BORIS

Cross **BO**rder **RIS**k assessment for increased prevention and preparedness in Europe

Flood risk assessment in transboundary regions

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Pavia – BORIS Final Workshop

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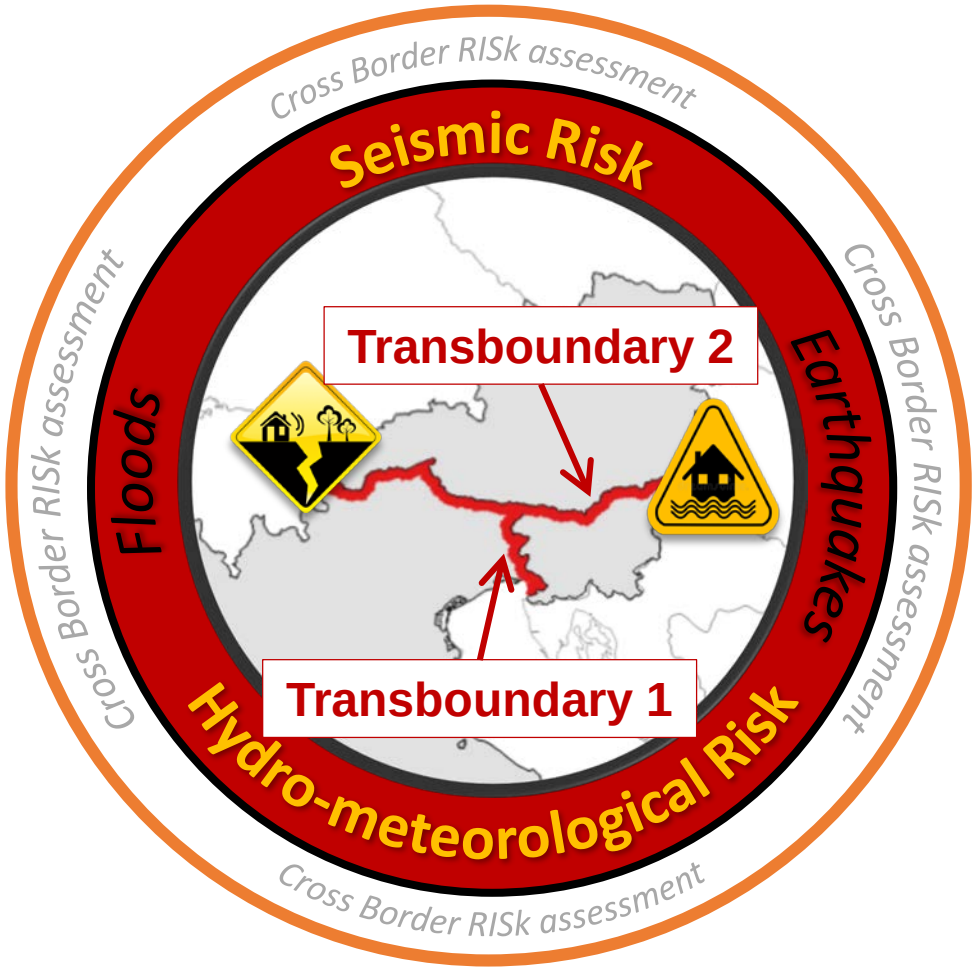
GA n° 101004882 - BORIS - UCPM-2020-PP-AG - Project co-funded by the European Union Civil Protection

HARMONIZATION of Cross-border FLOOD risk assessment



RISKS:

- ✓ MULTI-RISK (EQ+FL)
- ✓ EARTHQUAKES (EQ)
- ✓ **FLOODS (FL)**
  - ✓ HAZARD - INPUT CHARACTERIZATION
  - ✓ VULNERABILITY MODELING
  - ✓ EXPOSURE (INVENTORY DATA)
  - ✓ DAMAGE/IMPACT EVALUATION

➢ **TRANSBOUNDARY 1**: **PILOT 1**

Italy-Slovenia

➢ **TRANSBOUNDARY 2**: **PILOT 2**

Slovenia-Austria

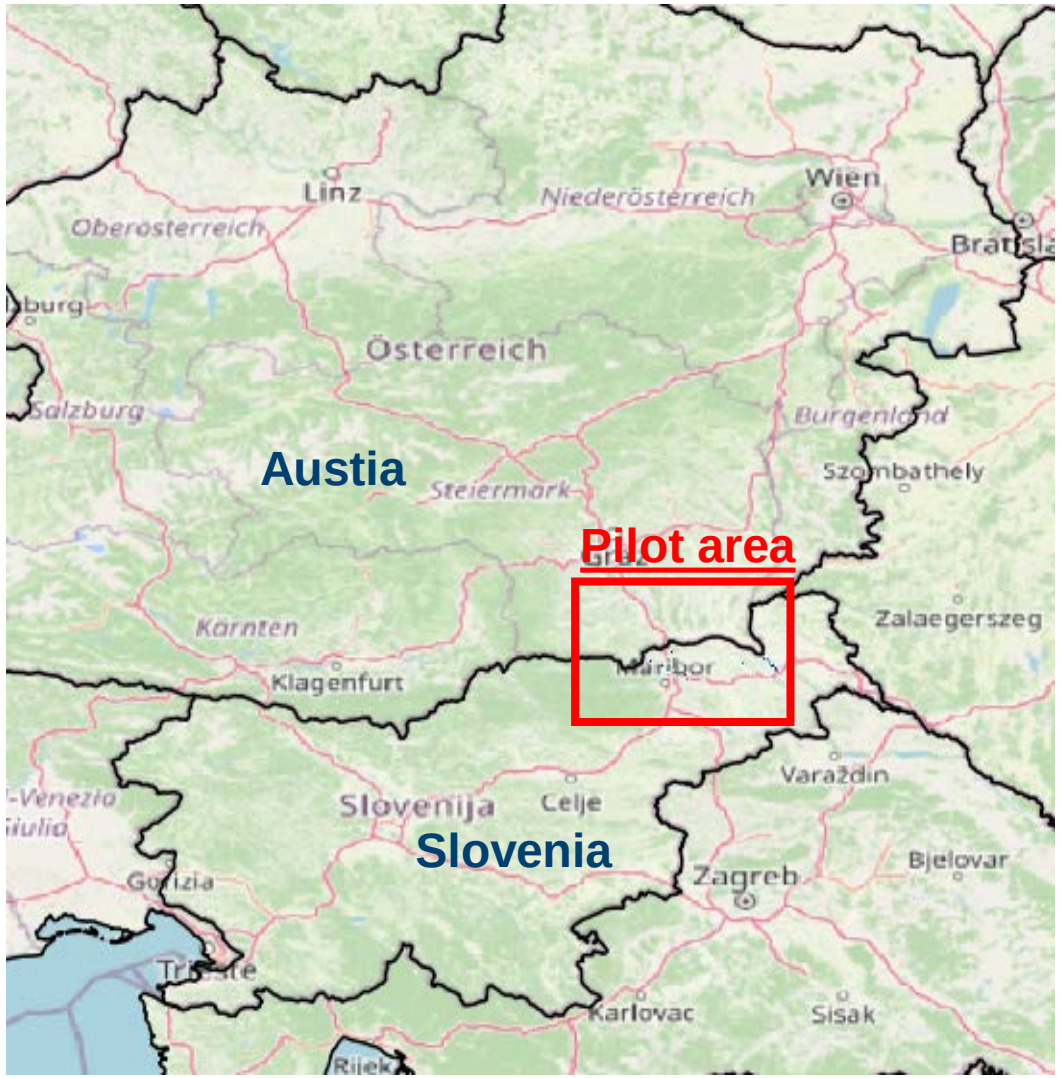
HAZARD: Cross border Italy – Slovenia

Area of interest:

The area of interest is the hydrological basin of **Isonzo river.**

- The Isonzo river **originates in** Val di Trenta (**Slovenia**)
- **near Gorizia it enters** Friuli Venezia Giulia (**Italy**)
- Its **hydrographic basin of about 3500 km²** (3416 km²) develops for about **2/3** in **Slovenia** and **1/3** in **Italy**

HAZARD – Cross border Austria – Slovenia

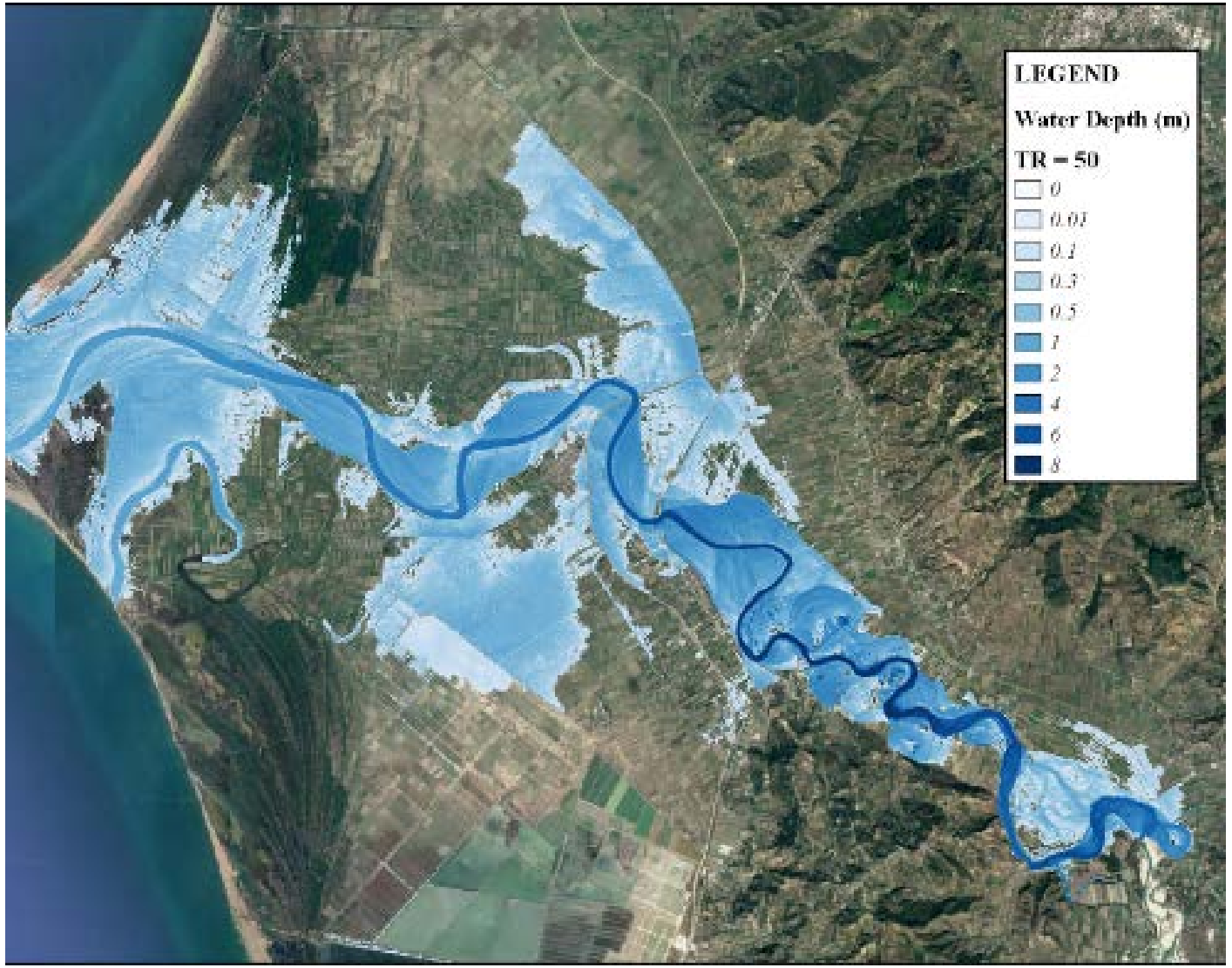


Area of interest:

The area of interest is the hydrological basin of the **Mura river.**

- The Mura river **originates in** Styria (**Austria**)
- **flow along the Austria-Slovenia borders** and in Slovenia moving towards Croatia and Hungary
- **hydrographic basin of about 14000 km²** flowing across Austria, Slovenia, Croatia and Hungary

HAZARD – from EU Floods Directive



A requirement for flood risk mapping are the hazard flood maps. Hazard flood maps are maps of flood extension and depth for a specific probability of occurrence (return period)

Goal of the activity is to obtain homogeneous hazard maps (same return time) that can be used for risk mapping having as input not homogenous maps of flood prone areas (different return period and without depth)

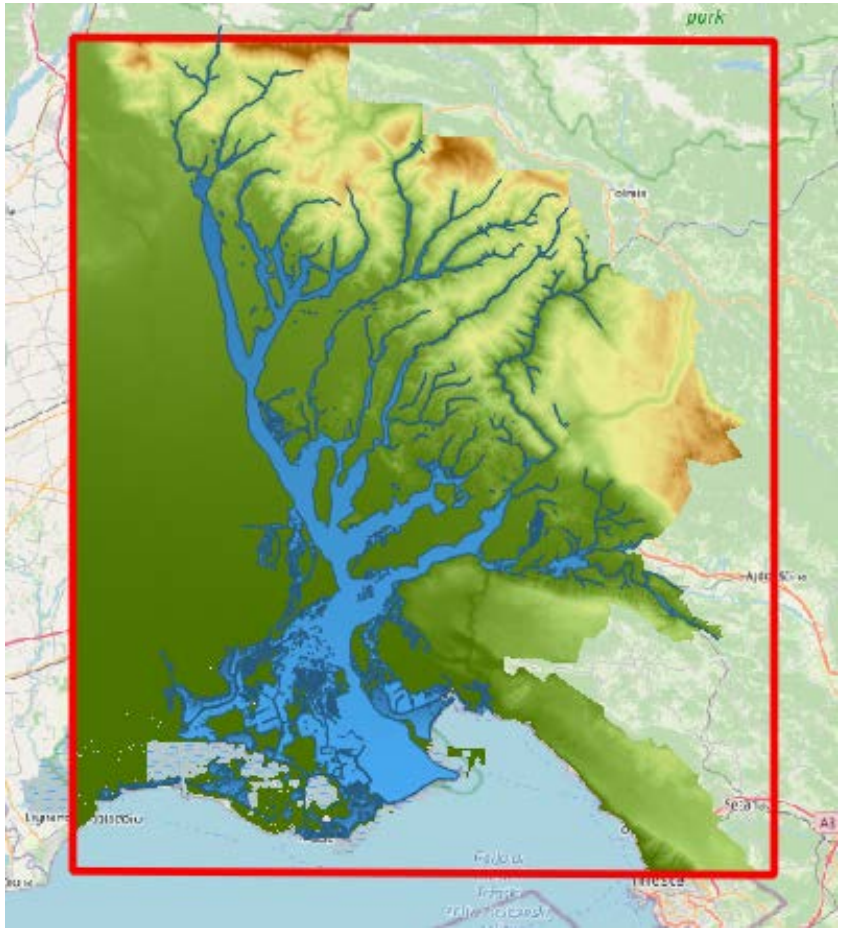
HAZARD

Problem 1 → just flood extension maps are easily available

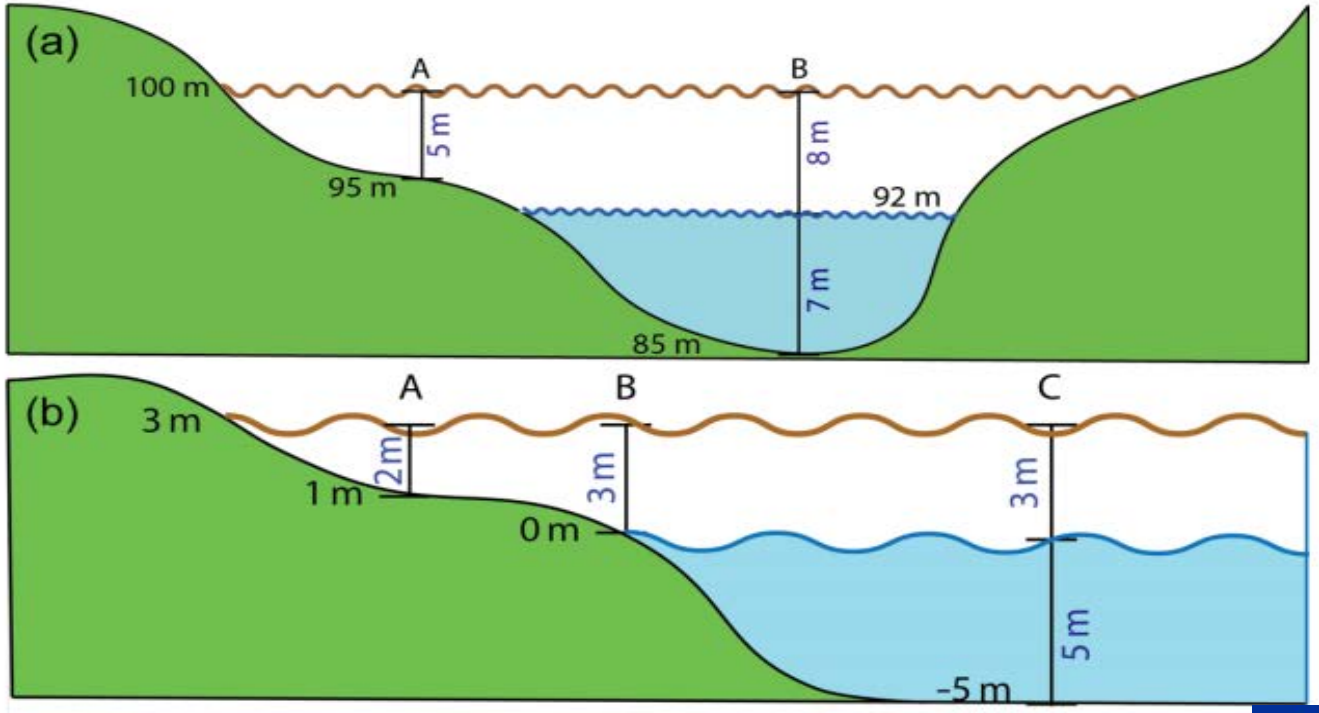
HAZARD: A methods for water depth estimation

INPUT DATA

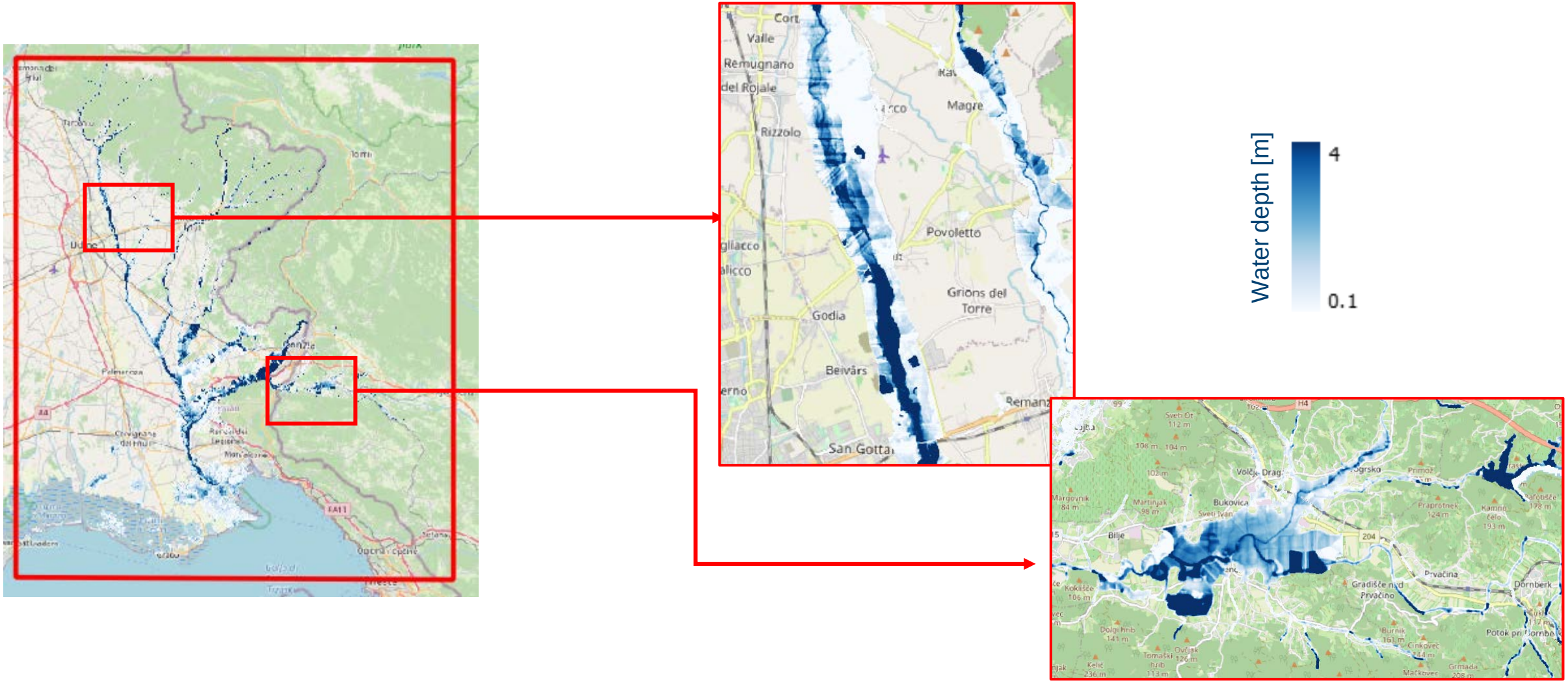
- Flood prone areas from EU Floods Directive
- 5 m DTM



The **Floodwater Depth Estimation Tool (FwDET)** identifies the floodwater elevation for each cell within the flooded domain based on its nearest flood boundary grid cell (Cohen et al., NHESS, 2019) - Implemented of FwDET on Google Earth



HAZARD: Floodwater Depth Estimation Tool (FwDET)



HAZARD

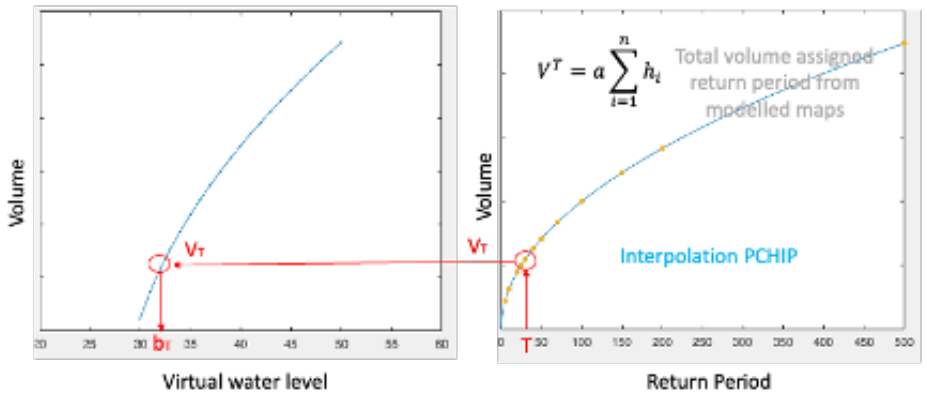
Problem 1 → **just flood extension maps are easily available**

Solution 1 → **We** can use FwDET and a high-resolution DEM to **complete the available flood prone areas with water depth**

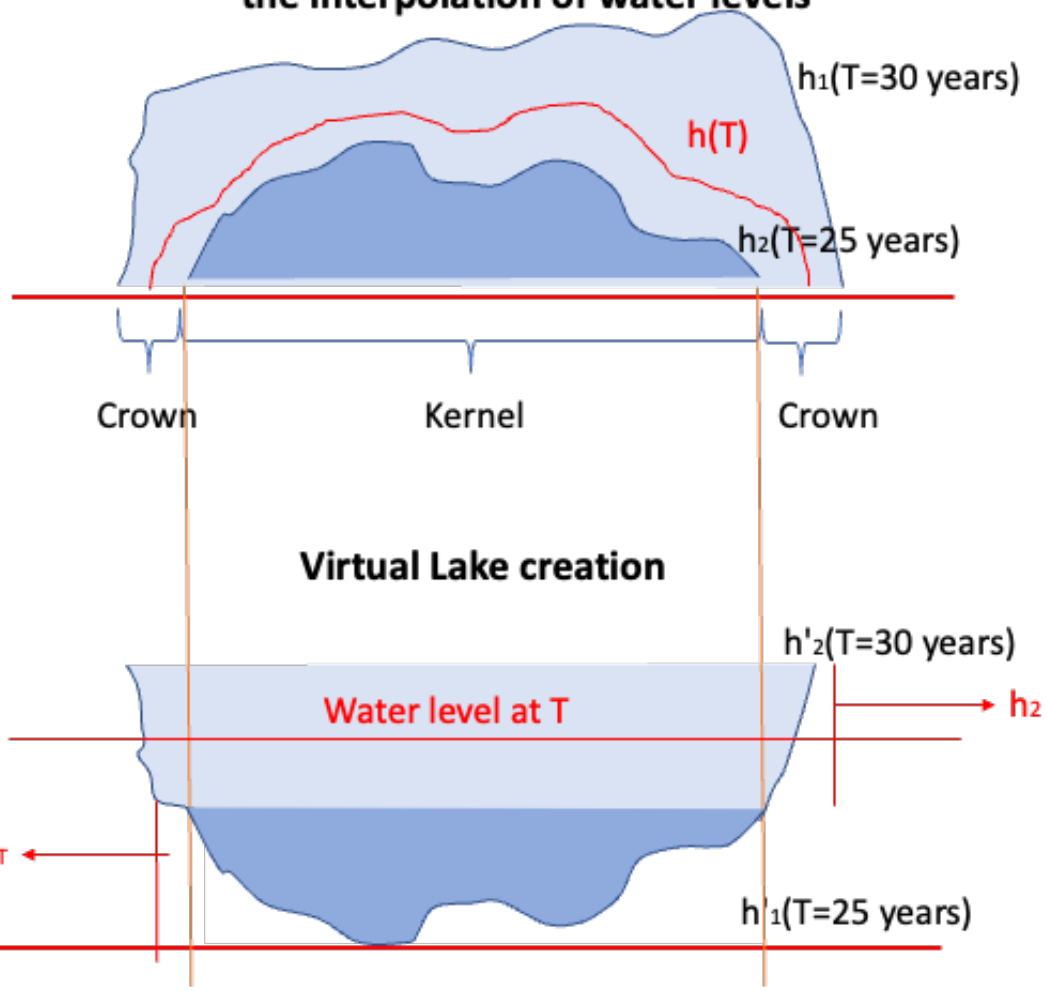
Problem 2 → the **maps available** are for **3 return periods** (high, medium and low probability) that can be **different from Country to Country**

HAZARD: Algorithm for the creation flood maps (level and depth) for different return periods

Creation of volume curves



Definition of the 3d spatial distribution of the interpolation of water levels



Equations

$$h_1 = \max(h_{NOMINAL\ LOW})$$

$$h_2 = \max(h_{NOMINAL\ UPPER}\ (Crown))$$

$$h_T(Crown) = h_2 - b_T$$

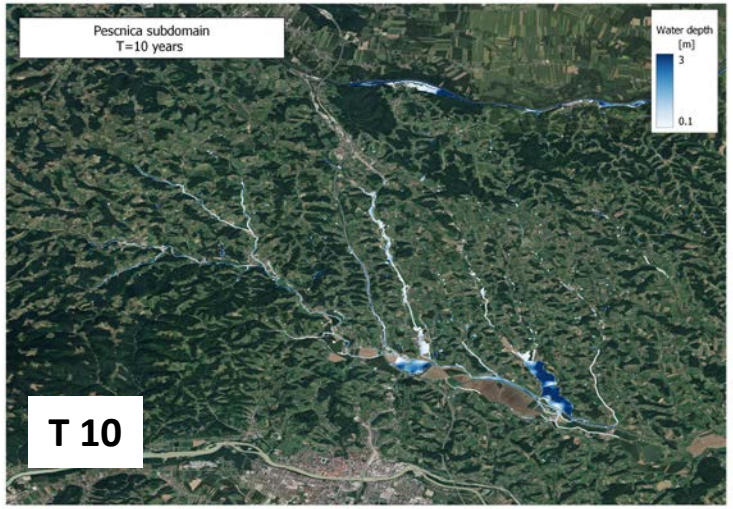
$$h_T(Kernel) = (h_{kernel} - b_{T,kernel} - h_1)\gamma + h_1$$

$$\gamma = \frac{h_1'}{(h_{1,nucleo}) + (h_{2,nucleo}) - b_{T,nucleo}}$$

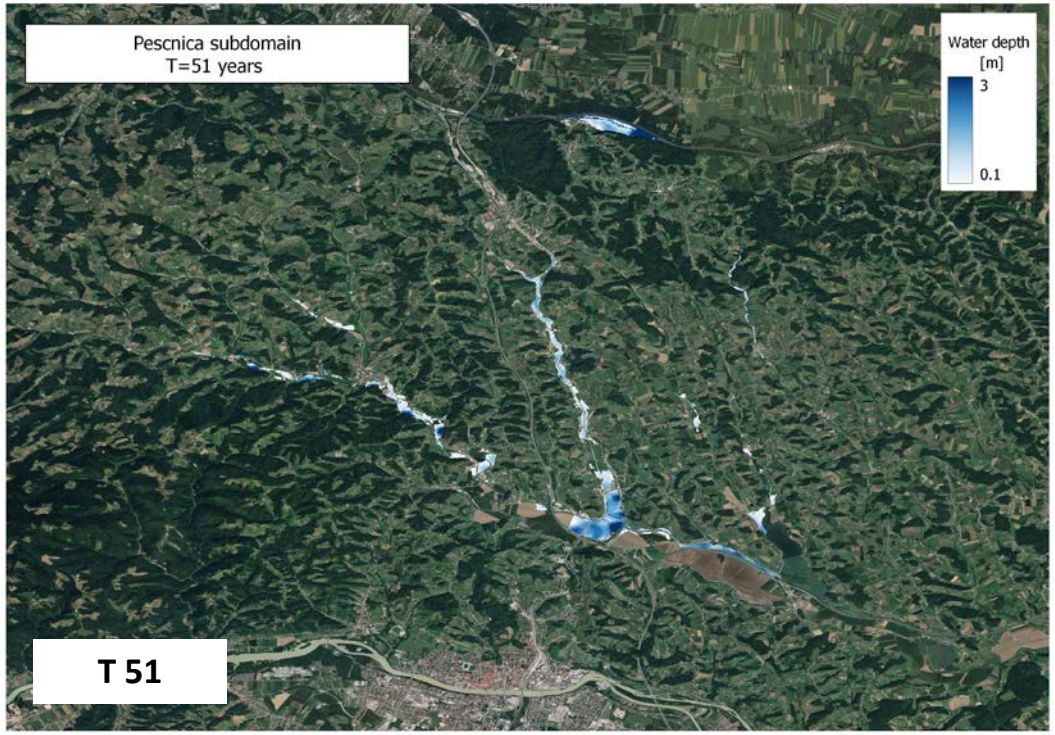
Corrective coefficent for the kernel

HAZARD: example of created with the interpolation algorithm

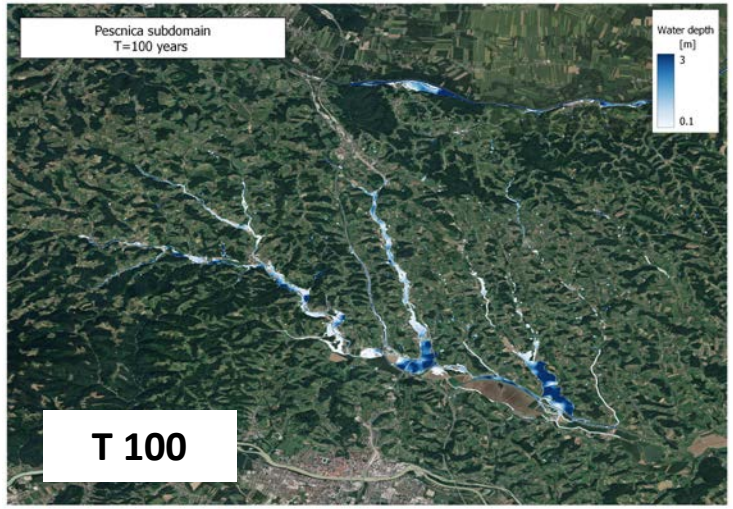
Input



Algorithm Output



Input



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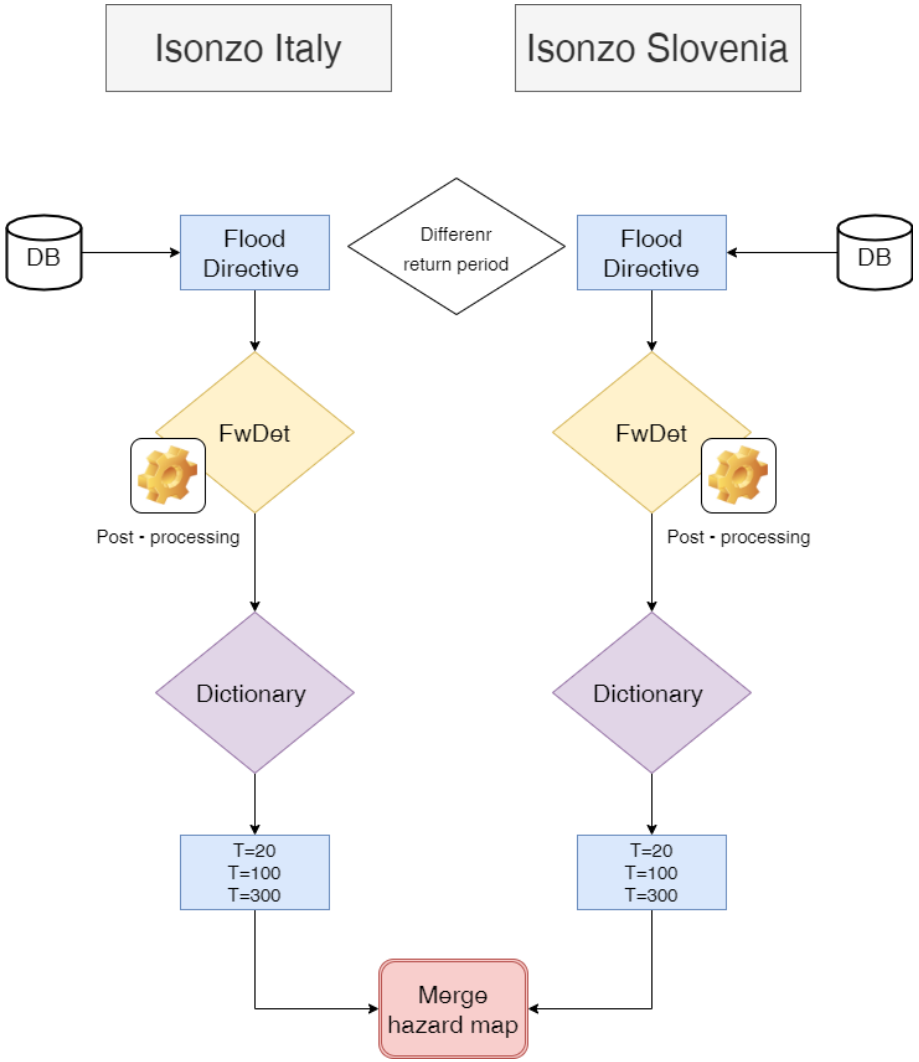
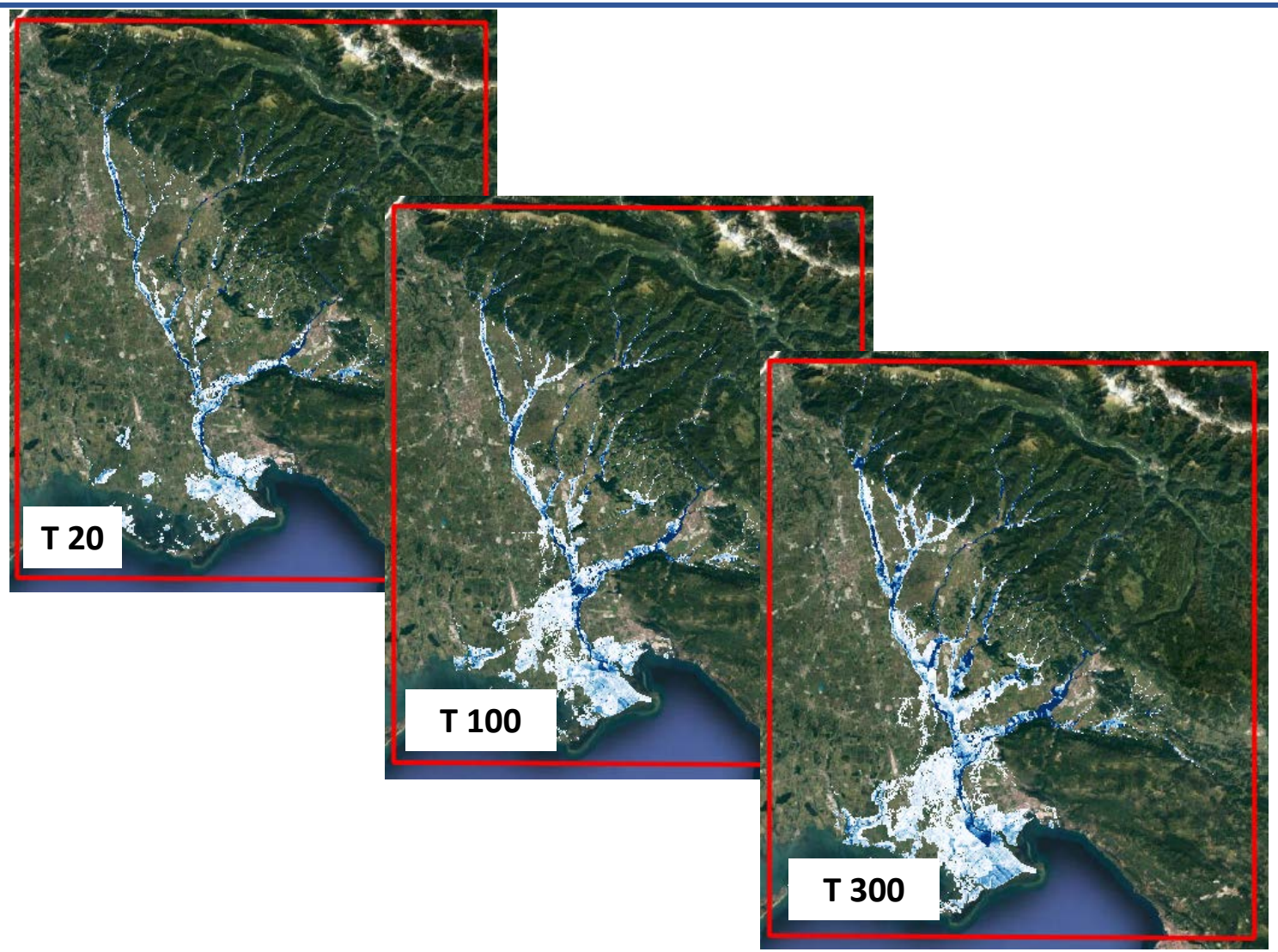
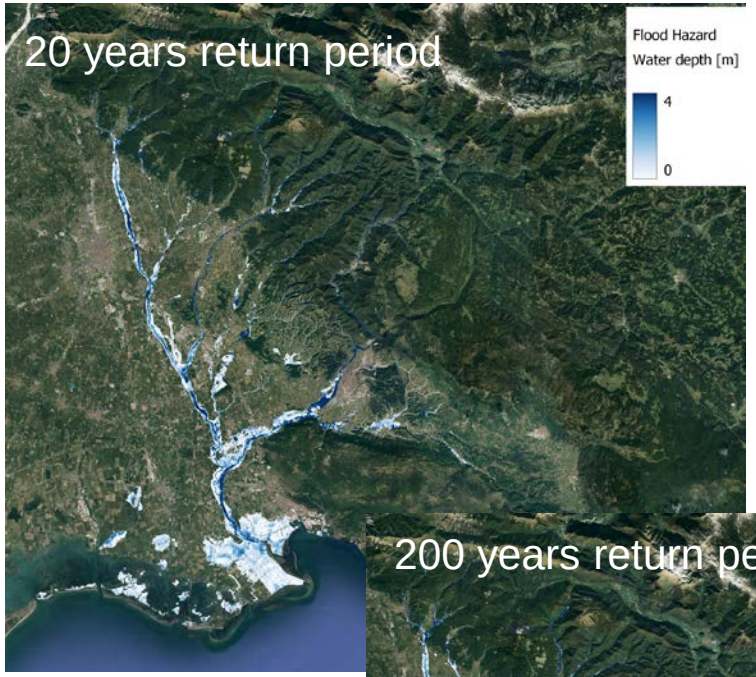
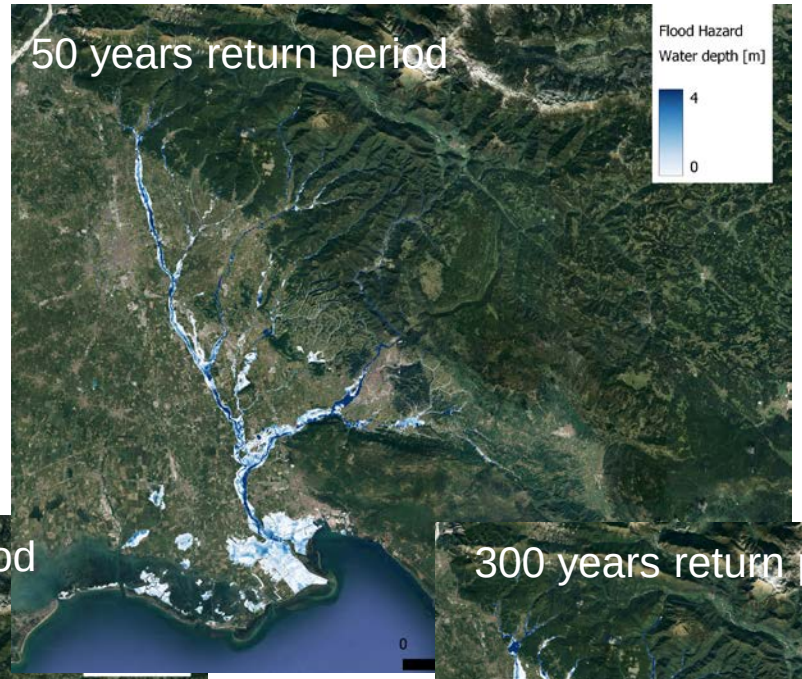
HAZARD: cross-border hazard maps harmonization

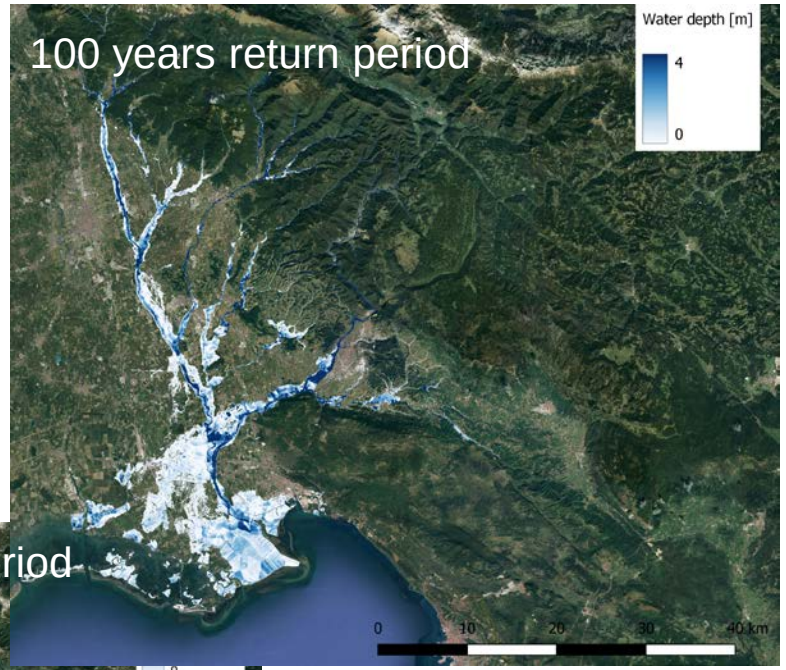


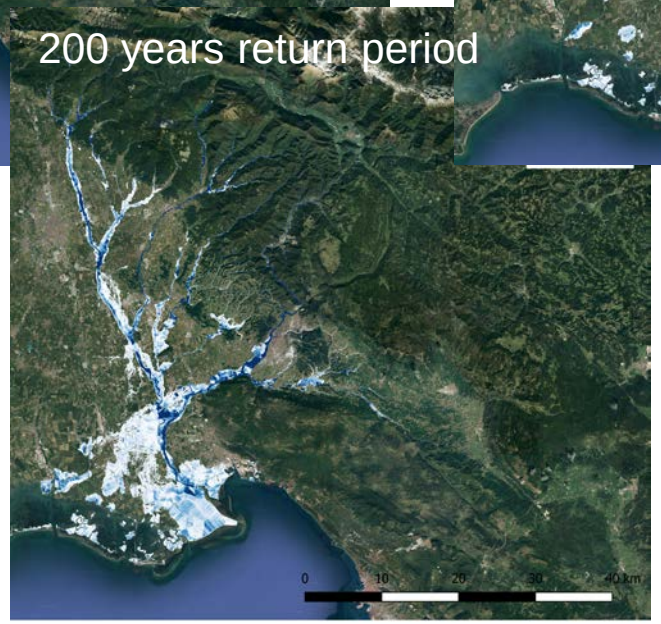


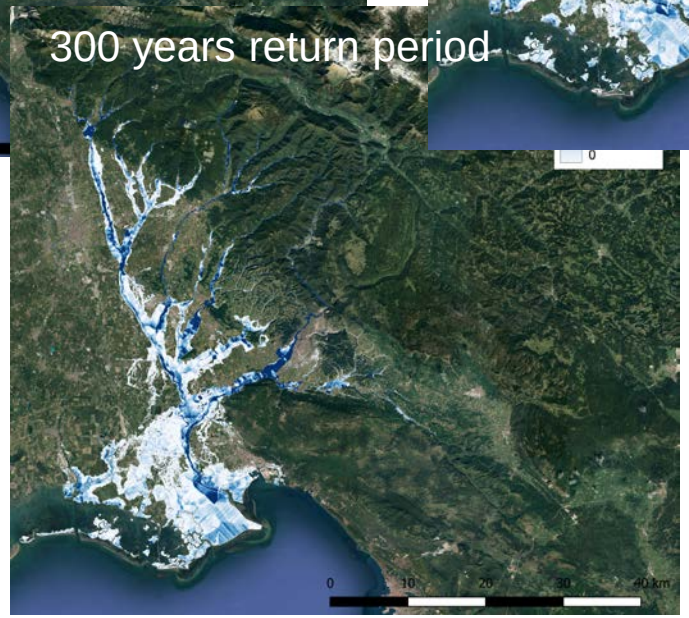
Hazard map Pilot 1











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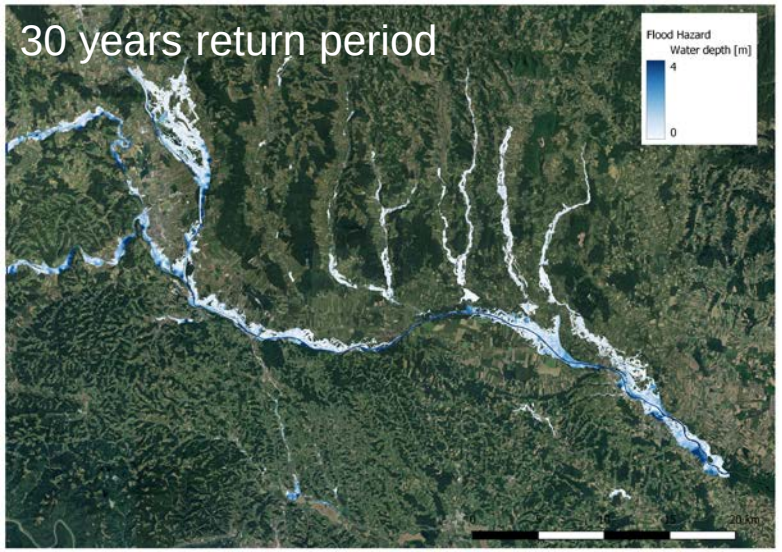
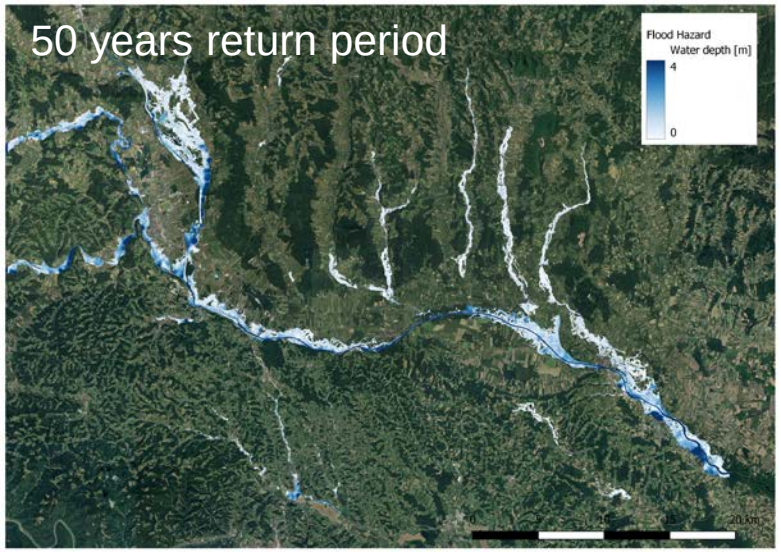
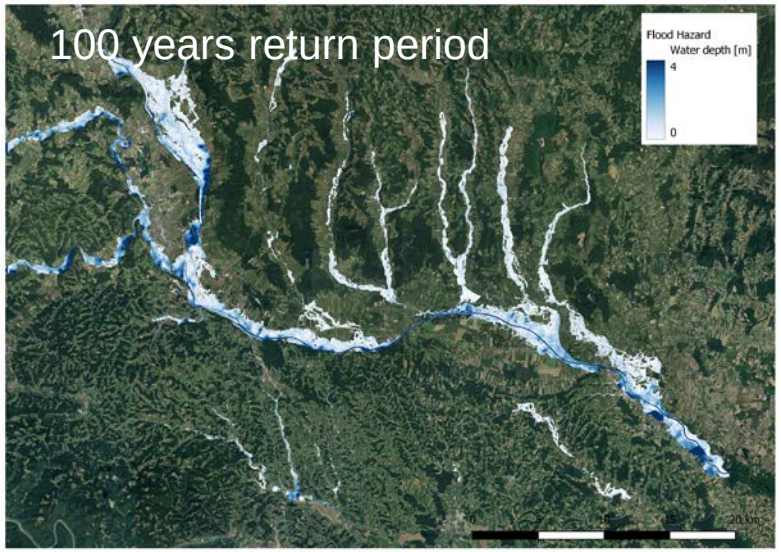
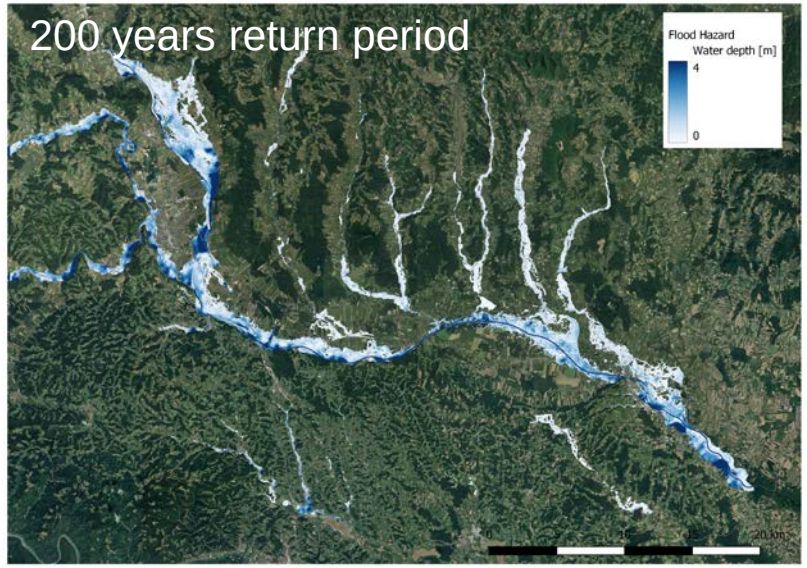
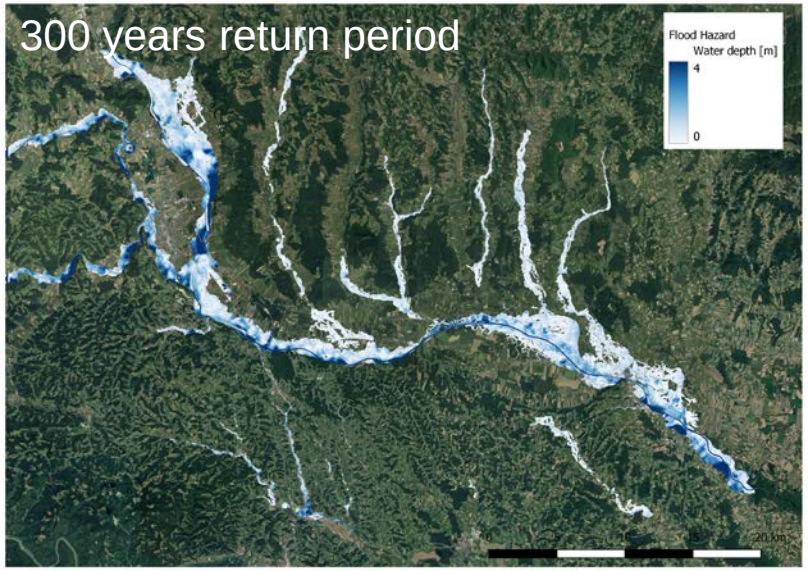
Hazard map Pilot 2











HAZARD - conclusions

For cross border areas **we start from EU Floods Directive maps** produced by each member state

This **to ensure transferability and replicability of the procedure to other cross-border areas in EU**

Problem 1 → **just flood extension maps are easily available**

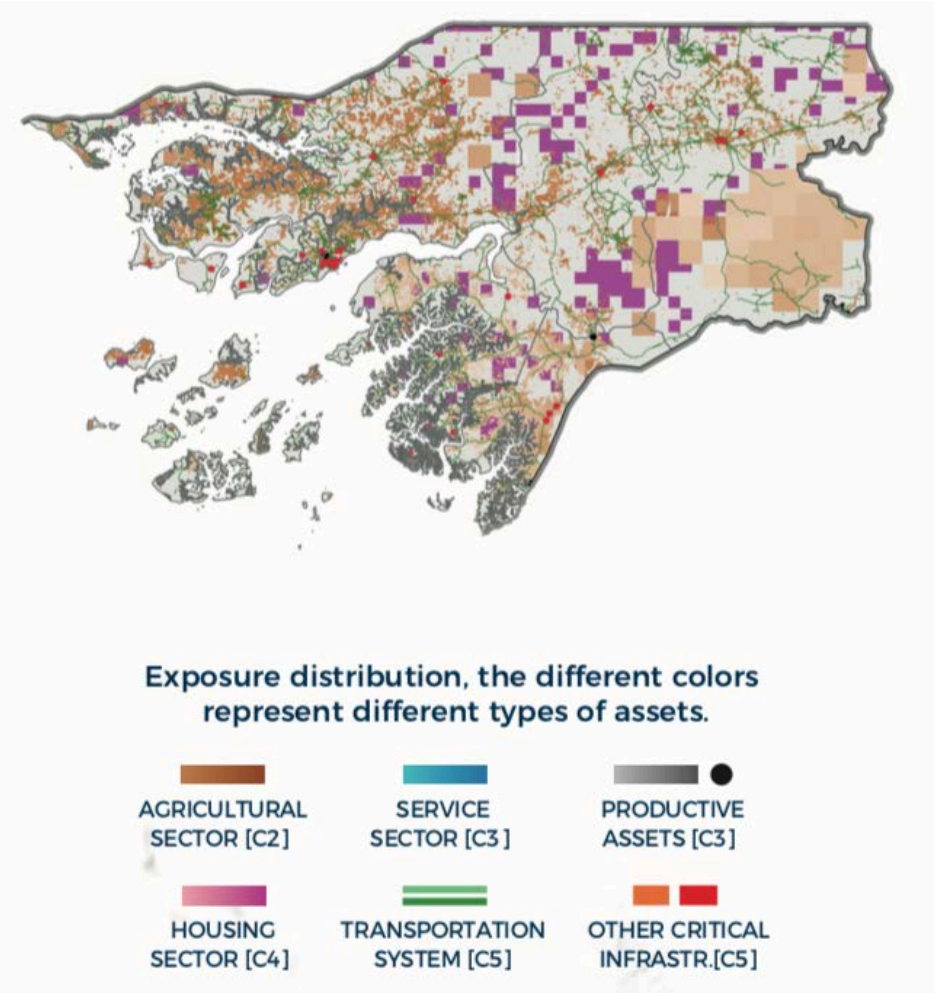
Solution 1 → **We** can use FwDET and a high-resolution DEM to **complete the available flood prone areas with water depth**

Problem 2 → the **maps available** are for **3 return periods** (high, medium and low probability) that can be **different from Country to Country**

Solution 2 → we can use an algorithm that "interpolates" flood hazard maps between two different return periods to have more hazard maps and for the same return periods

Exposure

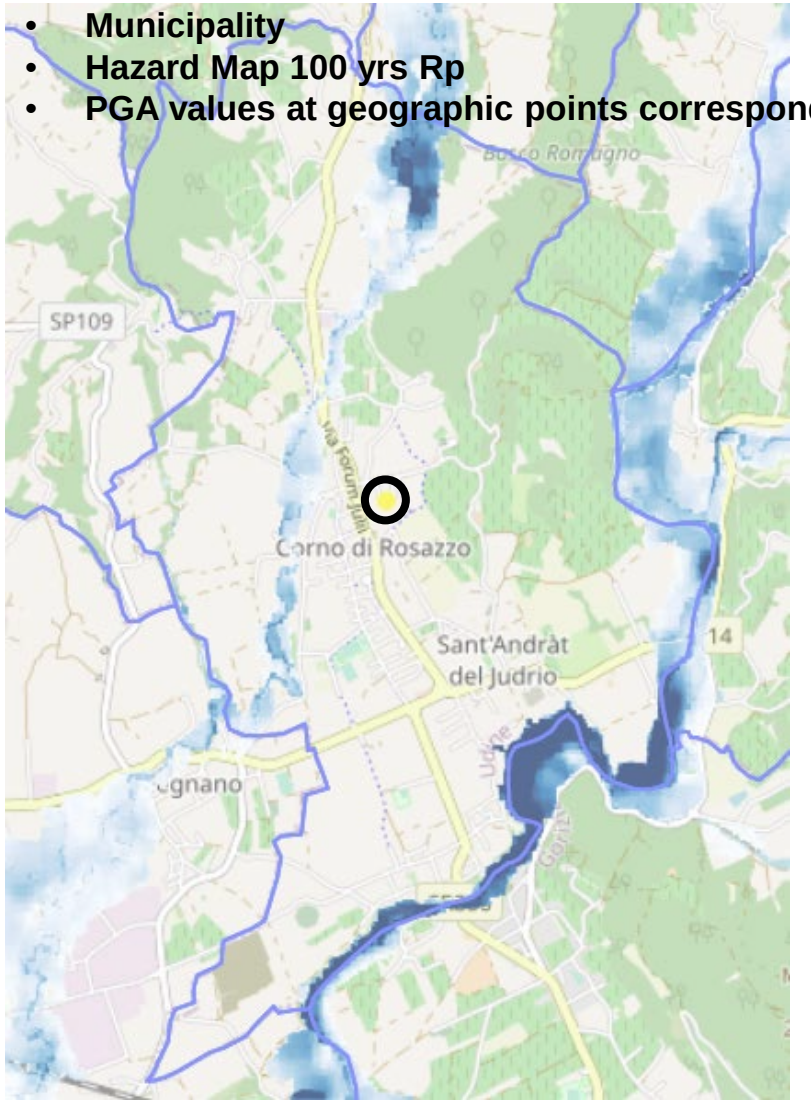
"The situation of people, infrastructure, housing, production capacities and other tangible human ***assets located in hazard-prone areas****."*
- UNISDR

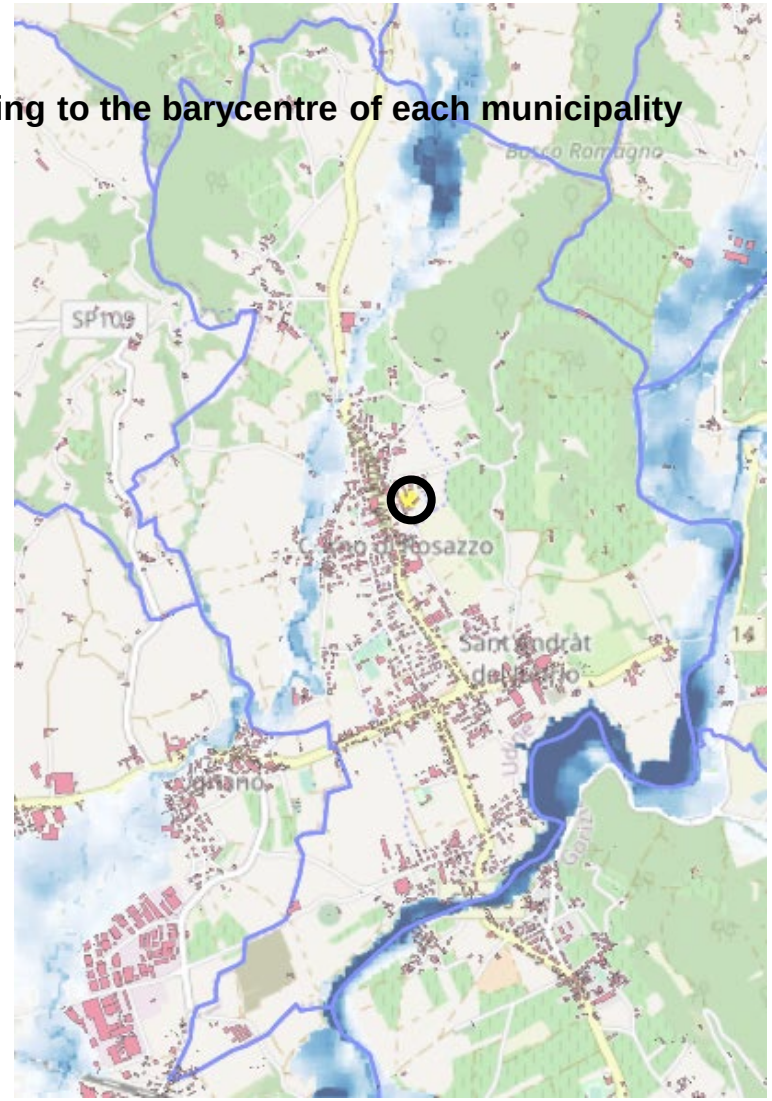


Flood Model Exposure at building-level

- EM are available for different **purposes and scales**;
- Scale needs to be **correlated to the other components of the risk** equation, above all the spatial resolution of the hazard;
- From macro-scale or regional level for countries evaluations to **micro-scale, building-level exposure**, particularly adopted in the context of pluvial flooding in densely **built-up areas**, as in some municipality of the cases study proposed in BORIS project.

- **Municipality**
- **Hazard Map 100 yrs Rp**
- **PGA values at geographic points corresponding to the barycentre of each municipality**



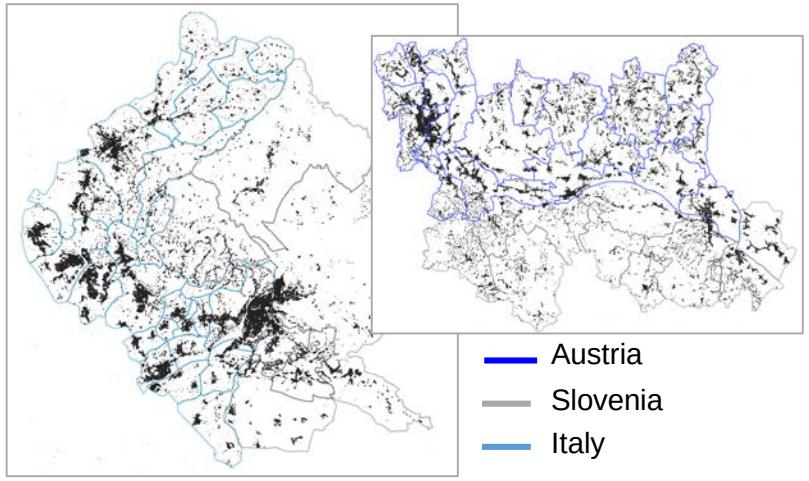


Flood Model Exposure at building-level

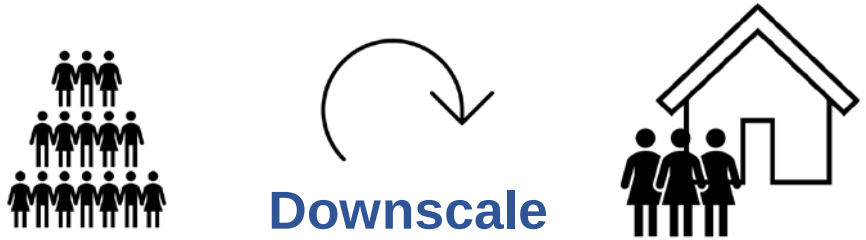
Assignment of the vulnerability characteristics

- OCCUPANCY
- BUILDING MAINTENANCE
- WITH BASEMENT
- WITHOUT BASEMENT
- NUMBER of FLOORS
- CONSTRUCTIVE MATERIAL
- TYPE of CONTENTS

Assignment of the value function of the surface – OSM Layer or Statistical Office



Assignment of the population to each building



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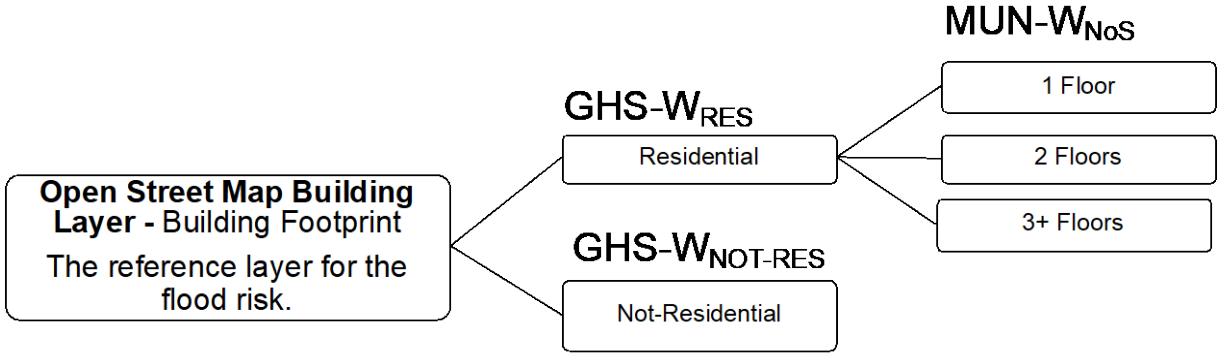
Flood Model Exposure at building-level

Assignment of the vulnerability characteristics

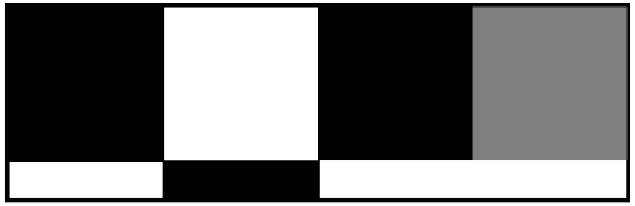
LOGIC TREE APPROACH to construct the exposure model



Logic-trees were made to assign the vulnerability characteristics to each building. Weights of discrete branches that represent alternative hypotheses and interpretations were determined by the:

- GHS-BUILT-S R2022A for the Building USE: The spatial raster dataset depicts the distribution of built-up surfaces, expressed as number of square meters. The data reports about the total built-up surface and the built-up surface allocated to dominant non-residential (NRES) uses.
- Local data aggregated at Municipality level for the Number of Storeys (adopted also in the seismic analysis)

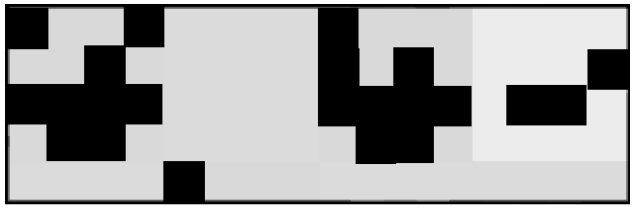
From Global and Statistical Data downscaled to each Building



Raster Data

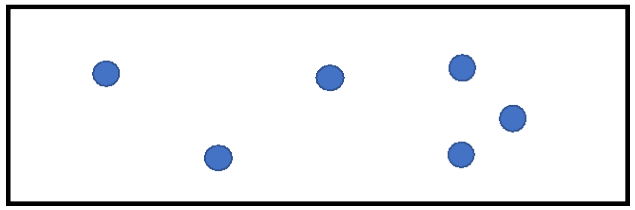
High level of aggregation

District level



Raster Data

Low level of aggregation



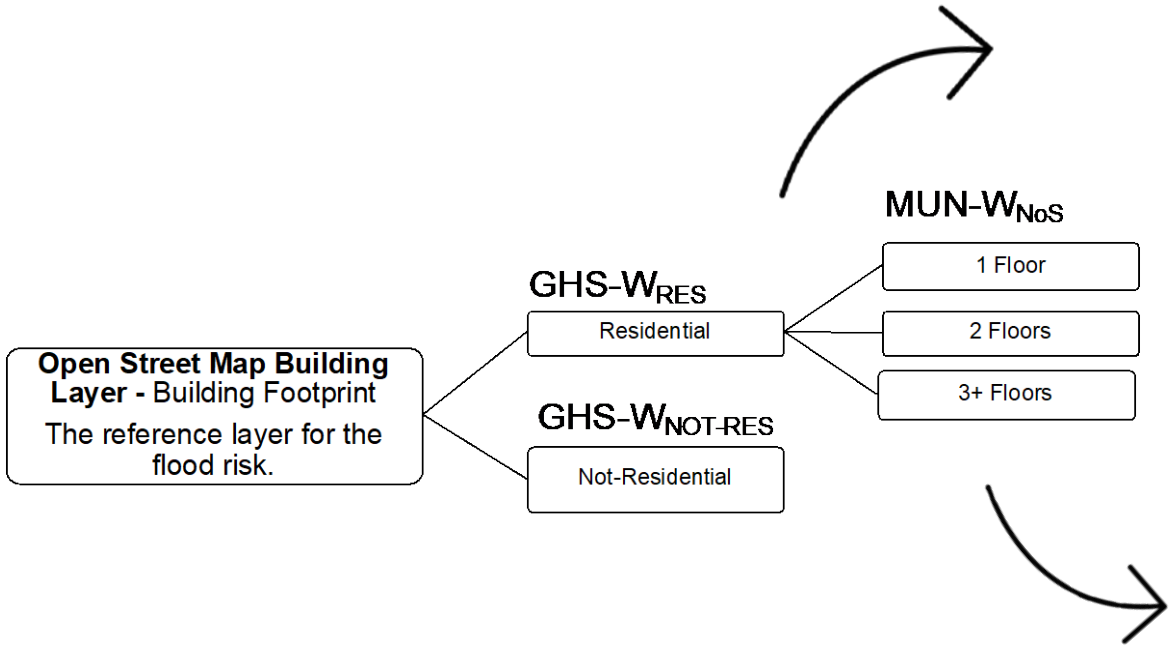
Census data

Information at element scale

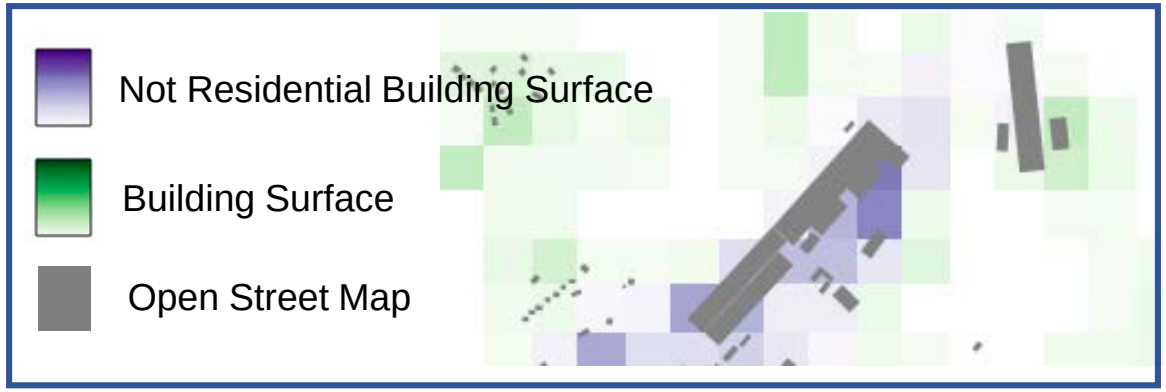
Asset level

Flood Model Exposure

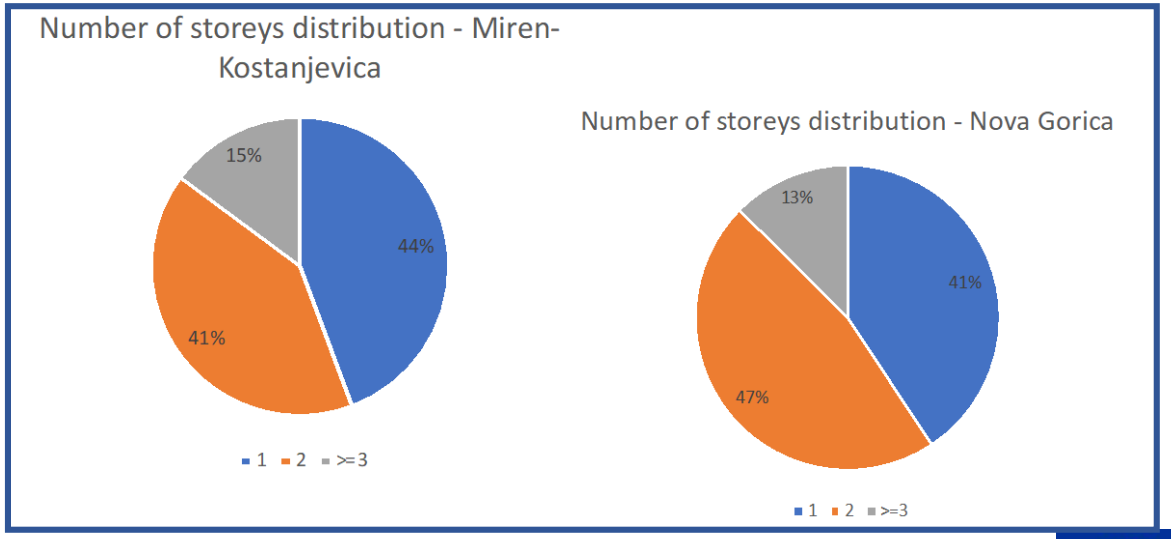
LOGIC TREE APPROACH to construct the exposure model



GHS-W$_{RES}$ and GHS-W$_{NOT-RES}$ are determined to GIS OPERATION called «ZONAL STATISTICS».



MUN-W$_{NoS}$ are determined throught statical data aggregated at municipality level



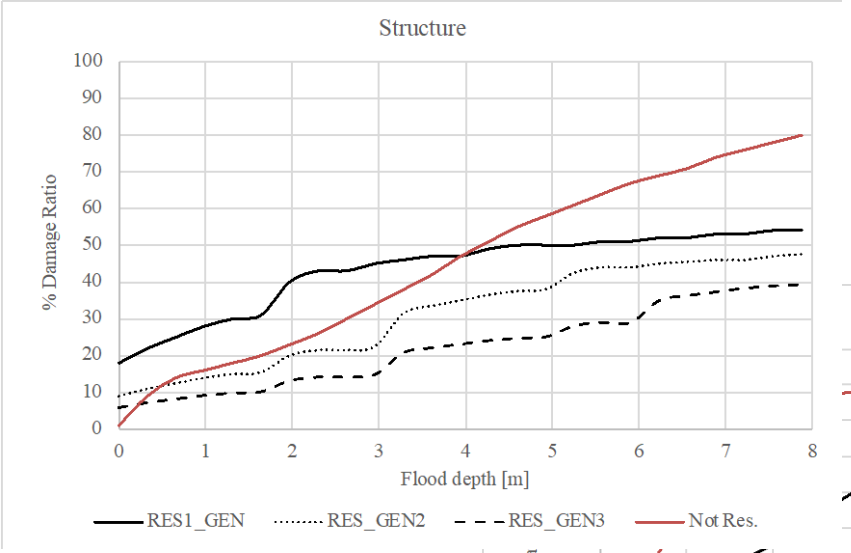
Vulnerability

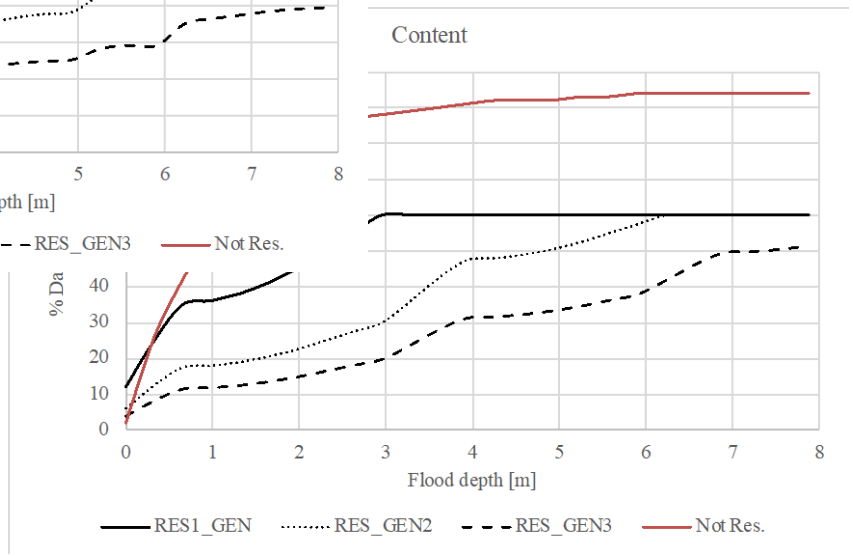
"The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards."

Physical Vulnerability

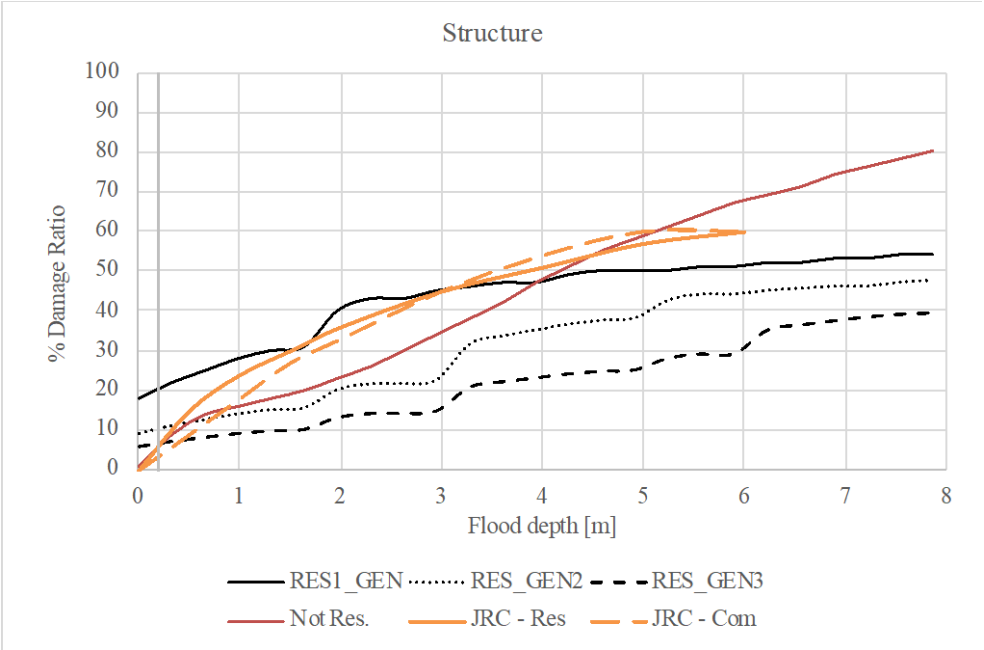
- The propensity of assets to suffer physical damages from hazardous events;
- Analysis of flood physical vulnerability performed by means of **damage functions** or **vulnerability curves** that relate flood intensity (usually expressed as flood depth, but also velocity, duration, …) with vulnerability/damage data;

HAZUS curve





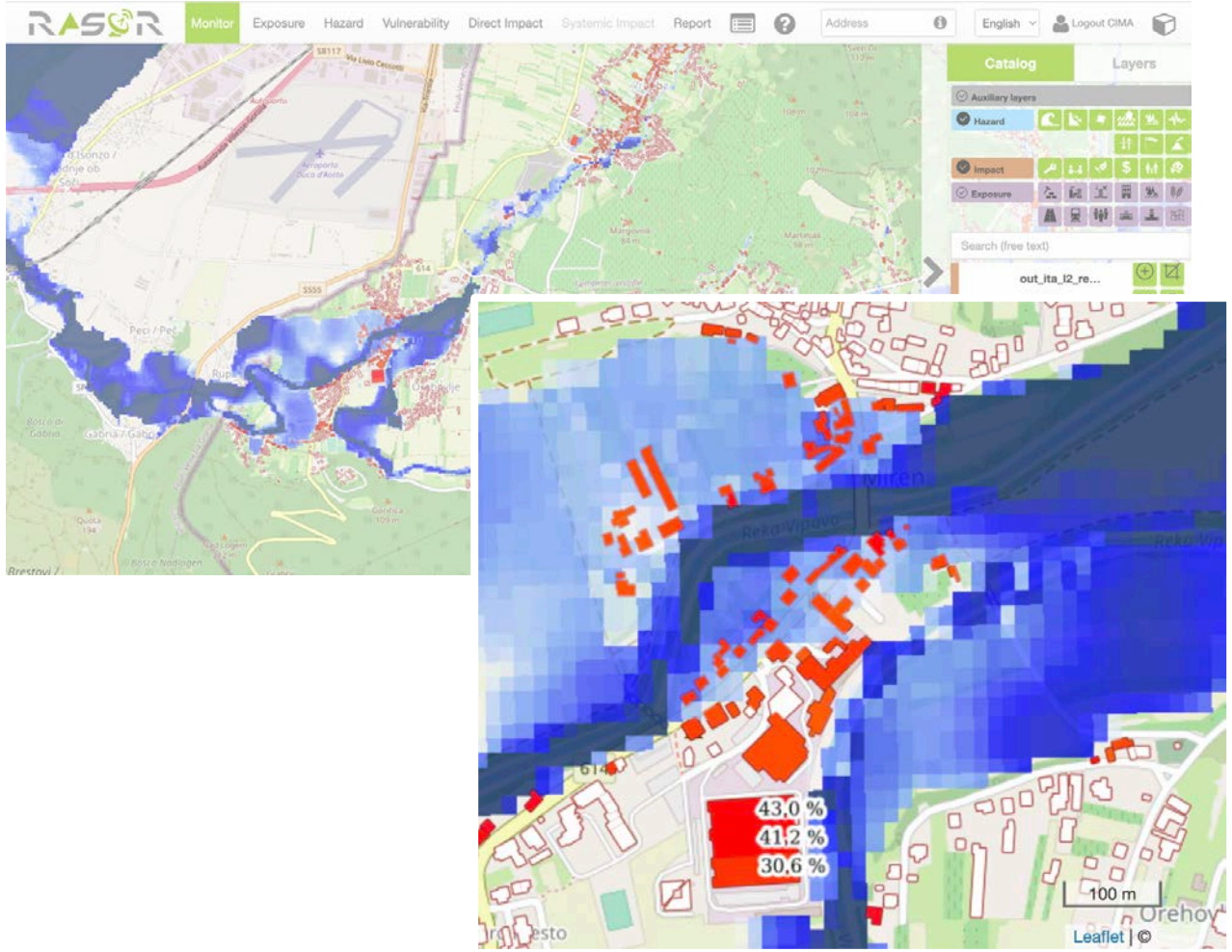
Comparison of vulnerability curves available in literature



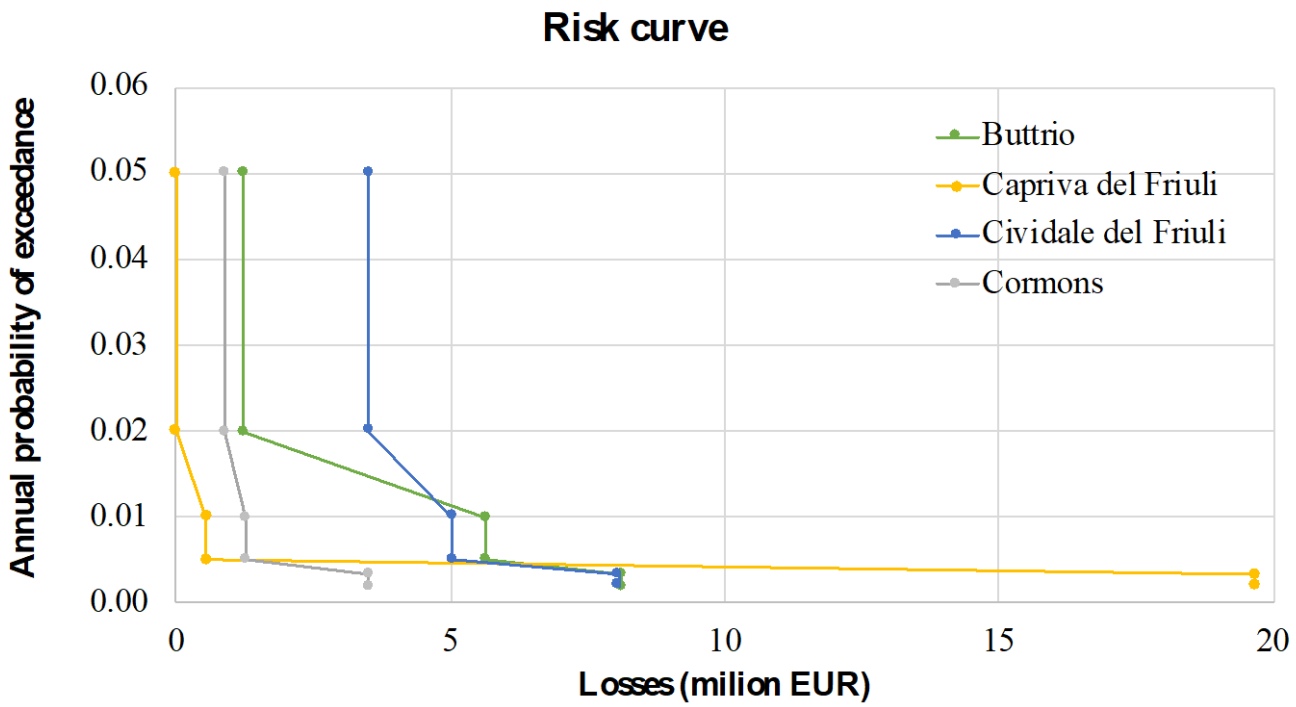
Risk Curves and EAL

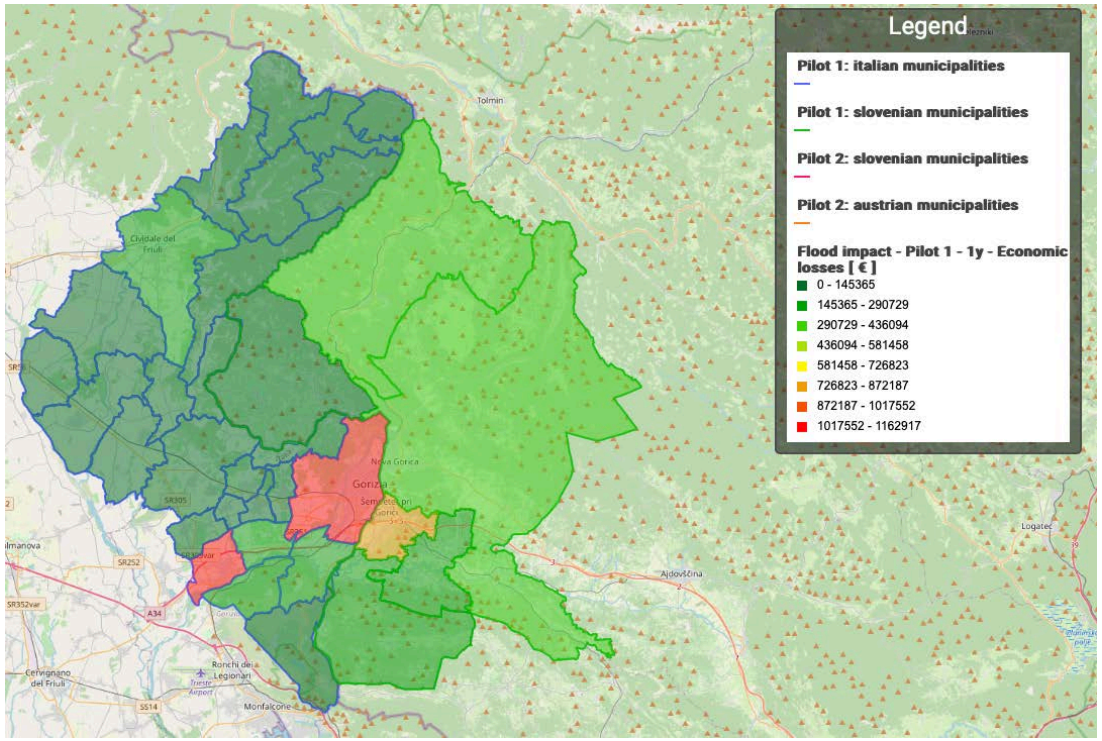
Each hazard map was used as input for the evaluation of impacts in terms of **potentially affected people, expected damage ratio** and **economic losses**; to this end, the following actions were performed and applied to each hazard map, also by adopting the **RASOR Platform** (Arrighi et al. 2018):

- A value of water depth – obtained through the overlaying with the hazard map – was assigned to each feature in the exposure model;
- By using specific physical vulnerability functions – depending on the physical characteristics of the assets – **the expected damage ratio was evaluated**;
- Such impacts are then used to obtain the **Average Annual Losses (EAL) and the Probable Maximum Losses (PML)** values for each return period, for each country, considering the product among the damage ratio [%], the replacement cost [€/m2] (adopted the same for the seismic analysis), the area of the footprint [m2] and the number of storeys;
- The **number of people potentially affected**, considering a water depth greater than 20 cm



Risk Curves and EAL

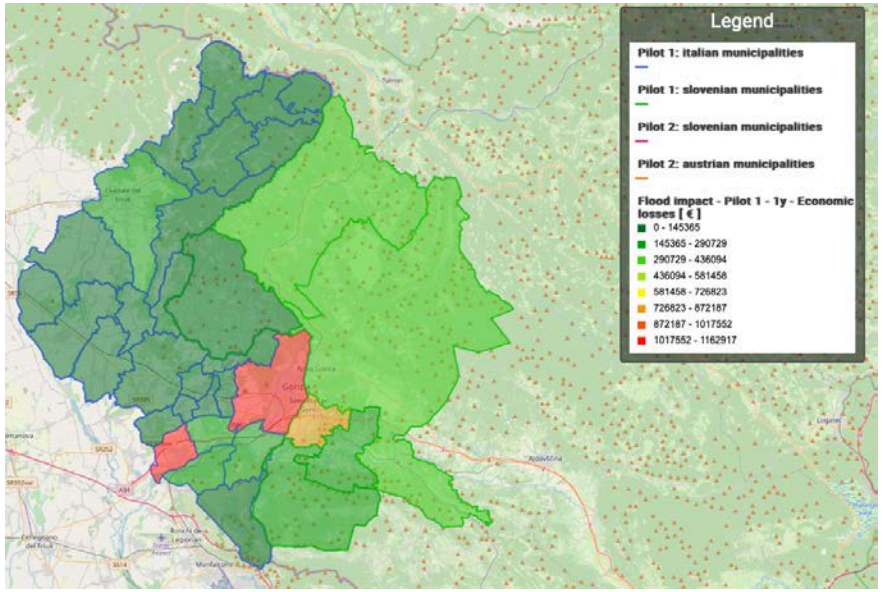




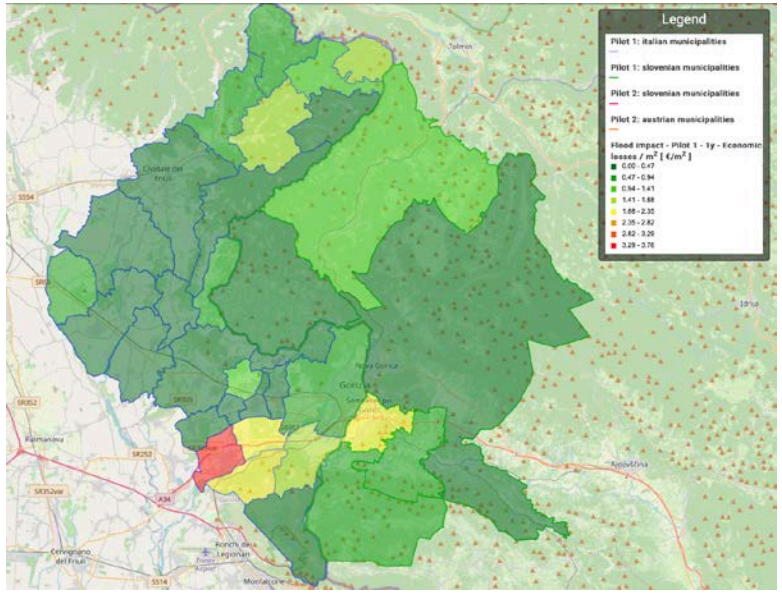
Map of EAL [€]– time frame 1 year

Municipality	Surface [m²]	EAL/Tot Value	EAL [€/m²]	EAL
Buttrio	195261	0.052%	0.71	1.38E+05
Capriva del Friuli	83674	0.078%	1.05	8.78E+04
Cividale del Friuli	546688	0.028%	0.39	2.12E+05
Cormons	349982	0.012%	0.17	5.86E+04

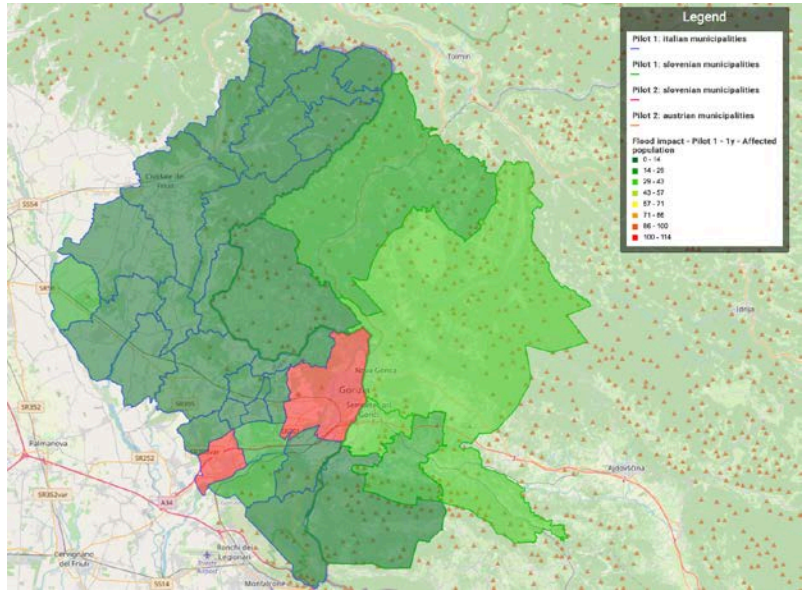
Risk Curves and EAL



Map of EAL [€]– time frame 1 year



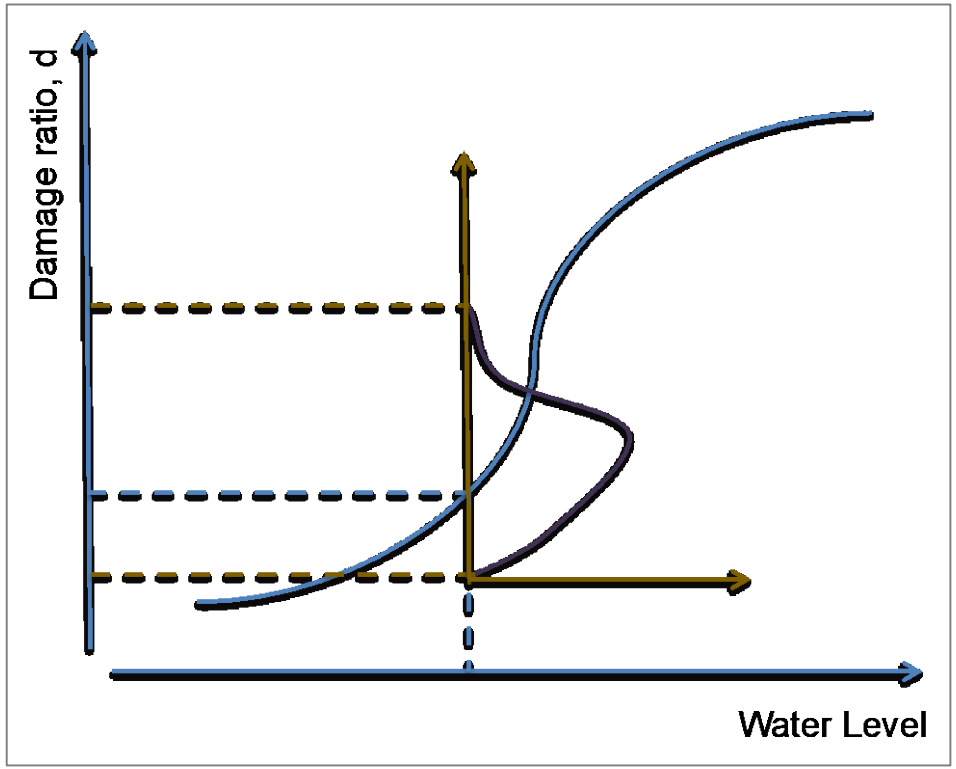
Map of EAL [€/m^2]– time frame 1 year



Map of population affected – time frame 1 year

Future Developments

- Introduction of the evaluation related to different mitigation strategies that can influence the elements of the risk equation, starting from the hazard and arriving to the consequences;
- Introduction of probabilistic criteria and dynamic issues for the different elements of the risk eqautions (e.g. resilience approach, related to seasonality, the uncertainty in the location and construction details of the exposed risk and the uncertainty in the amount of damage, given a water level);
- Introduction of scenario based evaluation.



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Thank you!

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