNDRR
UN Office for Disaster Risk Reduction

Goal: "Prevent new and **reduce** existing **disaster risk** through the implementation of (…) measures that prevent and reduce hazard exposure and vulnerability to disaster, **increase preparedness for response and recovery**, and thus **strengthen resilience**."

Priority 1: Understanding disaster risk

Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment.

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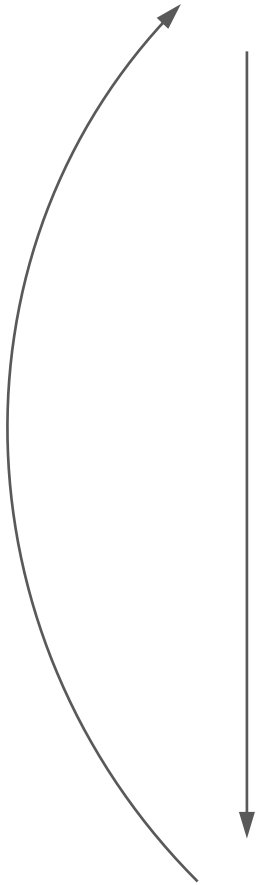
Disaster risk management cycle



Risk identification	• Improved identification and **understanding of disaster risk through** building capacity for **assessment** and **analysis**
Risk reduction	• Avoided creation of new risks and reduced risk in society through greater disaster risk consideration in the policy and investment
Financial protection	• Increased **financial resilience** of government, private sector and households **through financial protection strategies**
Preparedness	• Improved capacity to manage crisis through developing forecasting and disaster management capacities
Resilient recovery	• Quicker, more resilient recovery through support for reconstruction planning

(Global Facility for Disaster Risk Reduction)

Quantitative risk modelling

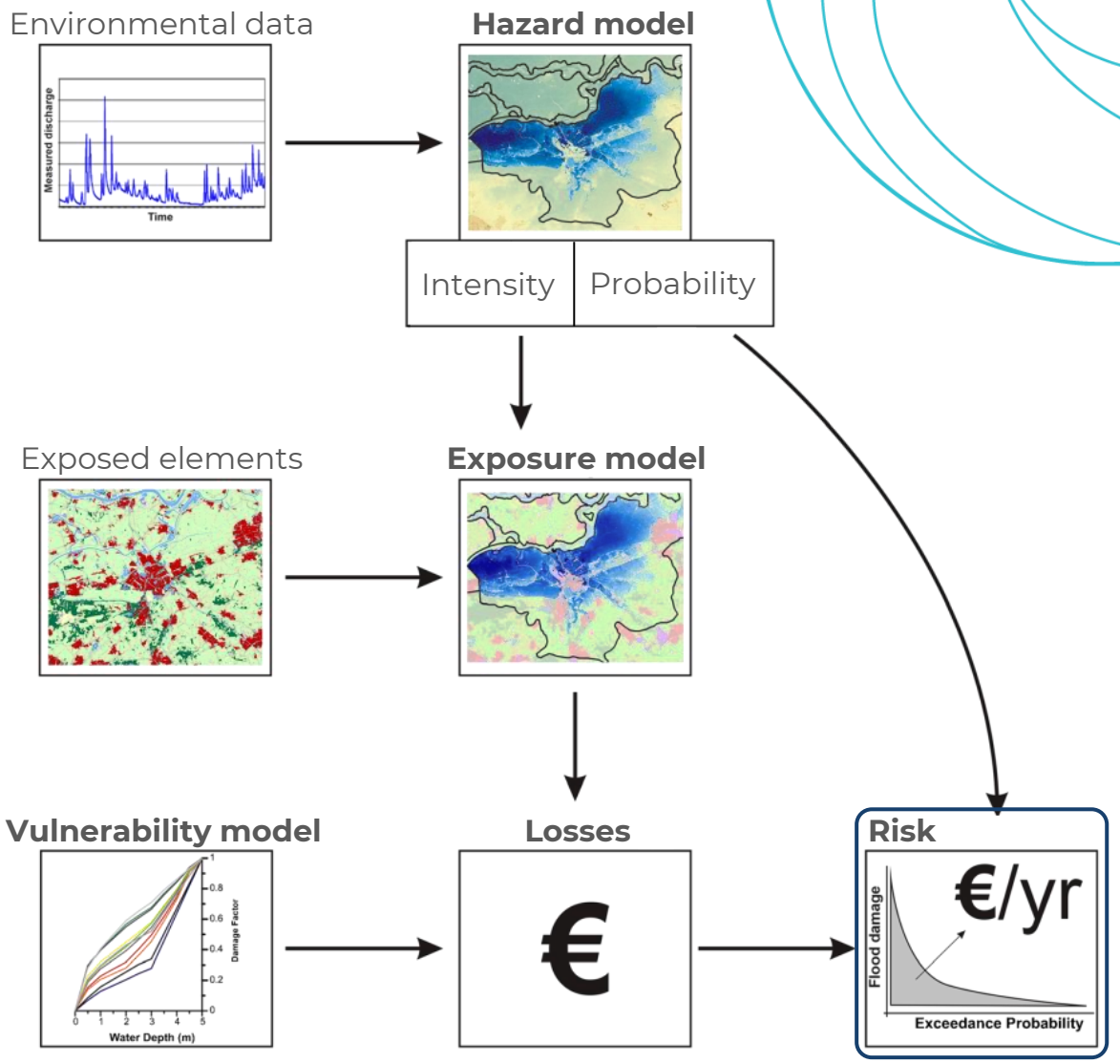
Risk: probability that a certain impact or loss will occur, function of three components:

Risk = Hazard × Exposure × Vulnerability

Hazard
Describes the frequency and intensity of a given peril (e.g., floods)

Exposure
Describes the spatial distribution, characteristics and replacement values of assets at risk

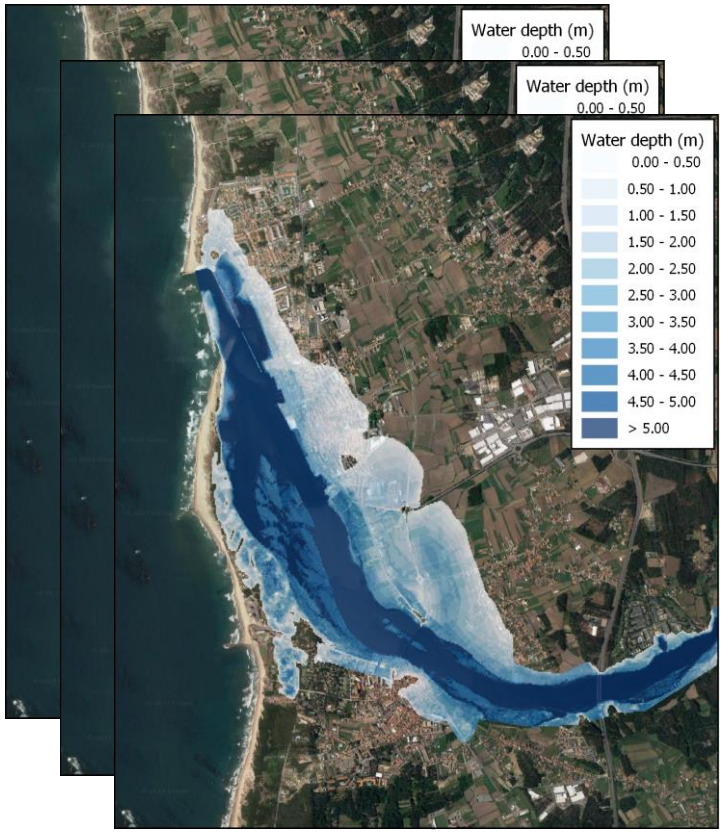
Vulnerability
Describes relationships between hazard intensity and potential impacts (e.g., economic losses)



(adapted from Merz and Thieken, 2004)

Hazard modelling

Hazard maps: describe areas exposed to a certain hazard intensity (e.g., for floods, most commonly water depth) for different return periods



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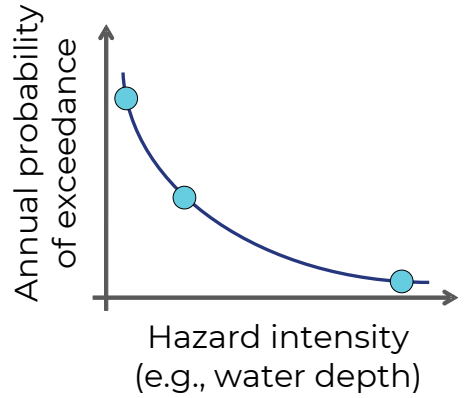
From a loss assessment perspective, hazard maps can be useful for:

- Providing a probabilistic representation of hazard intensities (and subsequently, losses) at local levels



- Computing impact metrics such as average annual losses

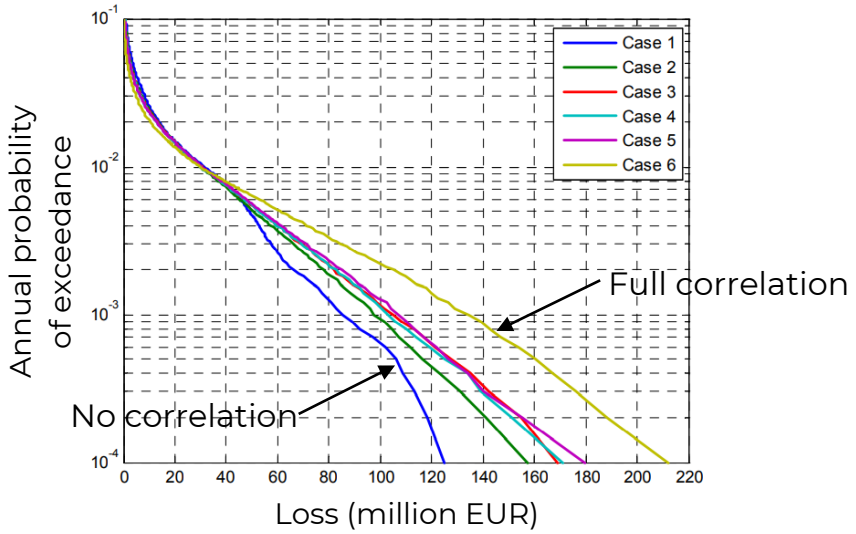
However, they lack information on the spatial correlation of event occurrence.

Hazard modelling

European 100-year return period flood hazard map (extents)

(Alfieri et al., 2015)

In order to obtain a **fully probabilistic representation of hazard and risk** in large areas, it is necessary to take into account the likelihood of having simultaneous events in different parts of the territory.



This can be achieved by developing a **stochastic event catalogue**, i.e., a large dataset of synthetically-generated flood events that are consistent with historical ones.

Exposure modelling

Exposure: elements that are present in hazard-prone areas and are, therefore, at risk of suffering losses

Exposure model: a geospatial dataset describing the **location**, **replacement values** and **characteristics** of the exposed elements

Examples:

- Building materials
- Construction date
- Presence of basements

Data collection

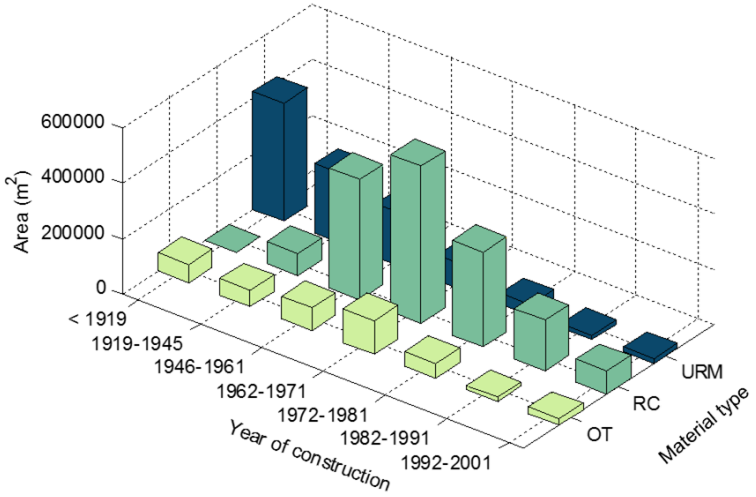
Local scales

Large scales

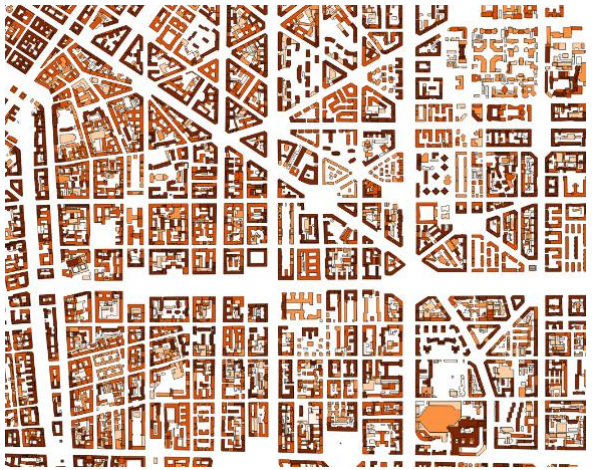
Exposure modelling

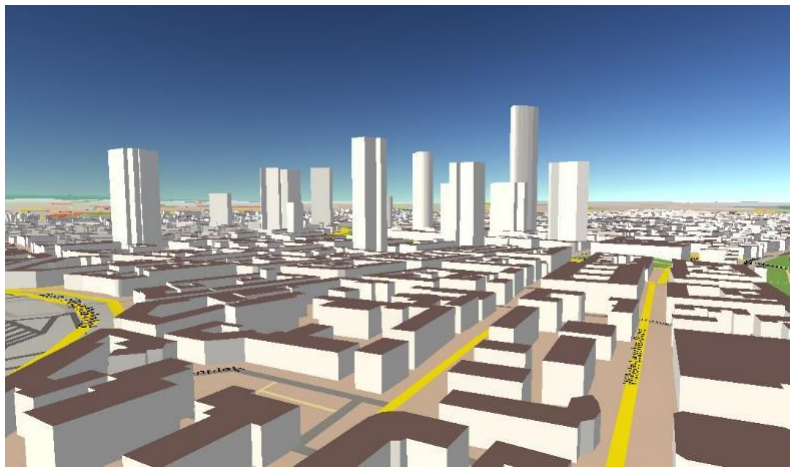
- Combination of **multiple sources of information**

- For building inventory data, **national census datasets** are typically used



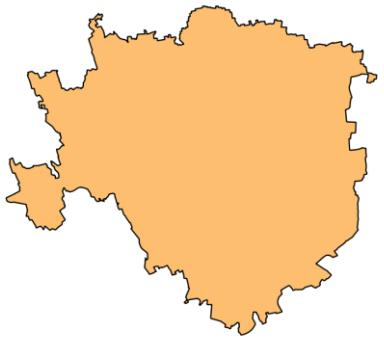
- **Open data** are increasingly available
  - OpenStreetMap (OSM)
  - National/regional repositories
  - Bing open building footprints
  - …





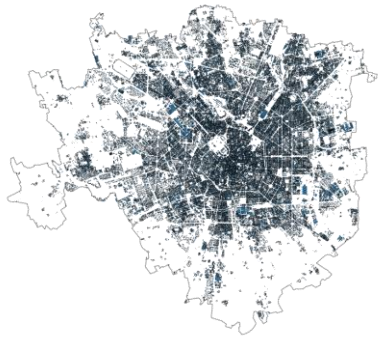
Exposure modelling

Census data



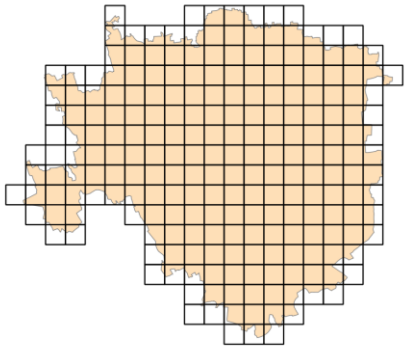
- Nr. buildings
- Area
- Nr. storeys
- Material
- Year of construction
- …

Building vector data



- Location
- Area
- Height
- …

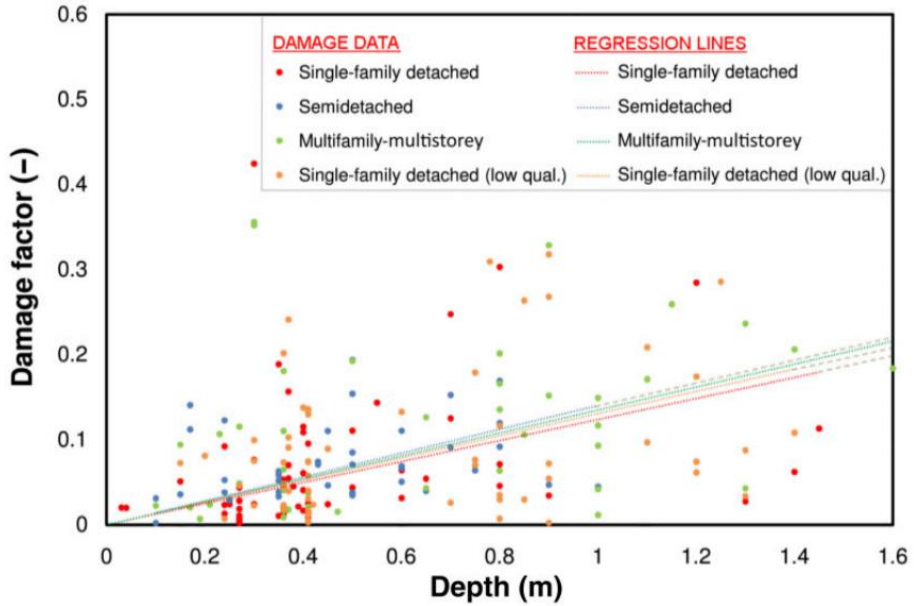
Exposure model



Vulnerability modelling

- **Vulnerability model**: relation between one or more hazard **intensity measures** and the corresponding **damage and/or loss**

- Example for floods: **depth-damage functions**



(Scorzini & Frank, 2017)

Two quantitative vulnerability modelling approaches exist:

– **Empirical**: functions constructed using collected damage data after flood events

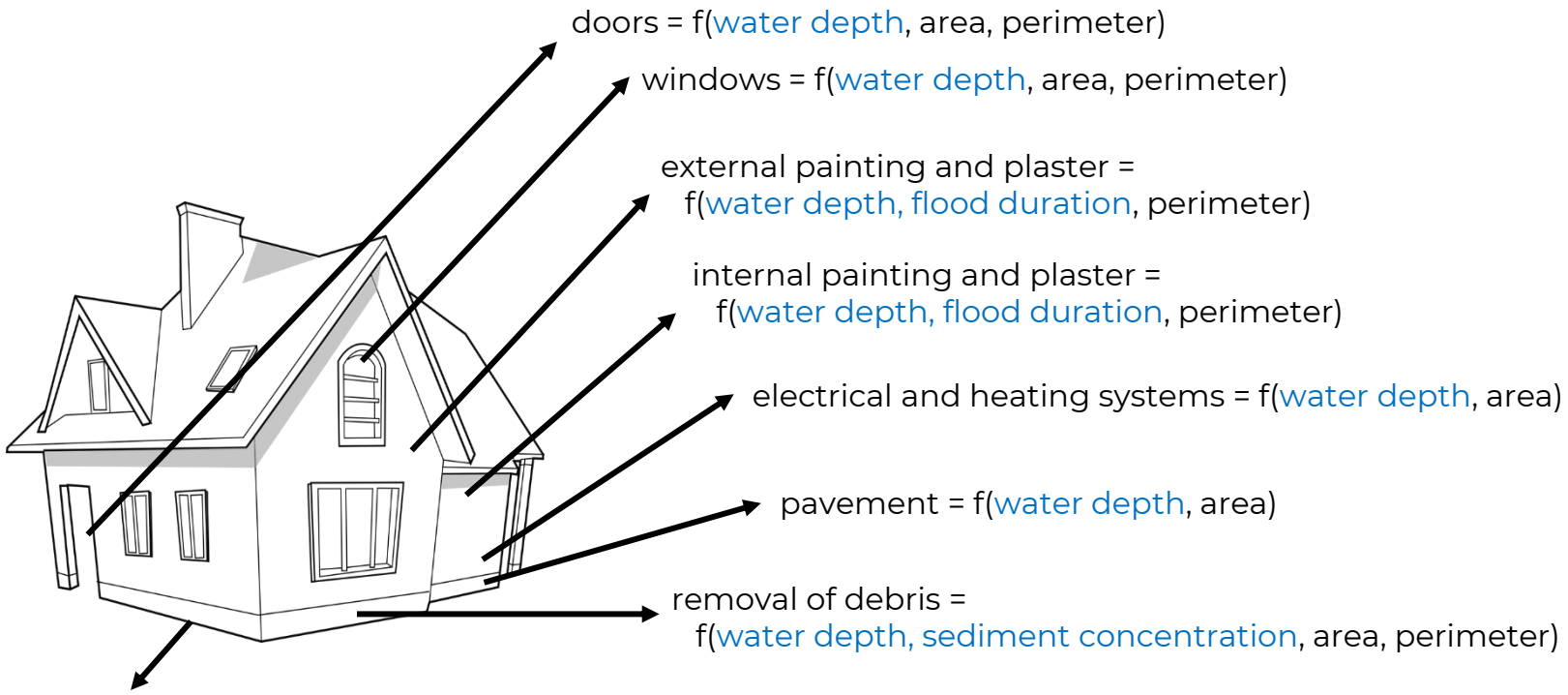
– **Synthetic**: functions constructed using expert knowledge, “what-if” analyses

Vulnerability modelling

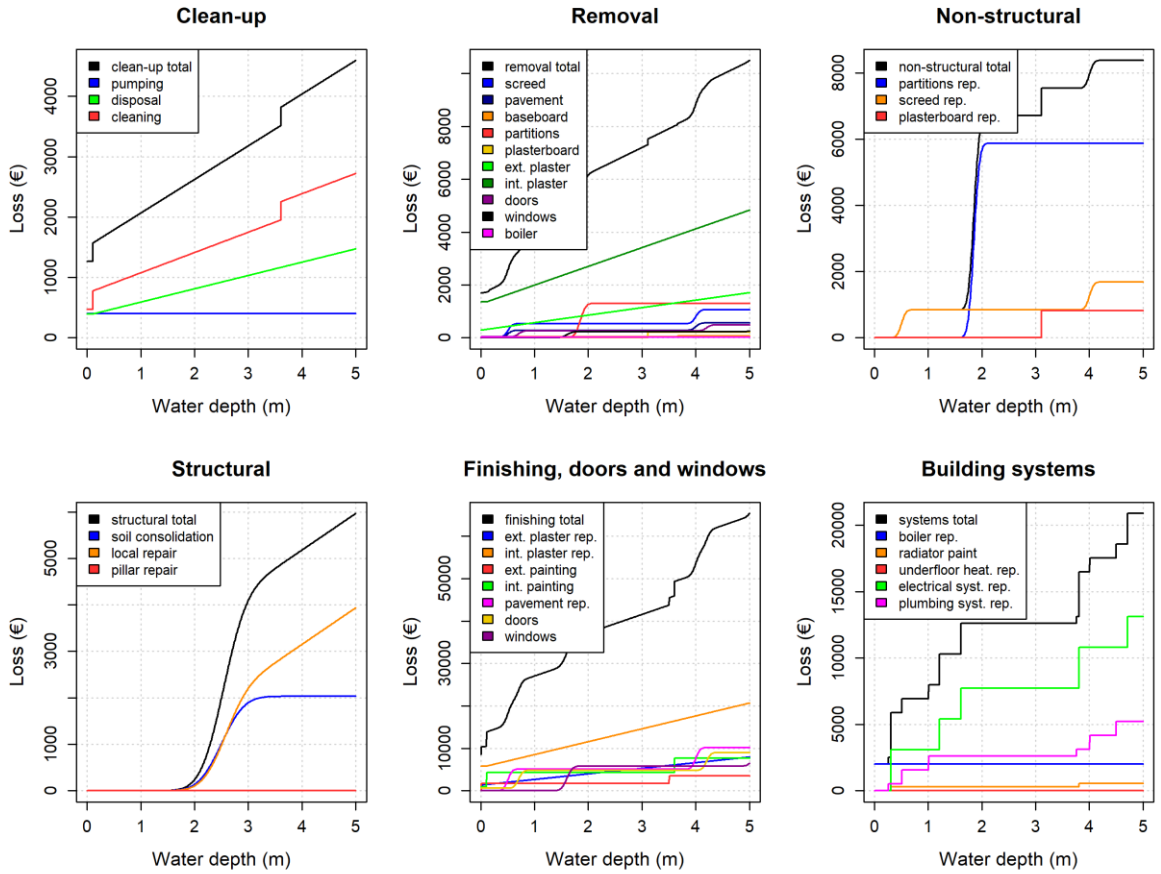
Example:

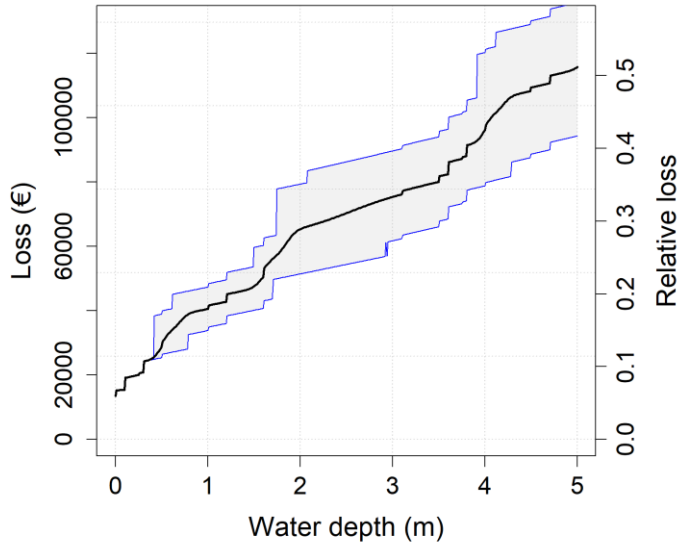
INSYDE: a synthetic, probabilistic flood damage model based on explicit cost analysis

(Dottori et al., 2016)



Flood vulnerability modelling





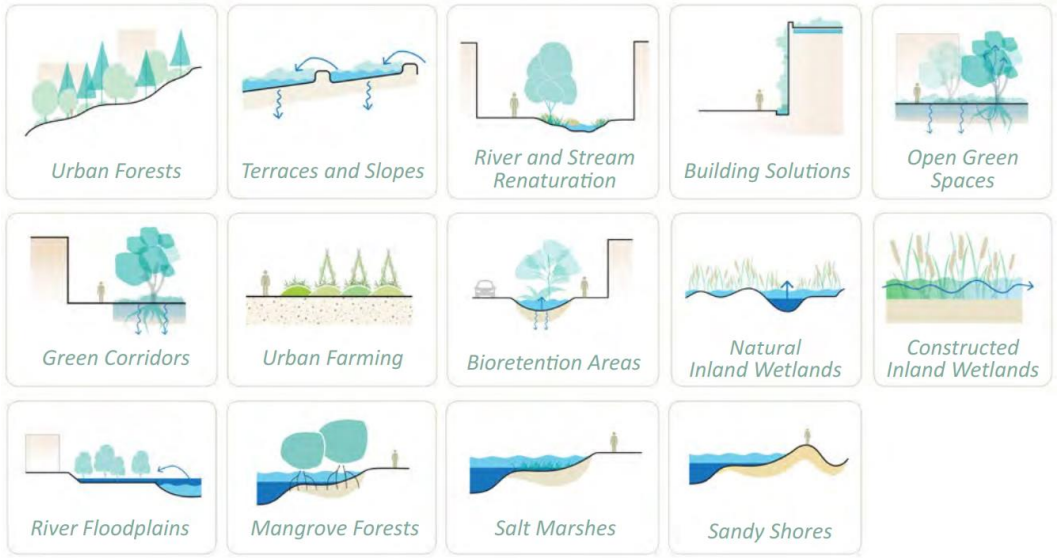
(Dottori et al., 2016)

Baseline and residual risk

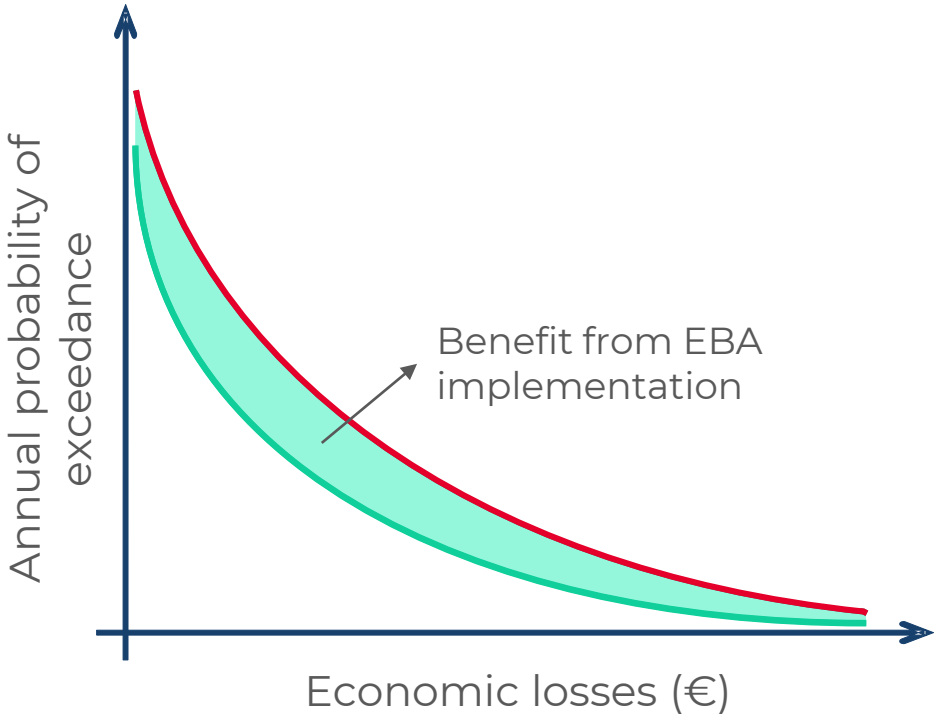
Risk = Hazard × Exposure × Vulnerability

In the context of **SCORE**:

- **Baseline risk** – before implementation of EBAs
- **Residual risk** – after the implementation of EBAs

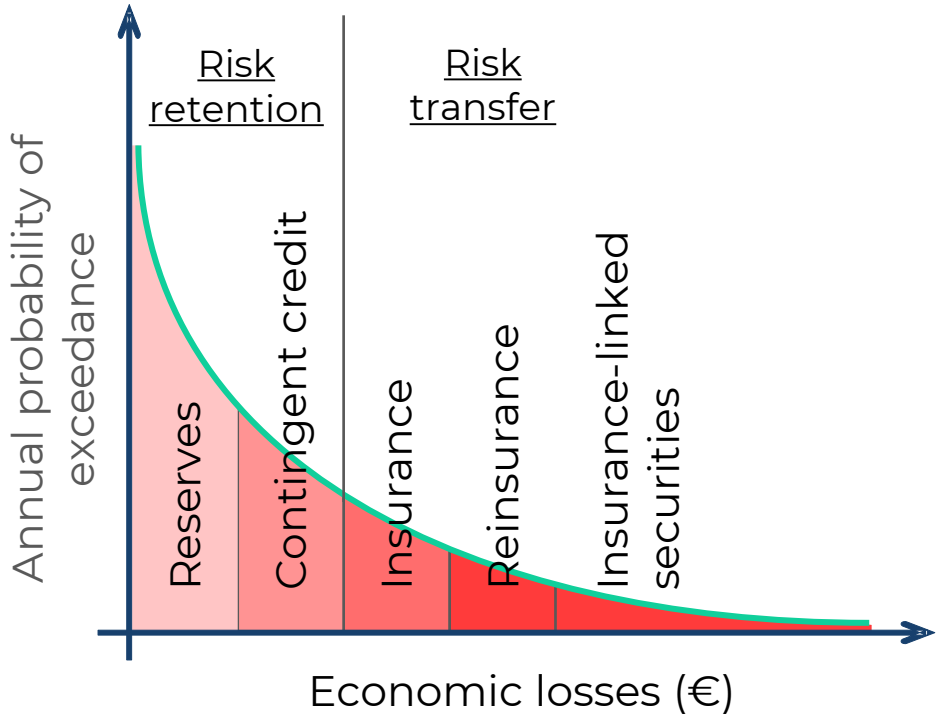


(World Bank, 2021)



Linking risk modelling to risk financing

- Risk assessments allow **estimating financing needs associated with natural risks**
- **Risk financing instruments vary** in:
  - Cost
  - Disbursement time
  - Availability of funds
- A **layered** risk financing strategy is often the optimal one
- Risk assessments can **support the definition of the optimal risk financing strategy**, e.g., for a SCORE Coastal City Living Lab (CCLL)



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Thank you!

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