Smart Control of the Climate Resilience in European Coastal Cities

Session 2: Data-Driven and Nature-Based Adaptation – Tools for Today and Tomorrow

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ECCA-2025 Rimini – 17 june 2025

RED Risk – LaMMA – MBI – UNIPI – UCD – CNR – TERO - ATU - SAMU - ENT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534

Take Home Messages

- **In SCORE**, **the complete Disaster Risk Financing** (**DRF**) **modeling chain was developed**, including: climate change data research and downscaling; development of hazard, exposure, and vulnerability models; flood loss and risk assessment; development of DRF strategy and guidelines.

- The implementation of a comprehensive DRF framework that includes **understanding risk** and **planning its reduction, transfer,** and **retention** are essential **to develop a sustainable DRF strategy** and **to strengthen resilience**.

1-Selection of weather, marine and climate data

- ✓ Collect climate data and information from the main climate services and initiatives available across Europe.
- ✓ **Open**, **free** and **reliable climate data** are needed.

The main services and collaborative initiatives identified:

- Copernicus Climate Change Service (**C3S**) and the Climate Data Store (**CDS**)
- Copernicus Marine Environment Monitoring Service (**CMEMS**) portal
- European Marine Observation and Data Network (**EMODnet**) initiative

EMODnet
European Marine Observation and Data Network

1-Selection of weather, marine and climate data

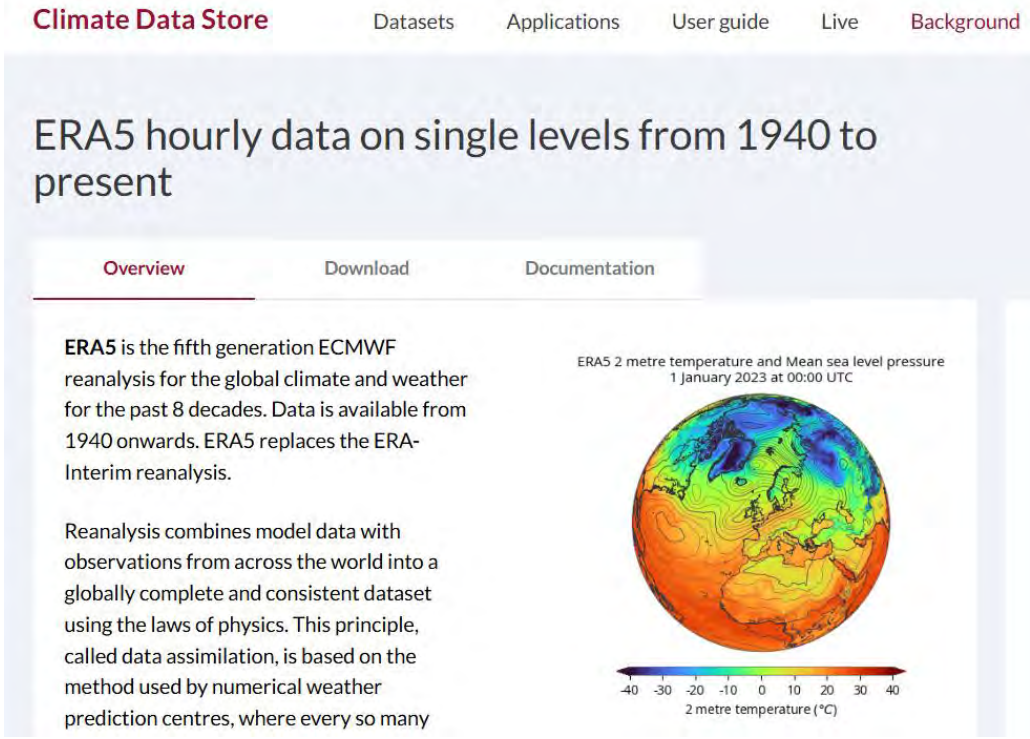
Examples of selected dataset

ERA5 family for **“historical”** period, e.g.

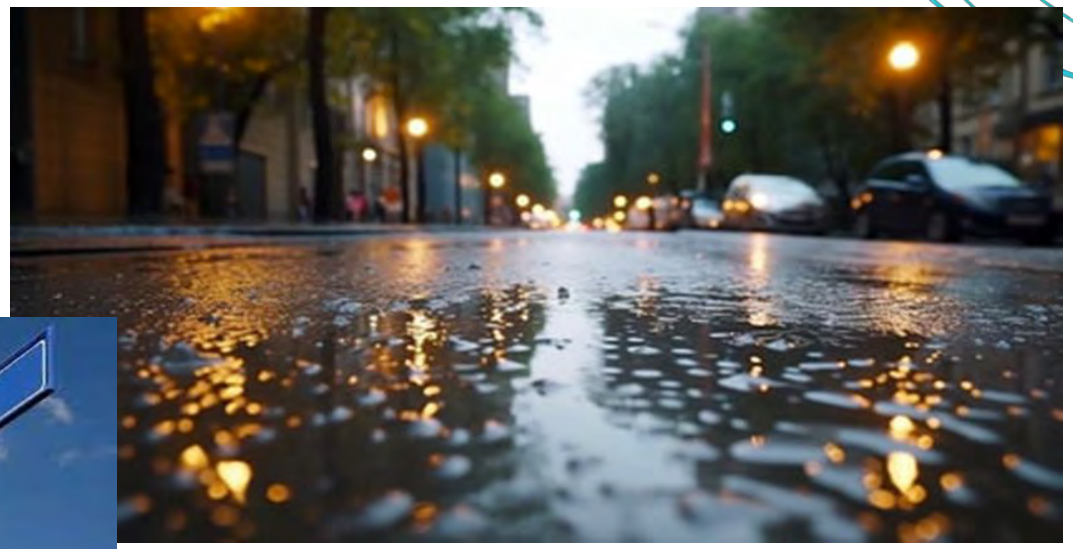
- ERA5 hourly data on a single level.
- ERA5-Land

EURO-CORDEX and Med-CORDEX for future “**projections**”, e.g.

- Water level change time series for the European coast from 1977 to 2100
- Surface wave time series for the European coast from 1976 to 2100.



2-Downscaling of identified data to the local scale



From Global (Regional) scale…

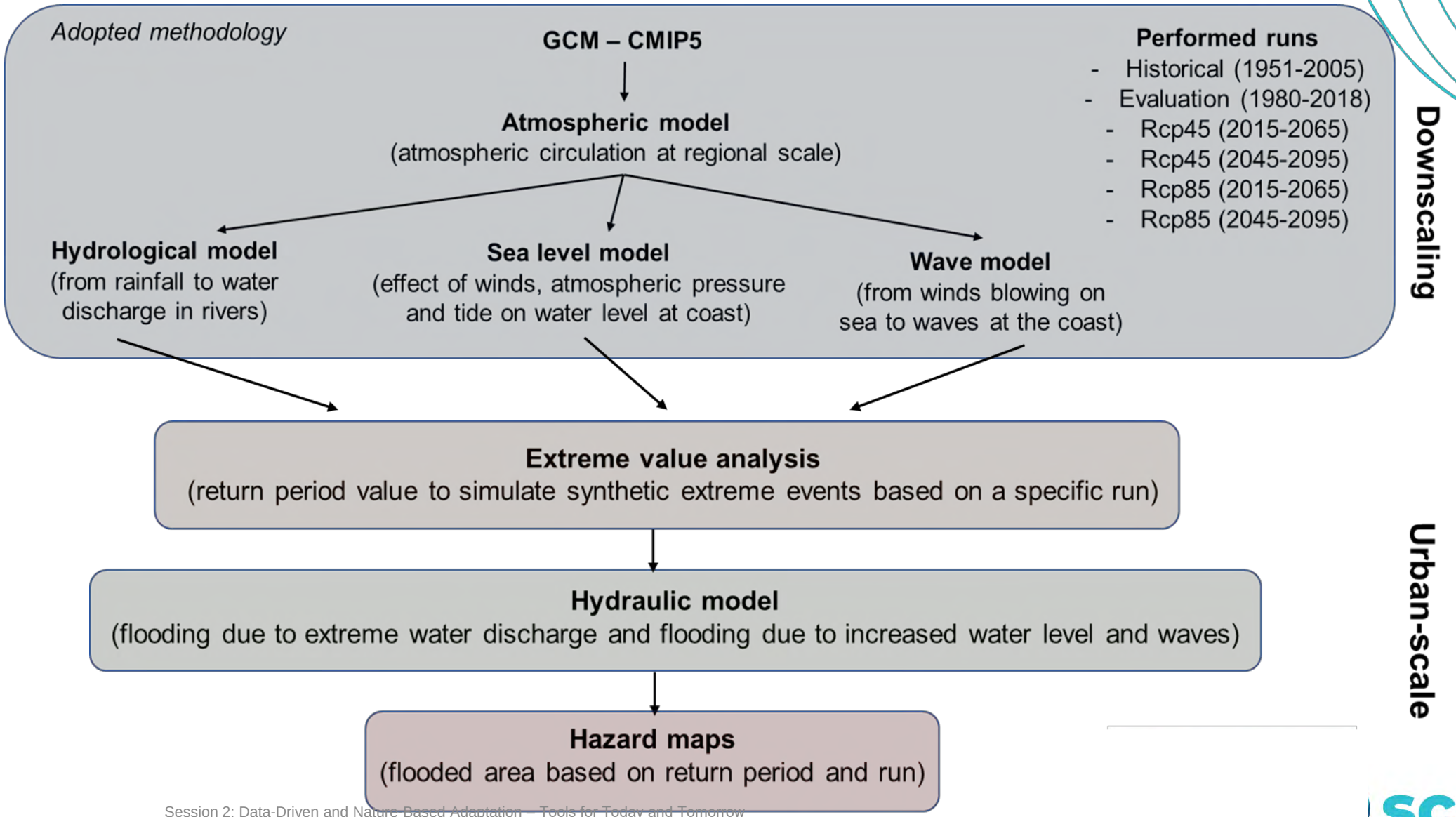
- The scale of the earth system
- Typical scale: 1000 km - 50 Km
- The climate service scale

… to local scale!

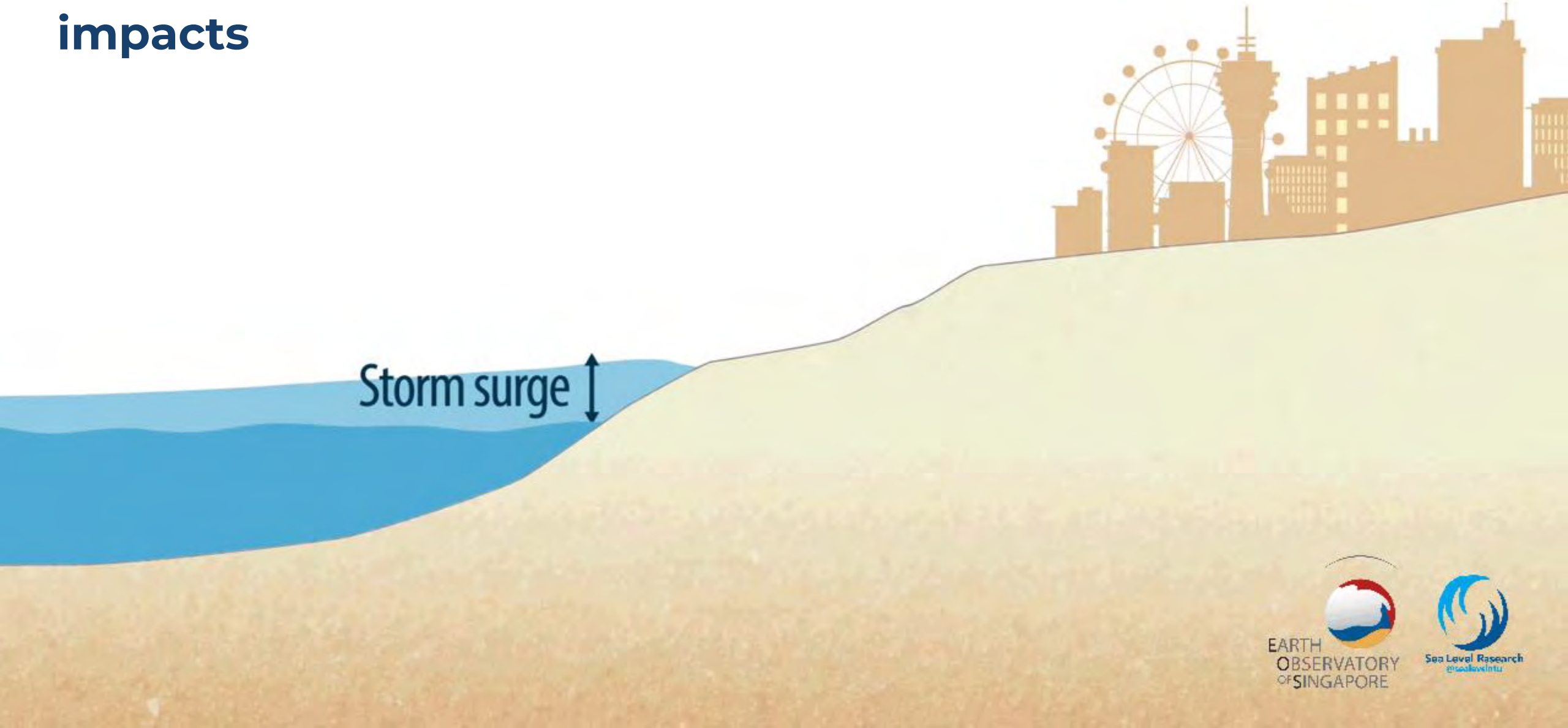
- The scale of everyday life!
- Typical scale: 1 km - 10 m
- The scale of the actions for climate change resilience : urban models, flooding points, etc.

2-Downscaling of identified data to the local scale

State-the-art, **open-source** advanced models



Relative Sea level rise as driver for extreme events impacts



EARTH OBSERVATORY OF SINGAPORE

Sea Level Research

3-Flood hazard maps

CCLLs
Massa
Oarsoaldea
Vilanova i la Geltrú

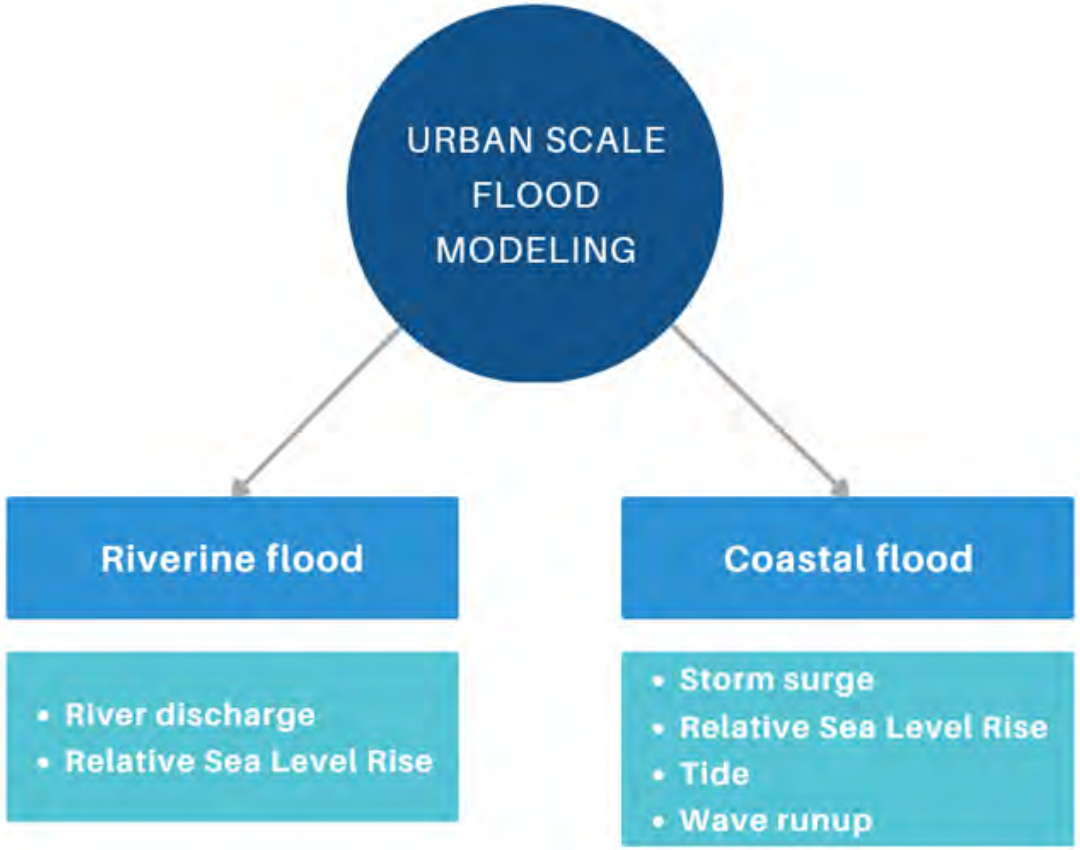
Perils	
Fluvial flooding	Current
	Post-EBA
Coastal flooding	

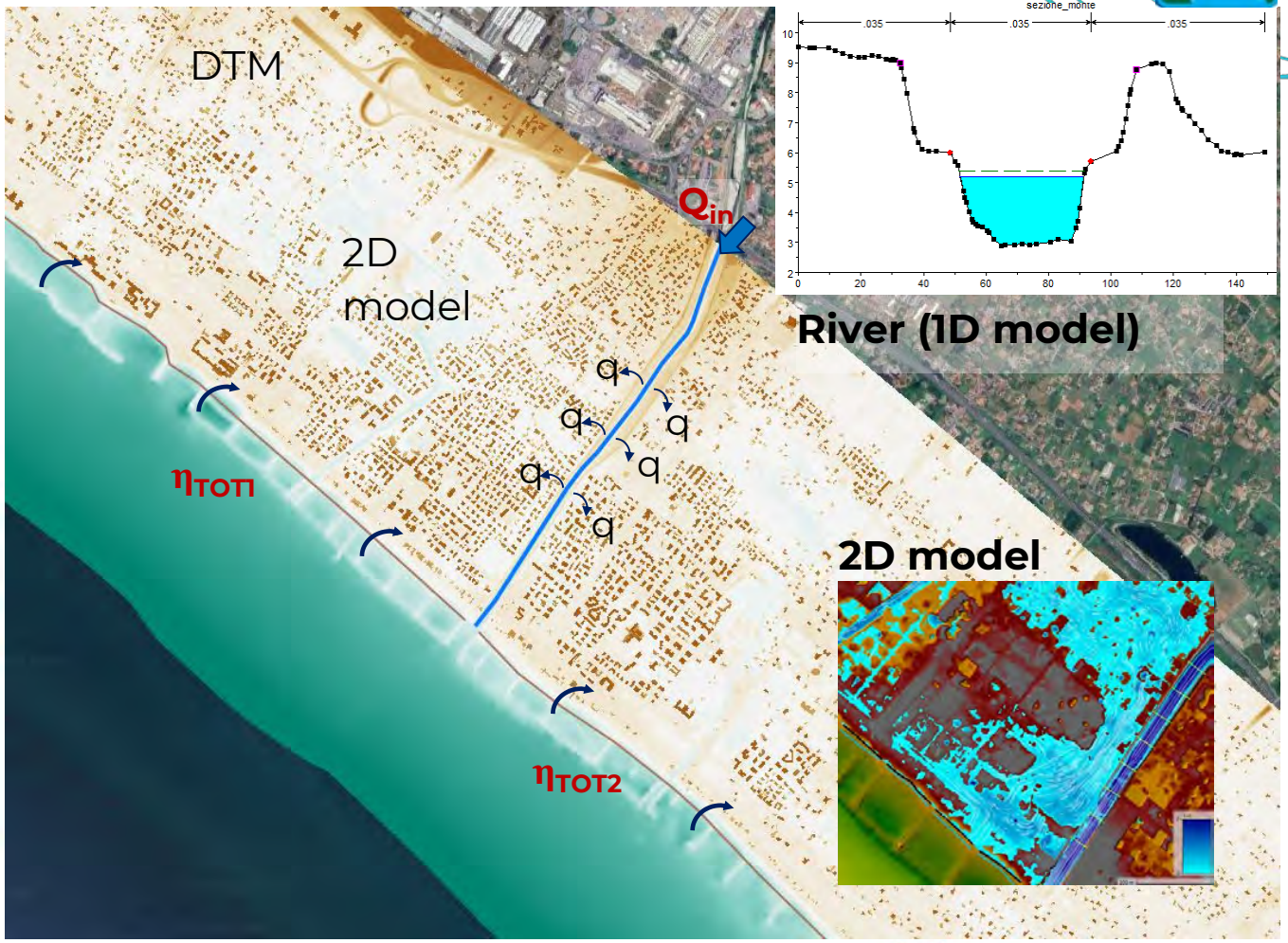
Climate scenarios	
Baseline	
RCP 4.5	2015-2065
	2045-2095
RCP 8.5	2015-2065
	2045-2095

Return periods (years)
5
25
50
100
200
500

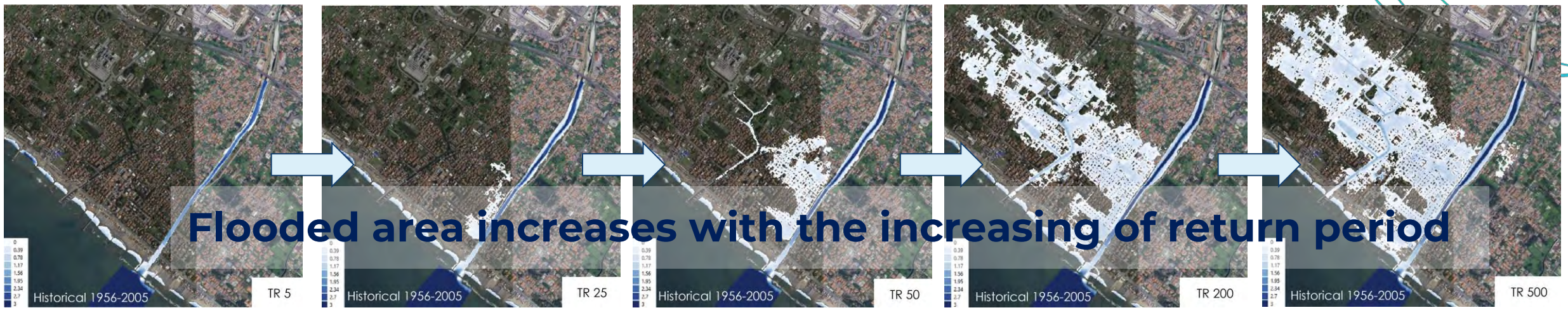
In catastrophe modeling, the **return period** (**RP**) is the average interval (in years) between events of a specified severity, calculated as the reciprocal of the event's annual exceedance probability.

Urban scale flood model





Massa hazard maps – Fluvial flood



Flooded area increases with the increasing of return period

Flooded area increases in future scenarios, more in the remote future and more in RCP 8.5

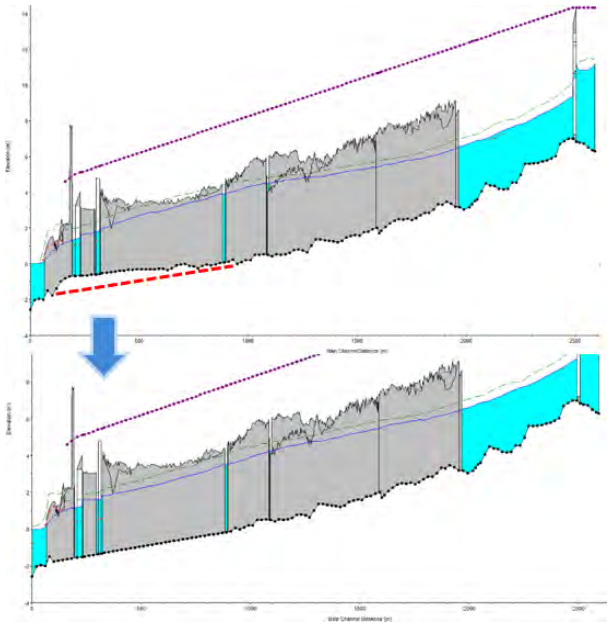
Implementation of EBAs → Hazard reduction

Massa

- Riparian reforestation
- Floodplain enlargement

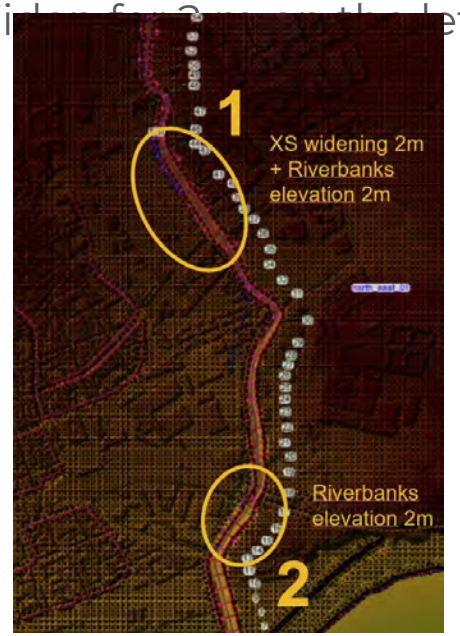
↓

Riverbed excavation



Vilanova i la Geltrù

- Green overbanks elevation
- Widen for 2 m on the right side
- Wi[illegible]eft side



Oarsoaldea

Reverse EBA exercise modelling what it would be like if the existing EBA did not exist and the river park was a built-up area

Hazard reduction → Risk reduction

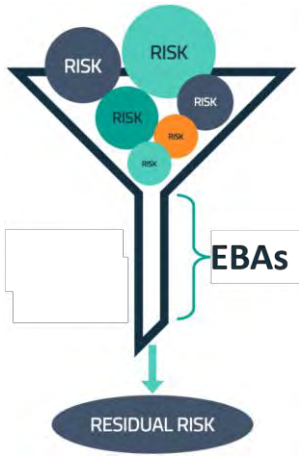
score

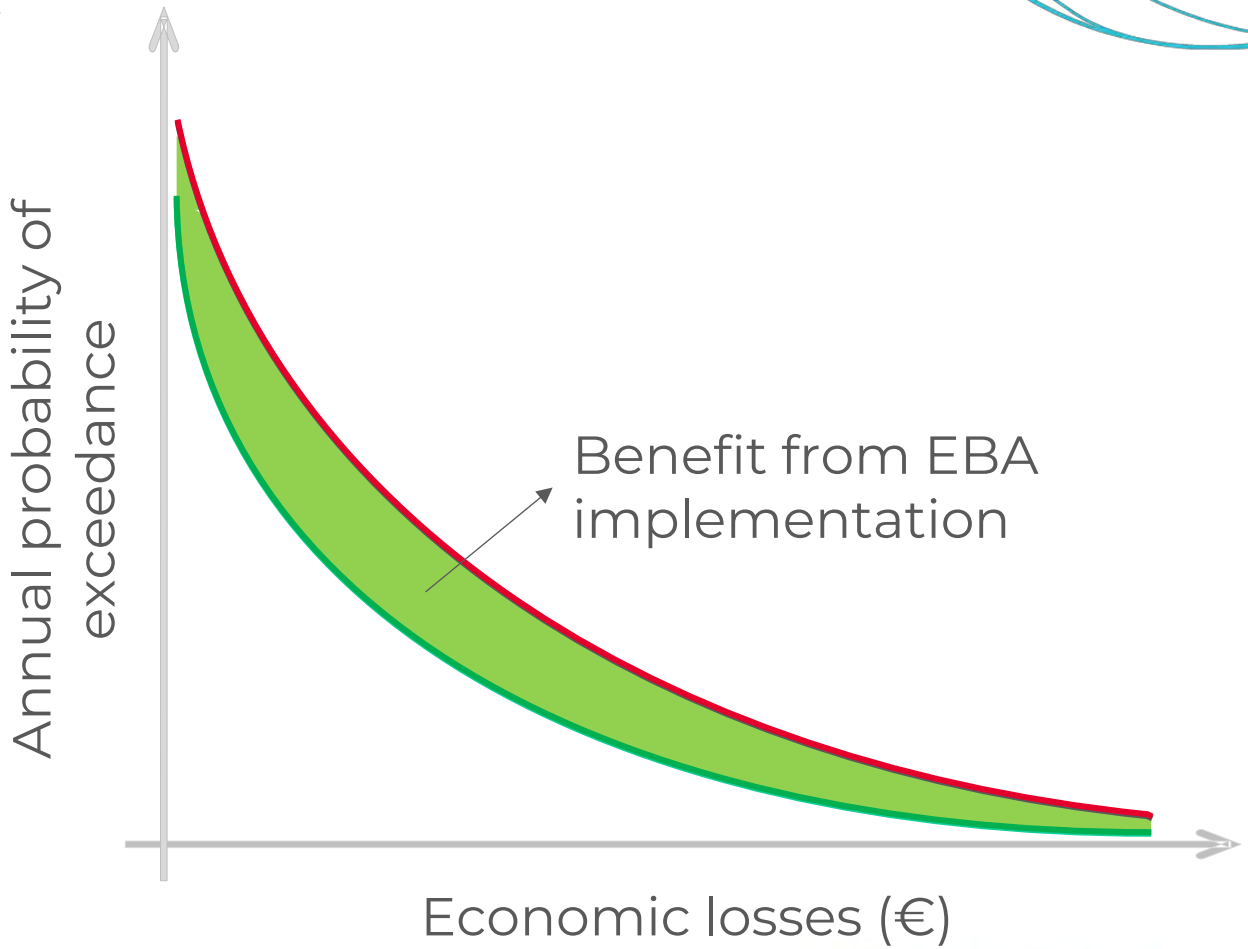
4-Development of exposure and vulnerability

Risk = Hazard × Exposure × Vulnerability

In the context of SCORE:

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





Exposure datasets

Building vector data
(scale: object)

Census data
(scale: municipality)

Ancillary data sources
(scale: variable)

Data elaboration:
state-of-the-art probabilistic exposure modelling methods

GIS tools and software
developed specifically for the SCORE project

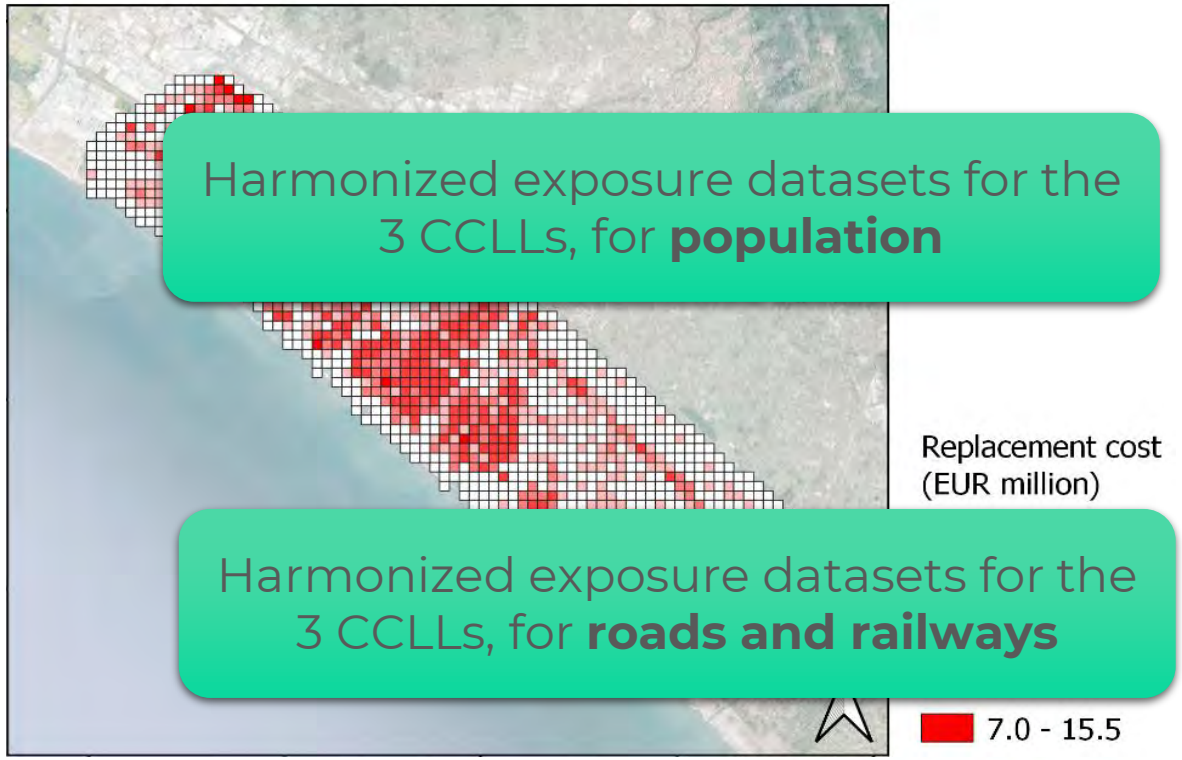
Building taxonomy
developed for the SCORE project

Replacement costs
(based on multiple sources: market survey data, scientific literature, etc.)

Harmonized exposure datasets for the 3 CCLLs, for **multiple building types of different occupancy classes**

Harmonized exposure datasets for the 3 CCLLs, for **population**

Harmonized exposure datasets for the 3 CCLLs, for **roads and railways**

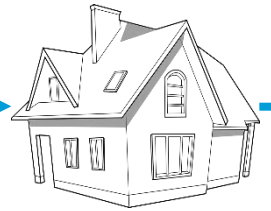


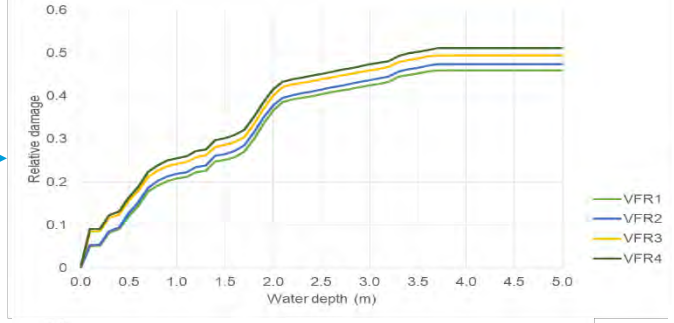
Example output: Massa CCLL

Vulnerability models

Buildings

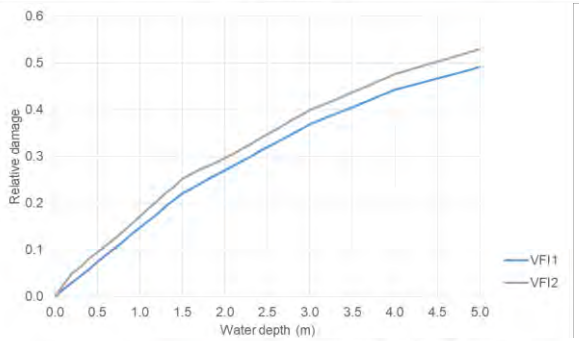
INSYDE (Dottori et. al 2016)





Vulnerability function code	Taxonomical classes
VFR1	RESMIX_RC RESMIX_OTH PUBLIC_RC
VFR2	RESMIX_MSN PUBLIC_MSN
VFR3	RESMIX_RC_B RESMIX_OTH_B PUBLIC_RC_B
VFR4	RESMIX_MSN_B PUBLIC_MSN_B

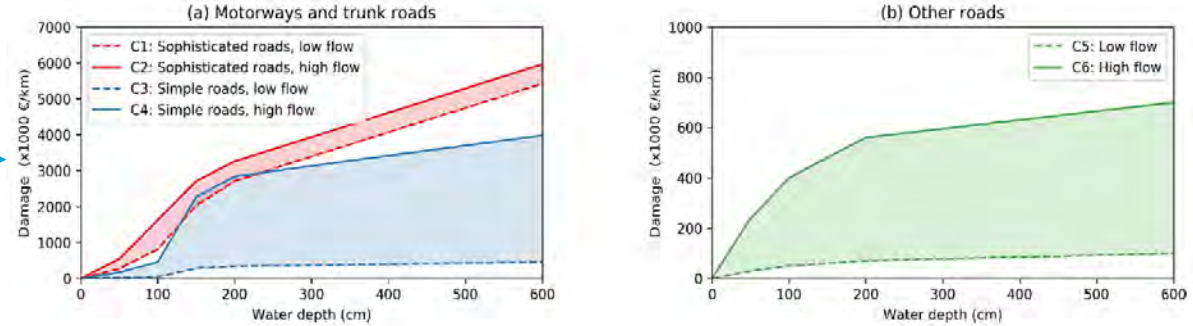
JRC (Huizinga, et al., 2017)



Vulnerability function code	Taxonomical classes
VFI1	INDCOM_RC INDCOM_MSN INDCOM_STL PRTBLD_RC PRTBLD_MSN PRTBLD_STL
VFI2	INDCOM_RC_B INDCOM_MSN_B INDCOM_STL_B PRTBLD_RC_B PRTBLD_MSN_B

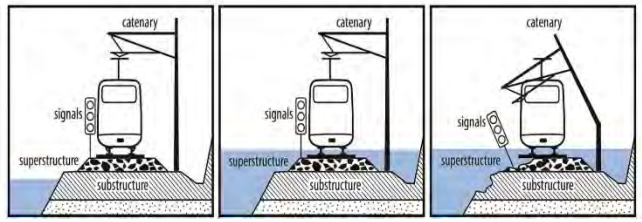
Roads

van Ginkel, et al., (2021)



Railways

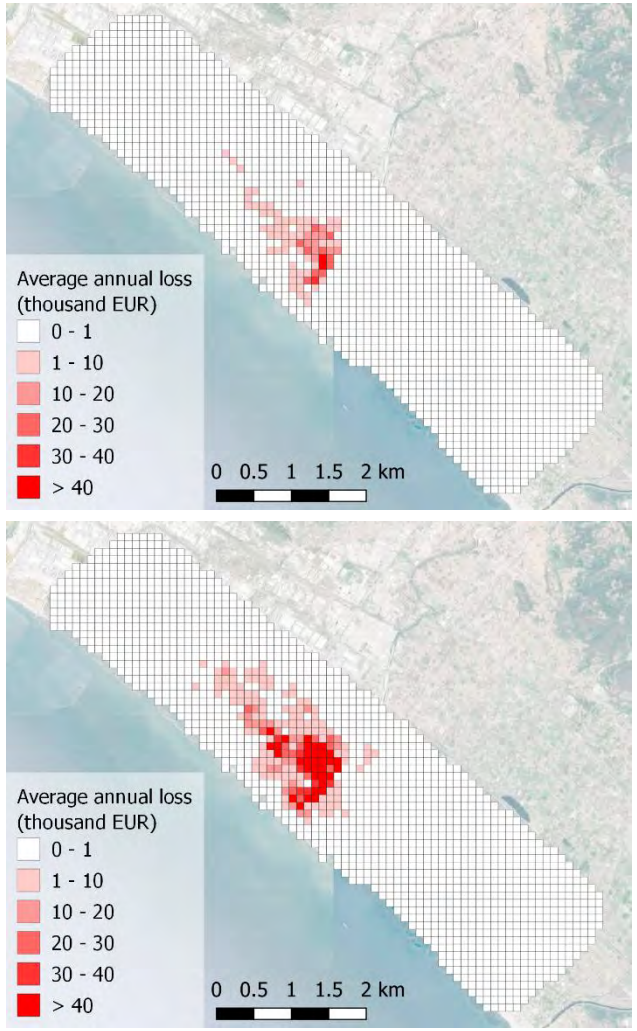
RAIL (Kellermann, et al., 2015)



Damage class 1	Damage class 2	Damage class 3

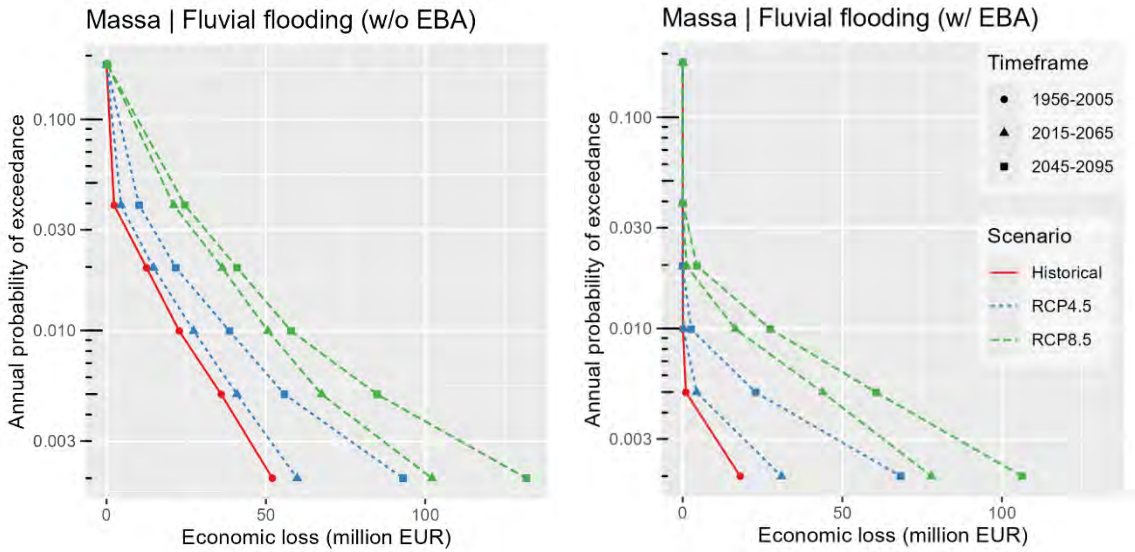
5-Risk and losses

Example output: Massa CCLL

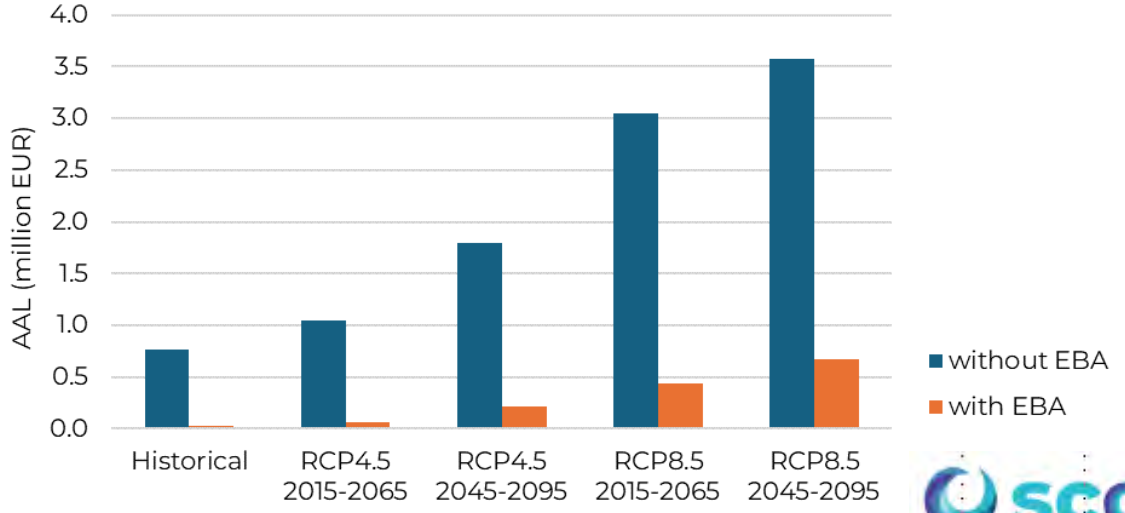


Spatial distribution of average annual losses due to fluvial flooding (without EBA)

Fluvial flood risk curves

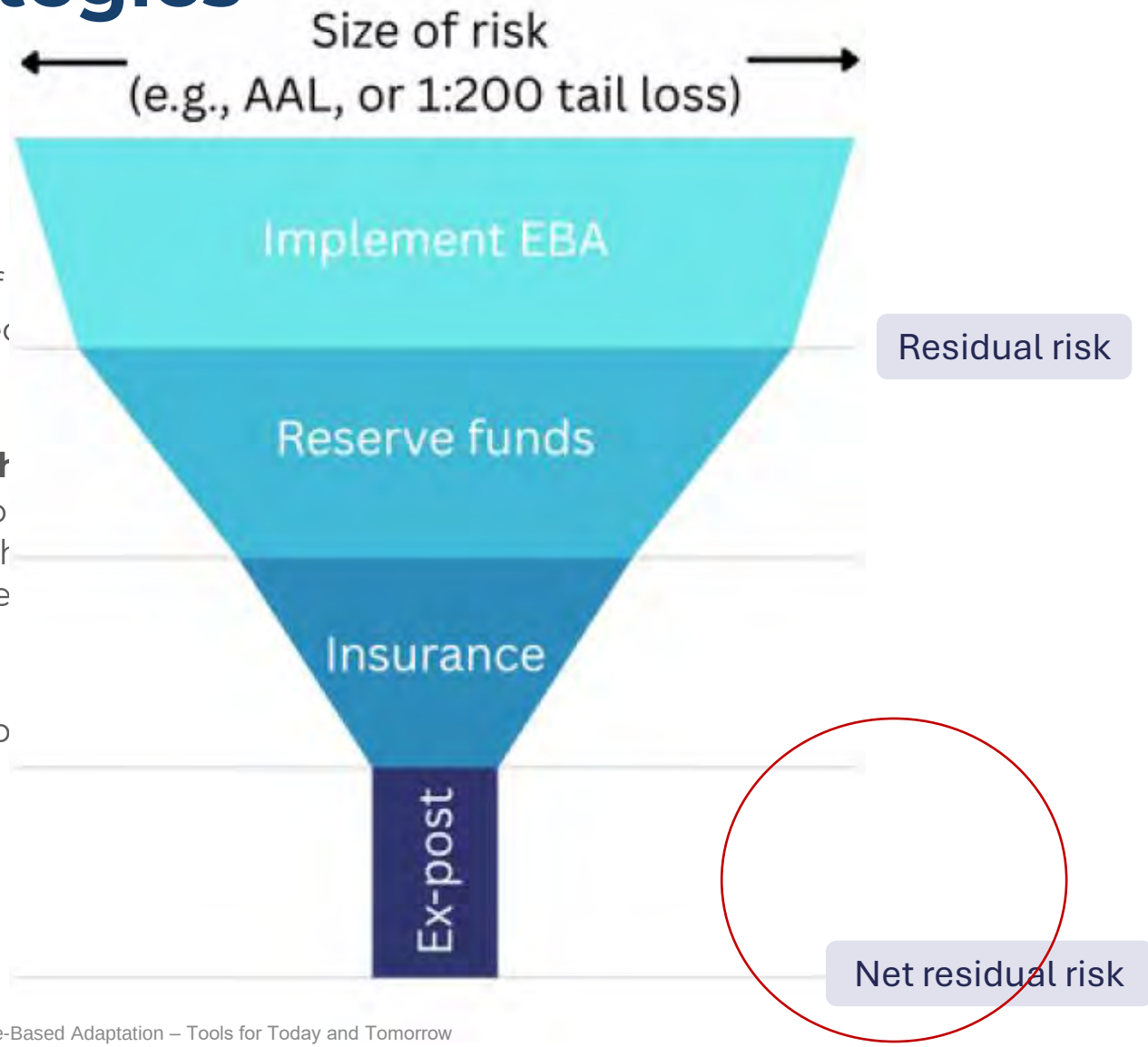


Average annual losses (AAL) due to fluvial flooding for each climate scenario and EBA situation

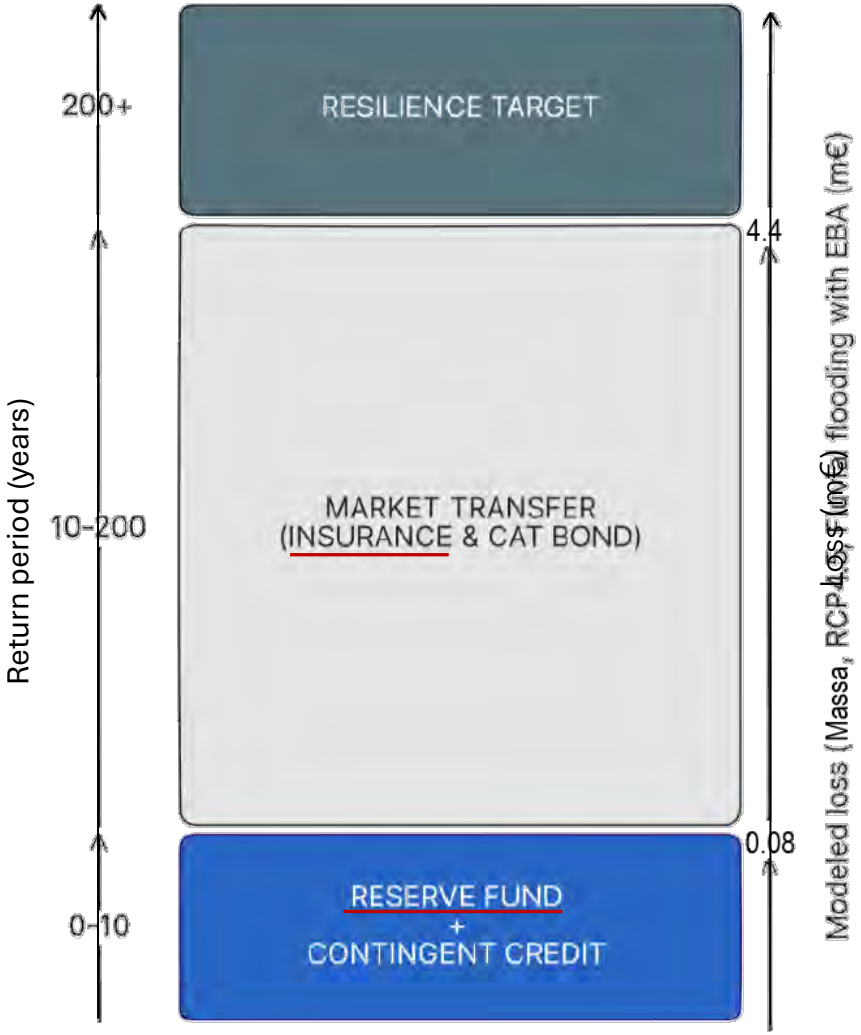


6-Financial strategies

- **Reduction**. Implementation of measures to compute the post-re (residual risk).
- **Retention**. **Pre-arranged mech** that provide risk holders access to The resources provided through th instruments come from those affe the disaster.
- **Transfer**. Insurance and more p parametric solutions.



DRF Strategy



Risk assessment results
+
Input decision variables

Optimization engine
(DSS tool)

Budget requirements

Financing gaps

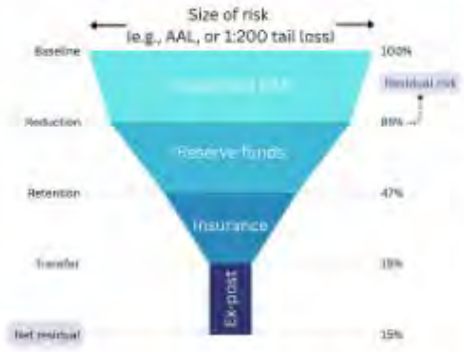
DRF = Distaster Risk Financing

DRF Guidelines

Investing in Climate Adaptation

Enhancing Massa's Climate Resilience

Disaster Risk Financing (DRF) Guidelines Aims: This strategy provides financial guidelines to help manage the increasing risks of climate-related disasters.



Flood Risk in Massa

- **Hazards:** Historically dominated by fluvial floods, but coastal flooding is an increasing concern.
- **Loss Estimates:** Average annual flood losses range from €0.75 - €3.0M before any risk management action is implemented.
- **Fiscal Exposure:** With no pre-allocated national funds, Massa competes for regional civil protection funding, heightening vulnerability.

Key Recommendations for Managing Risk

1. Risk Reduction - **Prioritise EBAs to reduce overall risk & financing costs.** *Implement Ecosystem-Based Adaptations (EBA) that reduce hazard exposure. In Massa, EBAs could cut average annual losses by 97%, reducing costs to €25,000.*

2. Risk Retention - **Reserve funds can cover frequent, low-severity losses.** *Thanks to the hugely successful risk-reduction layer provided by EBAs, risk retention would require modest savings, only a small fraction of the estimated budget.*

3. Risk Transfer - **Use parametric insurance for high-impact events.** *For rare, high-impact floods, parametric (index-based) insurance is recommended. Residual losses for rare (1-in-200 year) events can be covered for under €80K/year.*

Disaster Risk Financing Guidelines

Making Every Euro Count

Disaster Risk Financing (DRF) Guidelines Aims: This strategy provides financial guidelines to help manage the increasing risks of climate-related disasters.

1) Prioritise Risk Reduction

Risk reduction, especially through Ecosystem-Based Adaptation (EBA), is the most cost-effective strategy. In Massa (IT), EBAs cut average annual losses by over 95%. Global evidence affirms that reducing risk up front lowers overall financing needs and should always be the first DRF layer.

2) Use Exceedance Probability Curves

Loss exceedance probability (EP) curves are central to risk-layering. It identifies return-period losses (e.g., 1-in-200-year) to inform resilience targets and determine which risks to retain or transfer. Parametric (index-based) insurance can be tailored to match the local EP curve and offer fast payouts after major events.

3) Set Specific Resilience Targets

Resilience targets should reflect local priorities, risk appetite, and critical infrastructure. Engaging stakeholders ensures realistic goals, helping cities allocate between retained, transferred, or accepted risks effectively.

4) Explore Contingent Credit

Contingent credit lines efficiently finance high- to moderate-frequency events, avoiding large reserve funds' opportunity costs. They provide post-event liquidity, balancing risk retention without the burden of indefinitely holding excess cash reserves.

5) Diversify and Stay Flexible

A mix of instruments, reserves, insurance, contingent credit, and possibly bonds, enhances flexibility. As risks and markets evolve, annual reviews of DRF strategies ensure continued relevance and cost-effectiveness.

6) Engage EU & National Institutions

CCLLs should take the lead in initiating dialogue with their national, regional, and EU-level counterparts to emphasize the importance of evidence-based DRF, which is significantly more cost-effective and operationally efficient.

7) Risk Pools and Catastrophe Bonds

Though still rare, EU-level catastrophe bonds and risk pools hold promise. CCLLs can lead innovation by exploring regional pooling and capital market solutions.

8) Reassess Regularly

DRF strategies must adapt to macroeconomic shifts, including insurance market cycles and funding conditions. Regular reassessment helps cities remain resilient and fiscally sustainable.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534.

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Potential impacts and applications

For **all CCLLs**:

- Empower municipalities, researchers, and stakeholders in European coastal cities
- Make evidence-based decisions that enhance climate resilience and sustainable coastal management

For

- **Municipalities**: Enhance urban resilience planning through the accurate data produced
- **Researchers**: Facilitate development of predictive models for coastal and urban climate phenomena
- **Insurance Companies**: Improve risk assessment and policy pricing for flood hazards

The first SCORE letters mean "Smart Control"...

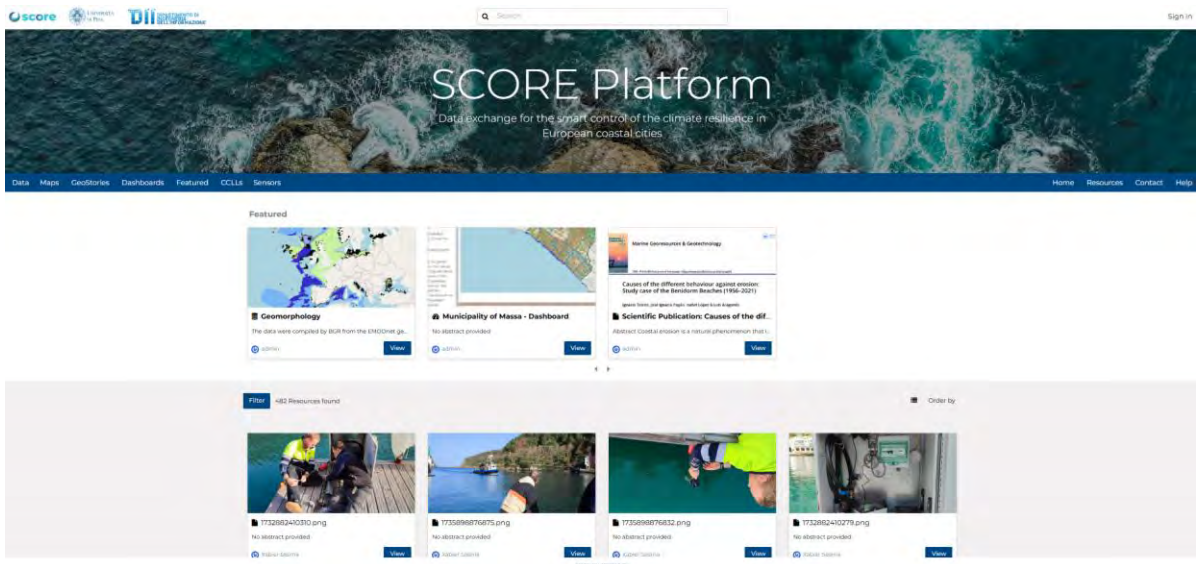
WITHIN SCORE TWO "SMART" DIGITAL TOOLS WHERE DEVELOPED:

mbi

UNIVERSITÀ DI PISA

The digital Twin - EWS

The SCORE data Platform



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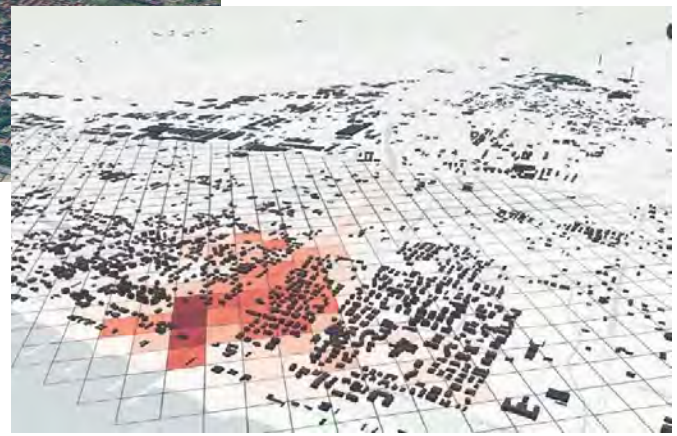
The Digital Twin and the Early Warning Sistem (EWS)

Digital Twin:
Support tool for Strengthening Coastal Cities' Resilience

The Physical Twin...

... the Digital Twin!!



User Scenario Evaluation (USE):

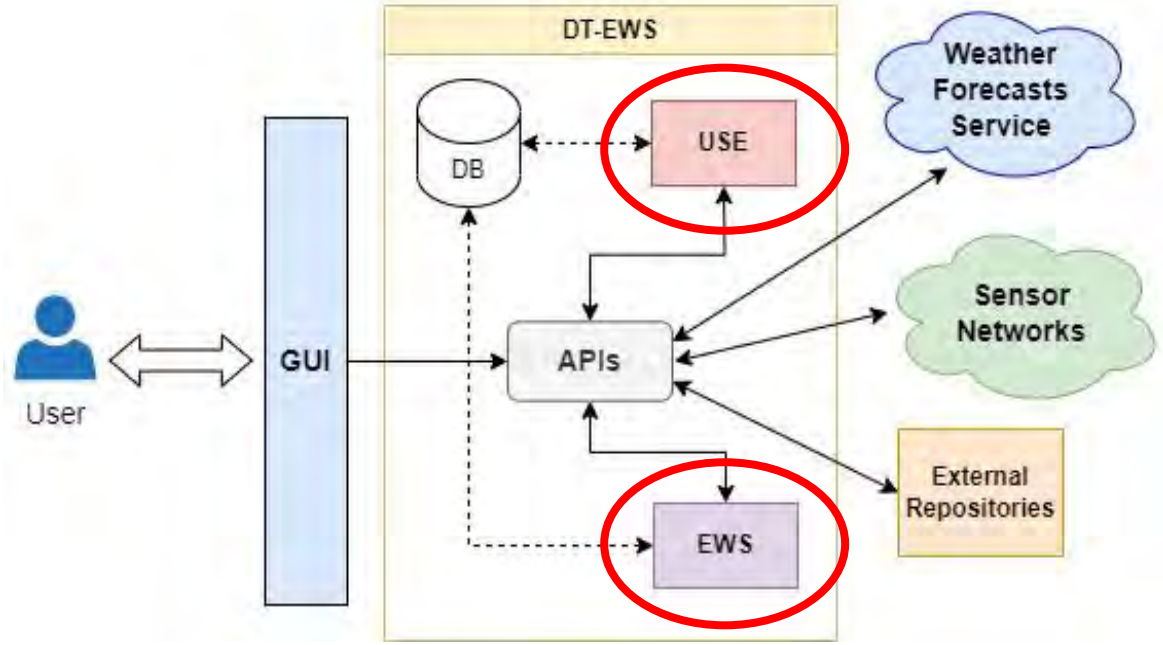
- Flood maps – Event simulation.
- Human and financial risk maps.
- Ecosystem-Based Adaptation (EBA) implementation simulation.
- Coastal erosion estimation.

Early-Warning Support (EWS):

- Allert sent in case of flooding or significant damage.
- Warnings in case of inconsistent data flows.
- Forecast flood maps.
- Forecast human and financial risk maps.

The Digital Twin and the Early Warning Sistem (EWS)

System Architecture



Inside the Digital Twin:

- Digital data (*DSM/DTM models, land use maps, riverbed geometry, flood exposure maps*).
- The idrological and sea state models (LISFLOOD-FP)
- The future scenarios data
- Sensors data (Istitutional and SCORE Sensor)
- Forecast data

- **USE:** User Scenario Evaluation
- **EWS:** Early-Warning Support
- **DB:** Database

- **APIs:** Application programming Interfaces
- **GUI:** Graphical User Interface

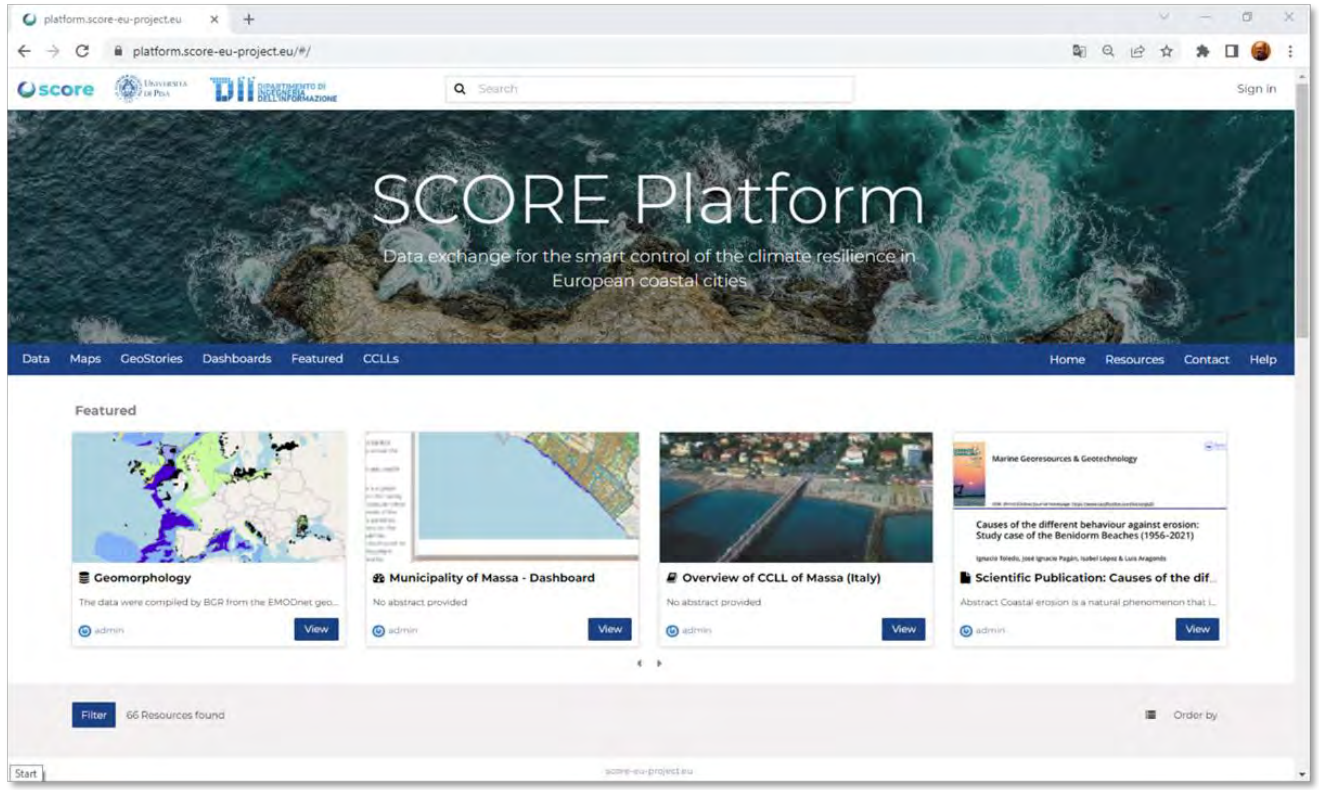
The Digital Twin and the Early Warning Sistem (EWS)

Digital Twin USE Output

The SCORE ICT data Platform (SIP)

Landing Page

https://platform.score-eu-project.eu/



SCORE project Knowledge Market Place

Concrete Resources:

- **Document:** generic resource representing unstructured data;
- **Spatial Dataset:** generic resource representing structured data;
- **Timeseries:** a dataset with temporal support.

Downstream Resource:

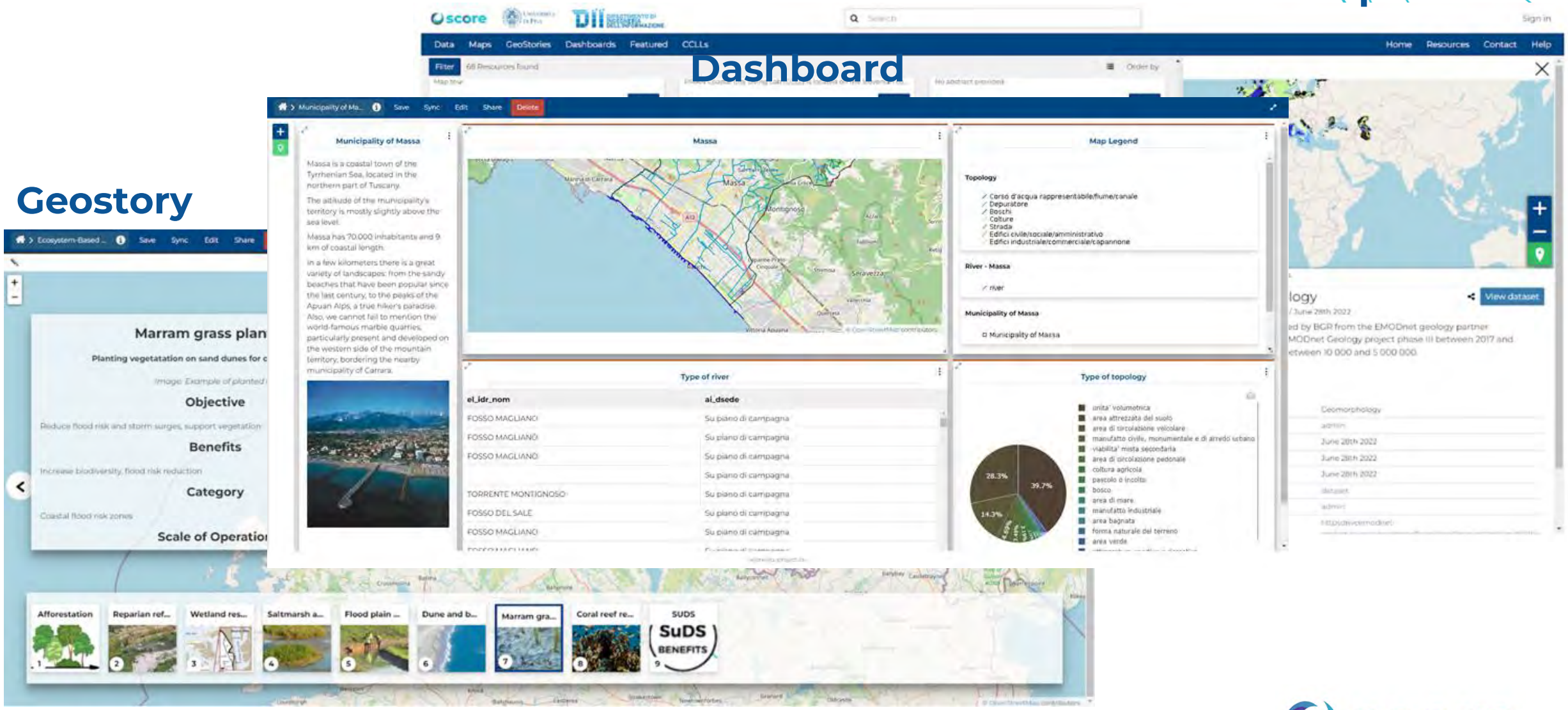
- **Maps**: a multiple spatial datasets and rich interactive map
- **Dashboards:** a virtual board where multiple widgets and maps are positioned
- **Geostories:** a vertically scrolling composition of media, maps and documents

The SCORE ICT data Platform (SIP)

Resource preview

Dashboard

Geostory

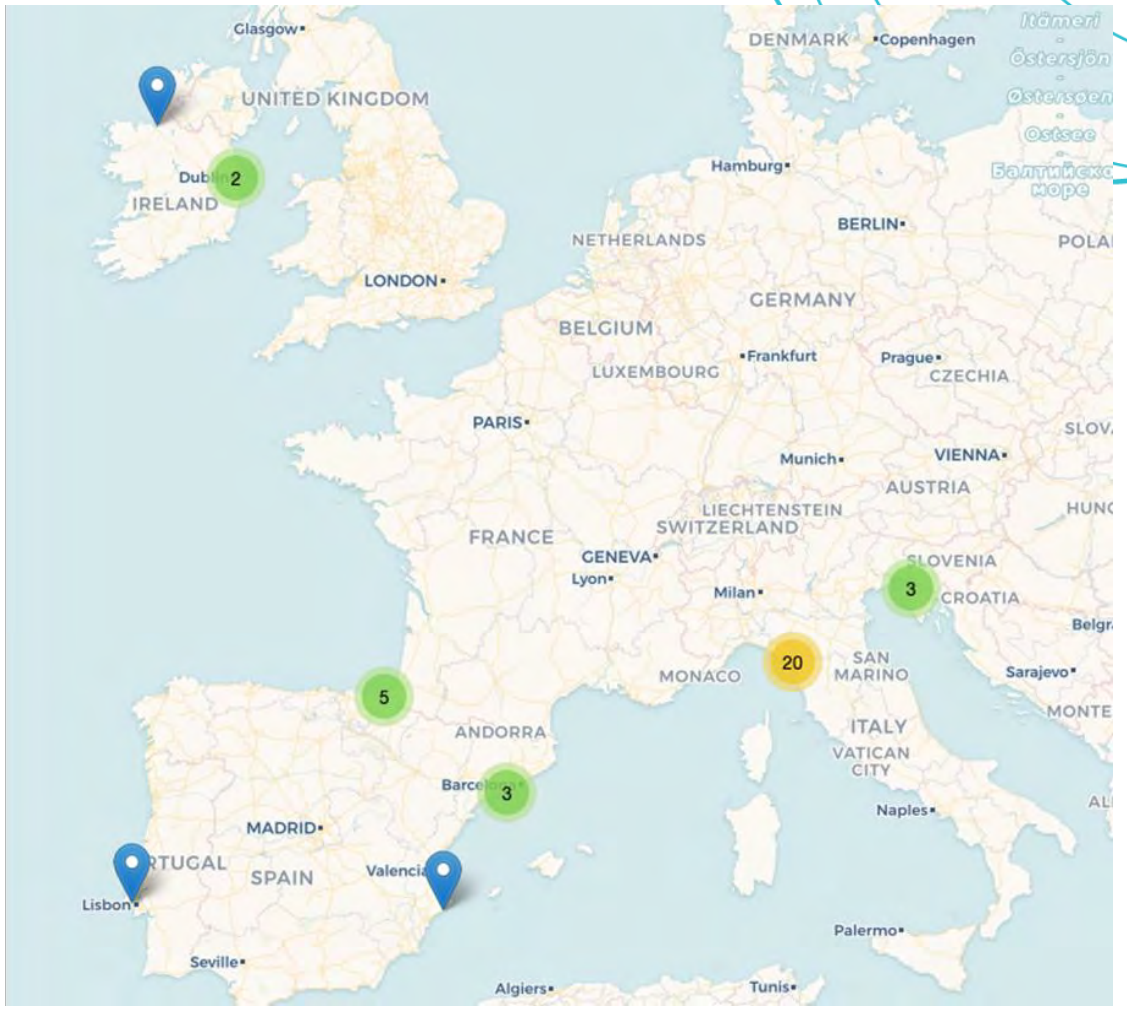


The SCORE ICT data Platform (SIP)

Sensor Service:

- **Collecting data** from both the institutional sensors and the SCORE citizen low-cost sensors used in WP4
- **Sharing the sensor data** to Early Warning Support and Digital Twin platform, WP8
- **Supporting citizen activities** by enabling the collection of field data within the CCLLs,
- **Connecting the CCLL sensors** with the SCORE ICT platform.

Data collection from Institutional & Professional Sensor Networks	
CCLLs	Massa, Sligo, Oarsoaldea, Benidorm, Oeiras, Piran, Dublin, Vilanova
Stations	36
Data streams	75
Observations (measurements)	> 7.340.000



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Smart Control of the Climate Resilience in European Coastal Cities

Thank you!

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- ECCA 2025, 17 June 2025

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Massa CCLL


MISERICORDIE

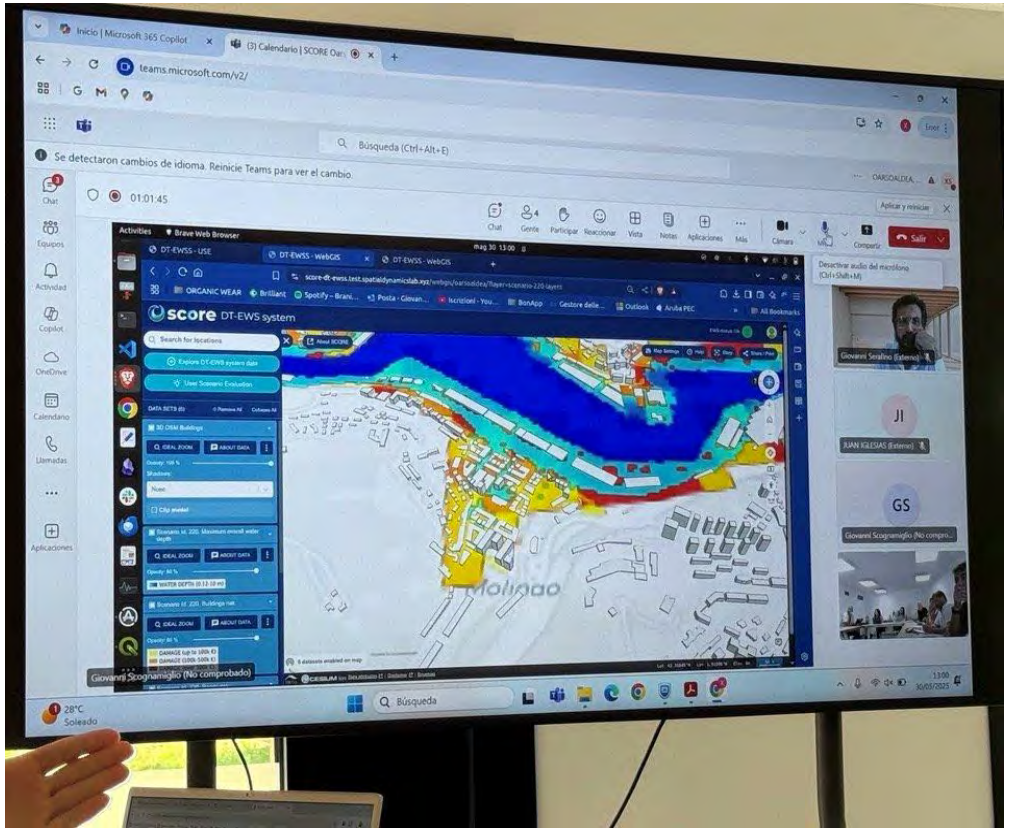
Smart Pebbles Experiment
Massa CCLL

DT-EWS Local Presentation Event

OARSOALDEA CCLL

DT-EWS

OARSOALDEA CCLL

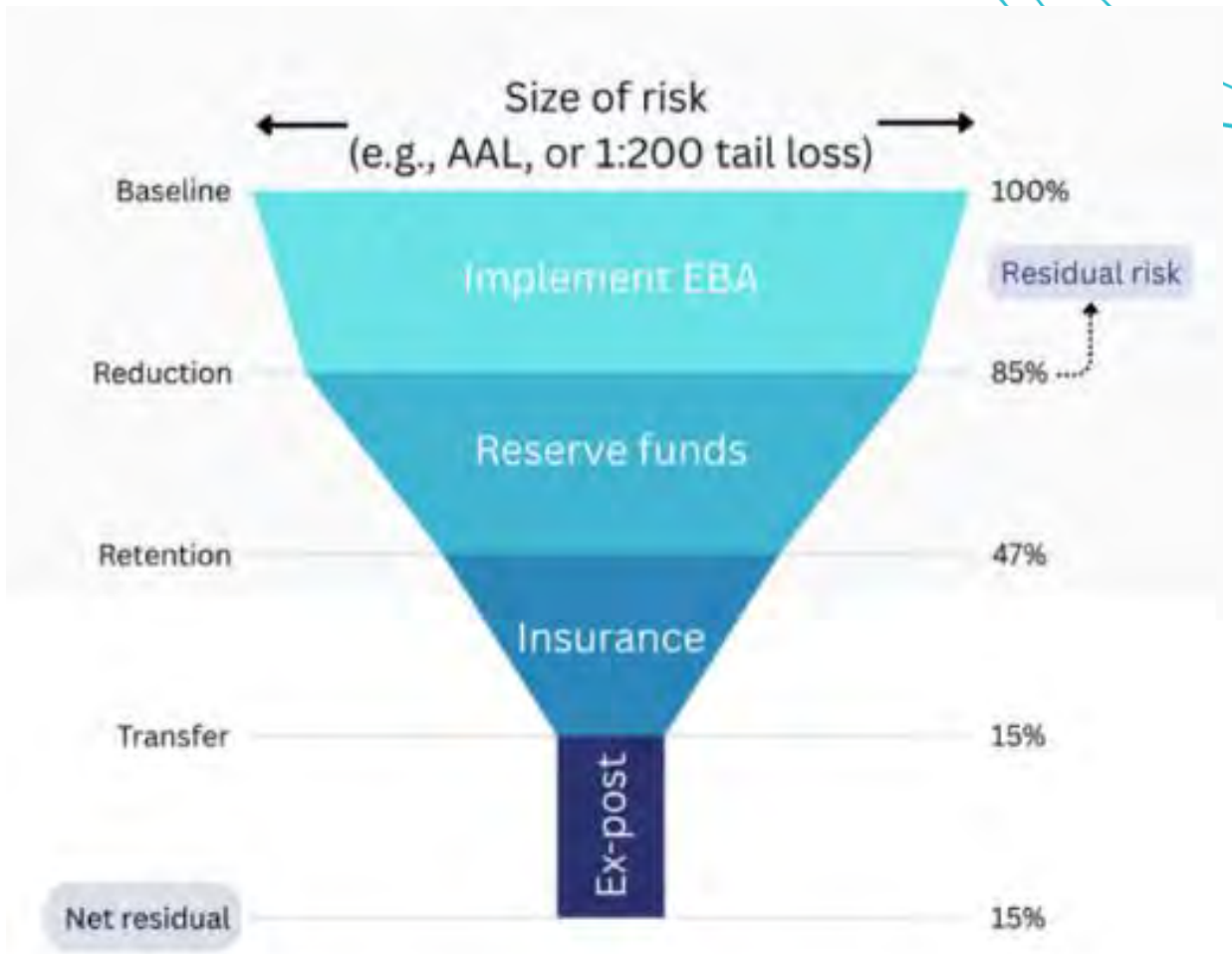


LOW-COST SENSORS

OARSOALDEA CCLL

FINANCIAL RESILIENCE STRATEGIES

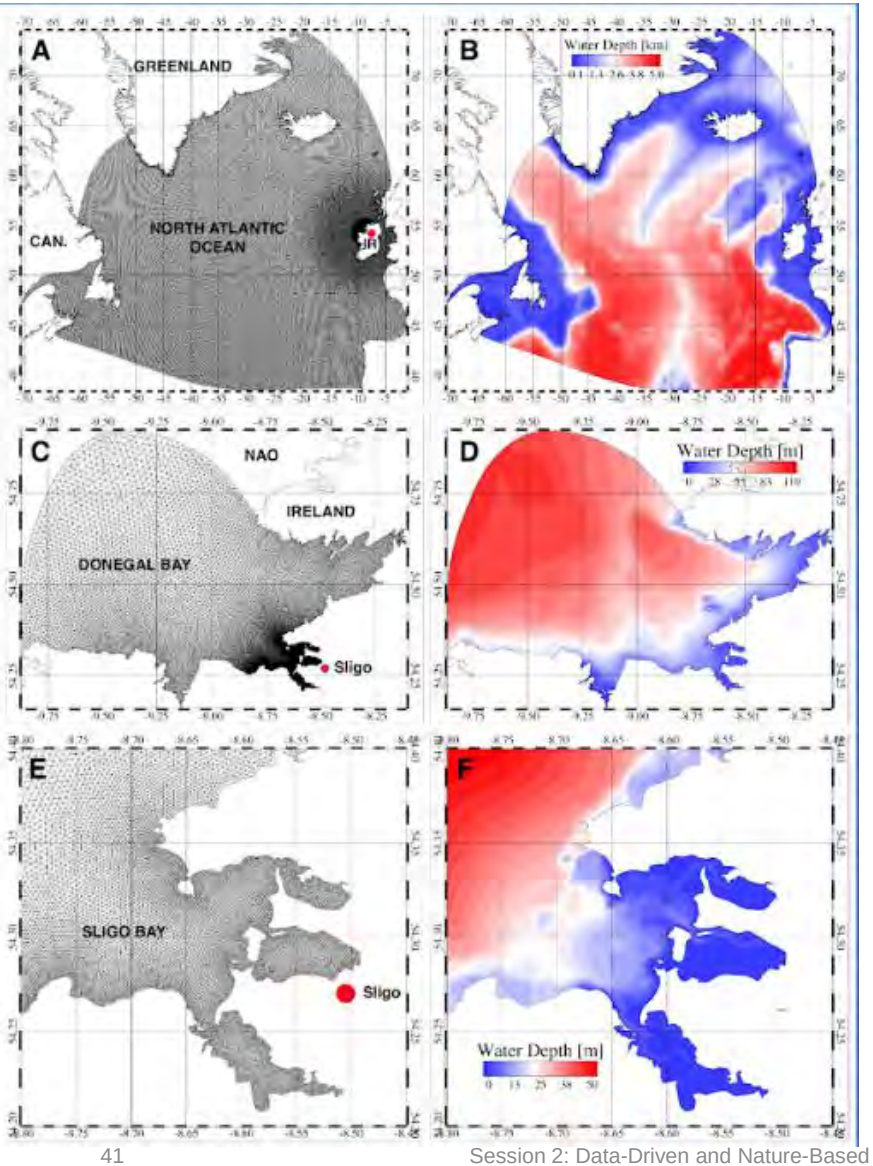
OARSOALDEA CCLL

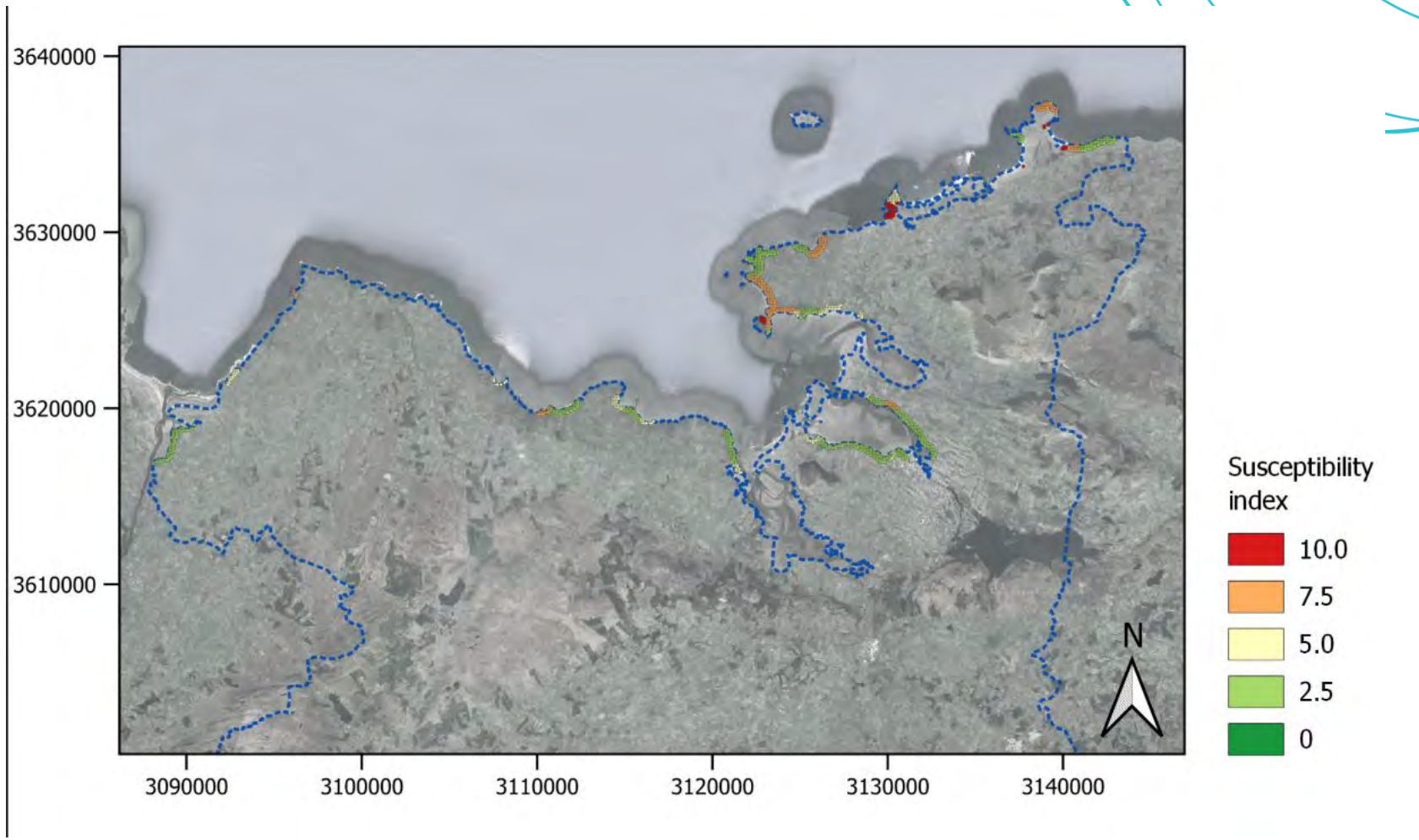


SLIGO CCLL
SMART PEBBLES

SLIGO CCLL

SLIGO CCLL


A
GREENLAND
CAN.
NORTH ATLANTIC OCEAN
IR
B
Water Depth [km]
C
NAO
IRELAND
DONEGAL BAY
Sligo
D
Water Depth [m]
E
SLIGO BAY
Sligo
F
Water Depth [m]


3640000
3630000
3620000
3610000
3090000
3100000
3110000
3120000
3130000
3140000
N
Susceptibility index
10.0
7.5
5.0
2.5
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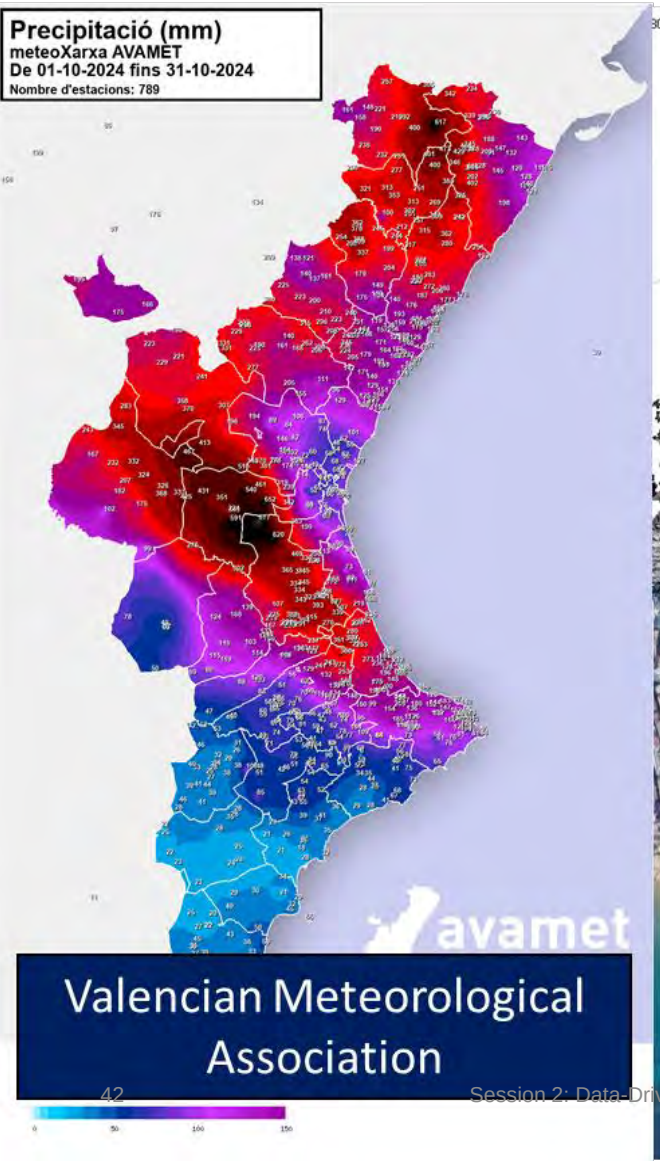
BENIDORM CCLL



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Smart Control of the Climate Resilience in European Coastal Cities

Thank you!

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