Danger Classification for Strong-Rain and Flood-Risks of Cultural Heritage Sites

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Overview

TRIQUETRA

Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage

- In the framework of the TRIQUETRA project a toolbox for risk assesment for cultural heritage (CH) sites for extreme water, snow & ice has to be developed
- In the following presentation we present the developed method for classifying areas endangered by strong rain

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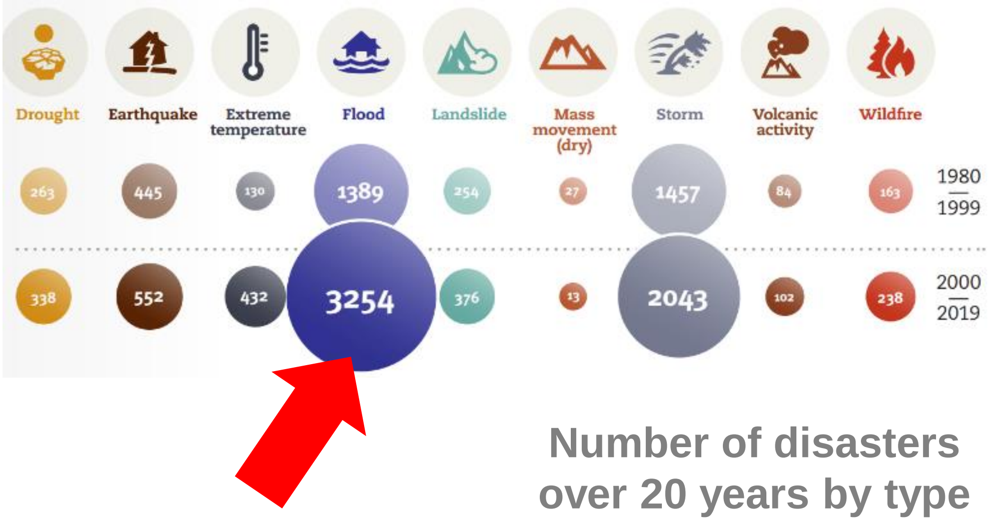
Overview

- Cultural Heritage (CH) sites are mostly exposed to natural elements
- Climate Change increased intensity of short termed extreme rain 3-19 % in the last 20 years (dT=1.2°C)
- Probability of strong rain raise by 1.2-9 times
- At 2°C intensity will increase up to 26 % and probability up to a factor of 11

UN report „Human Cost of Disasters“, 2020



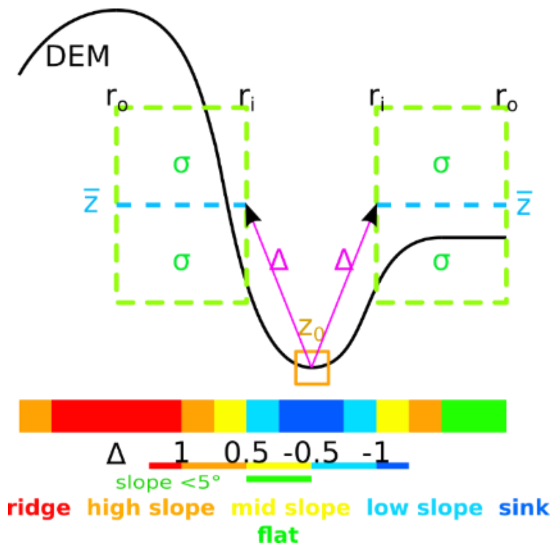
Number of disasters over 20 years by type

- The IPCC (Intergovernmental Panel on Climate Change) assessment report states also increase of extreme precipitation, pluvial and fluvial floods in Western and Central Europe with high confidence in case global warming reaches 2°C

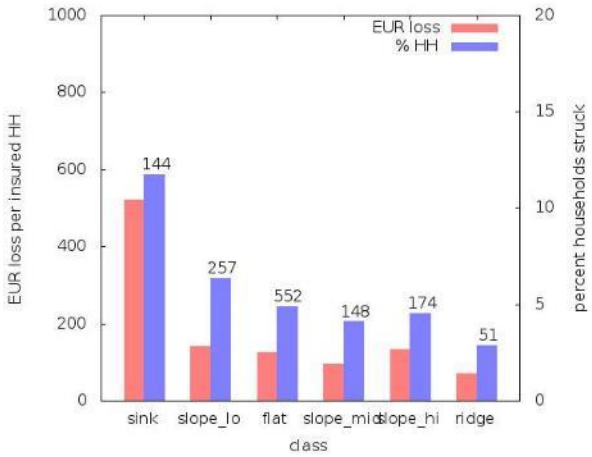
METHODS

Method 1: Terrain/topographic positioning index

- We developed a method for classifying areas endangered by strong rain
- Method is based on terrain positioning index, describing the local morphology of the terrain
- Provides a worst case estimation
- Calibrated with 10 years insurance data using DEMs (digital elevation models) ranging from 2.5 m up to 90 m resolution
- Generated strong rain danger maps for Germany, Austria and Cyprus



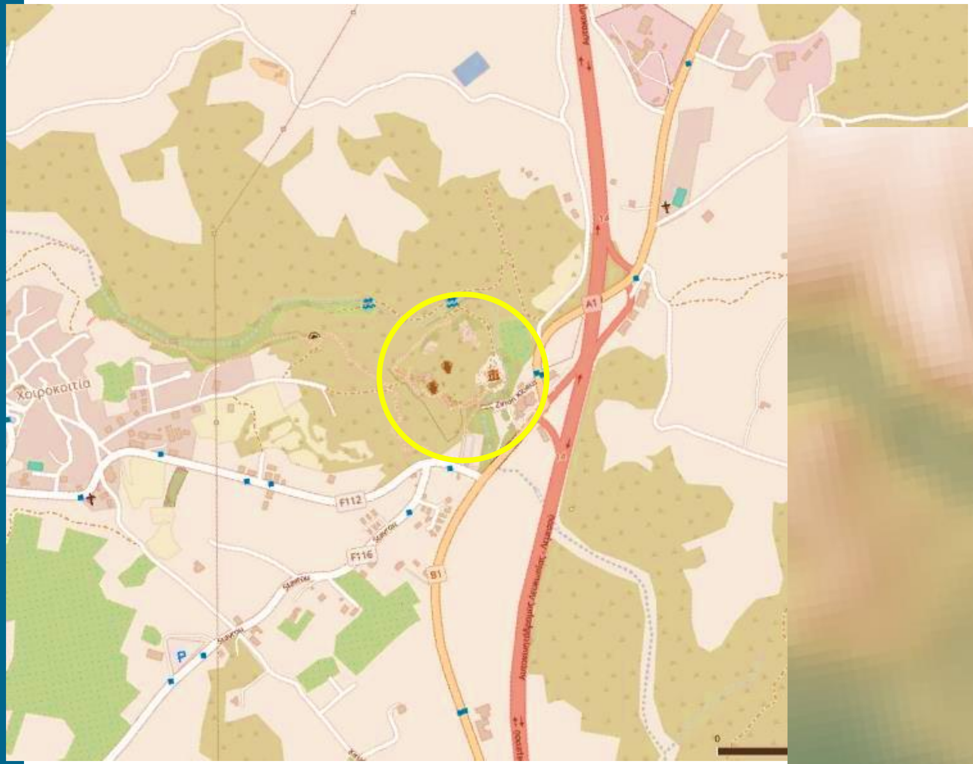
Terrain positioning index, resulting 6 danger classes



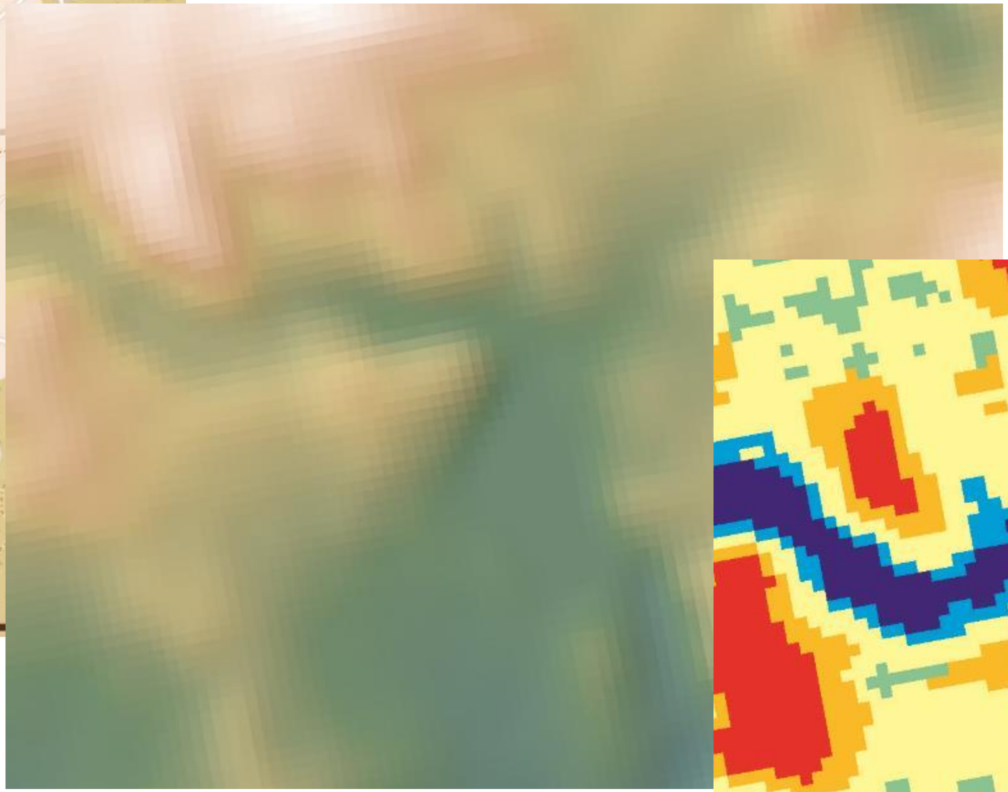
Probability getting struck by strong rain event (blue) average damage (red) per danger class

Method 1: Terrain/topographic positioning index

- ridge
- high slope
- mid slope
- low slope
- sink
- flat

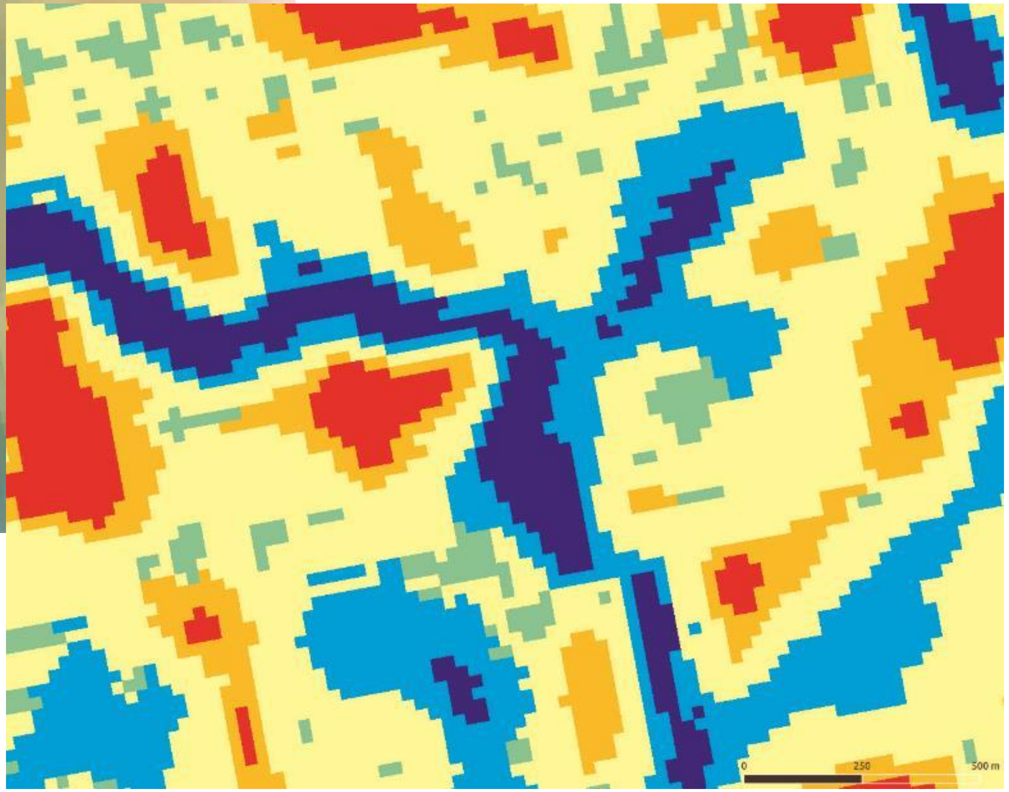


OSM map of pilot site
Choirokoitia, Cyprus

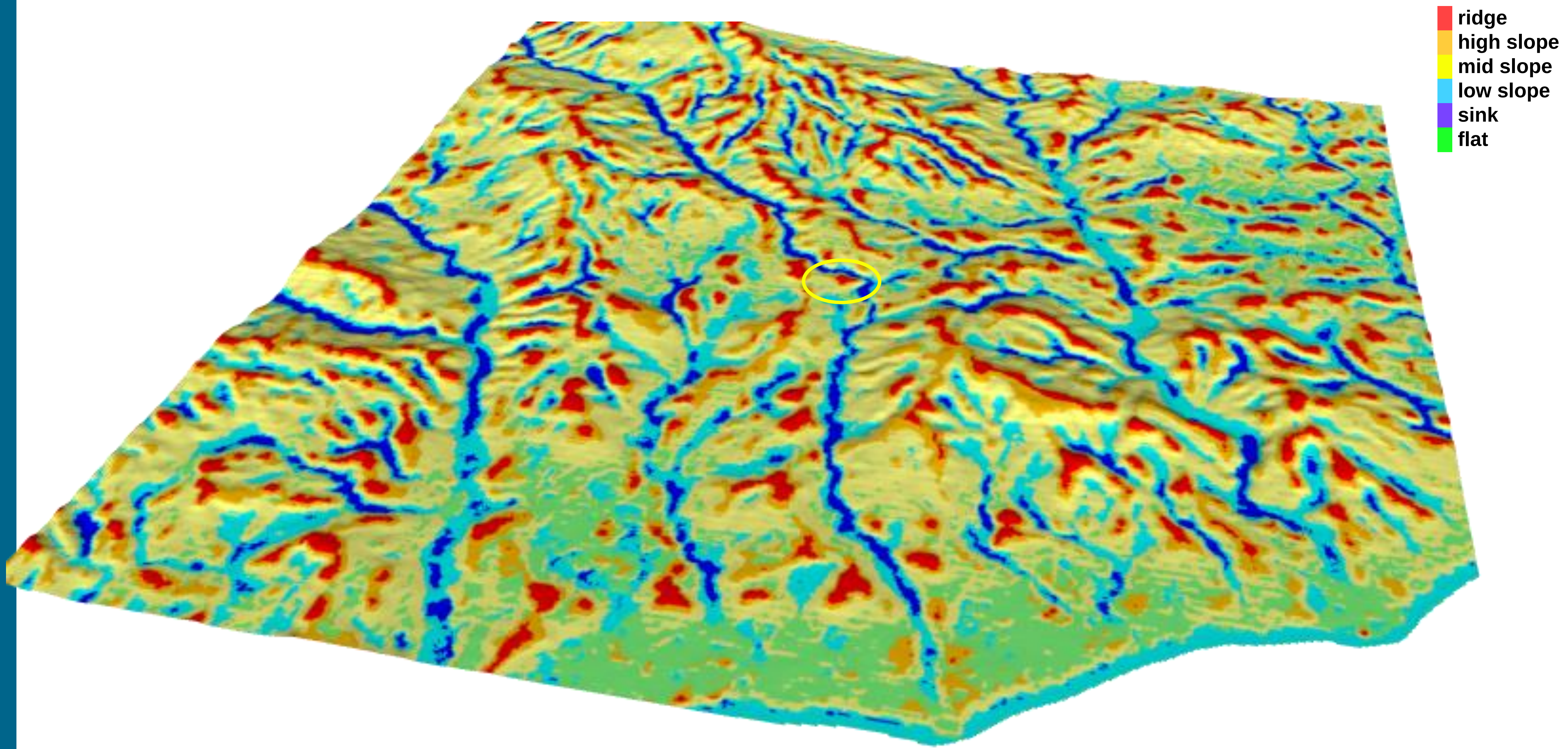


Digital Elevation Model (DEM)

Terrain Positioning Index (TPI),
resulting 6 danger classes



Results Method 1: Terrain positioning index



Example Choirokoitia, Cyprus: Terrain positioning index, 6 danger classes

Method 2: Water runoff estimation

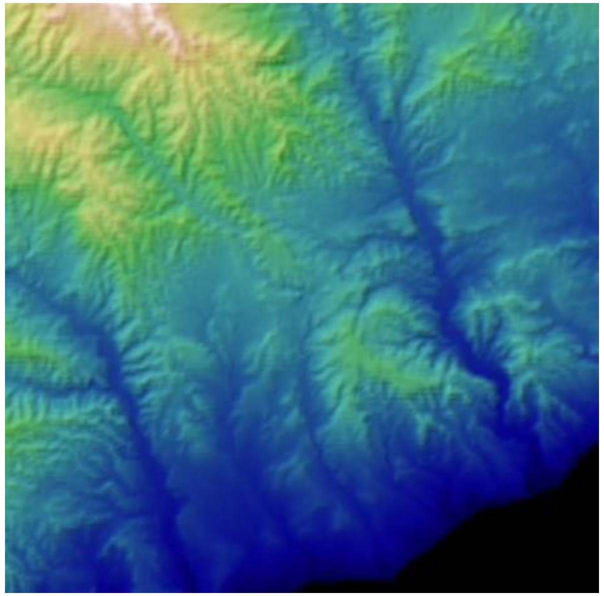
- Problems with the TPI-method (terrain positioning index):
  - Only takes into account the local neighbourhood of an area (~500 m)
  - Water flowing down from upstream regions is not taken into account
  - Especially strong rain danger in narrow valleys or flat bottomlands can not be estimated correctly
- This leads to:

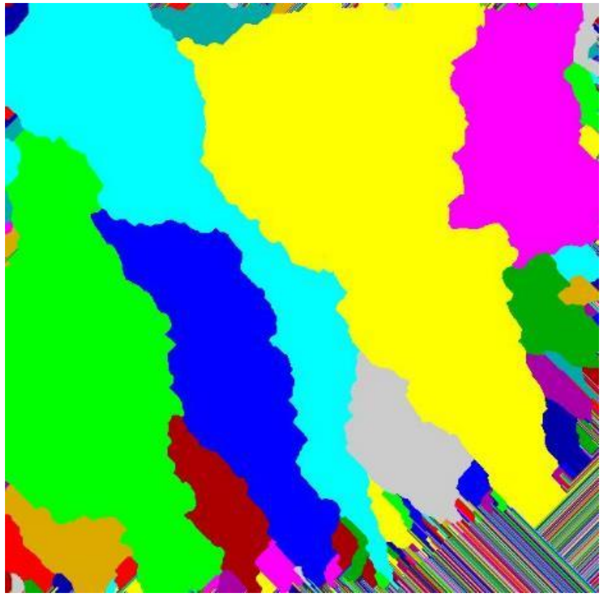
  Development of an additional method for a worst case strong rain danger classification from upstream water runoff

Method 2: Water runoff estimation – Creation of runoff-map

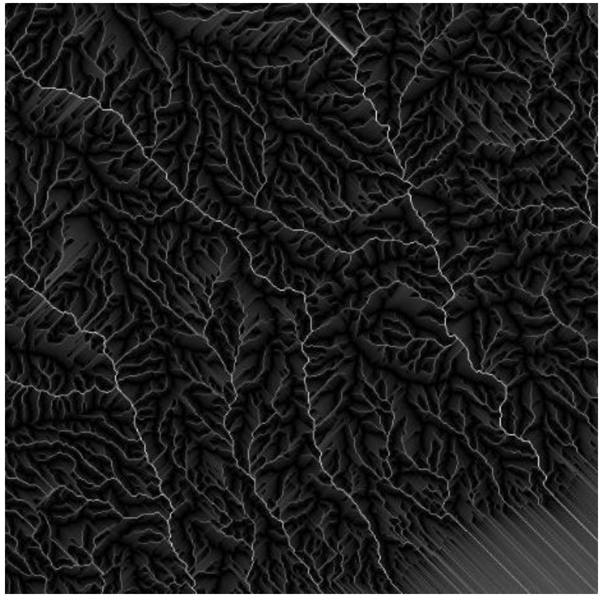
- Based only on a Digital Elevation Model (DEM) containing entire catchment area of region of interest
- Calculate cumulated runoff:
    - Fill local depressions in DEM
    - Calculate runoff directions map
    - Distribute initial rainfall amount on map
    - Cumulate runoff volume for each pixel following directions map until all water left the catchment

SRTM-DEM
25 m





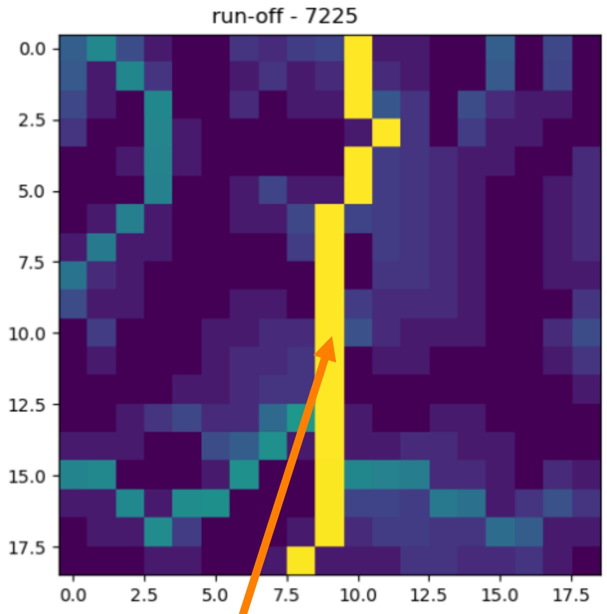
Catchments

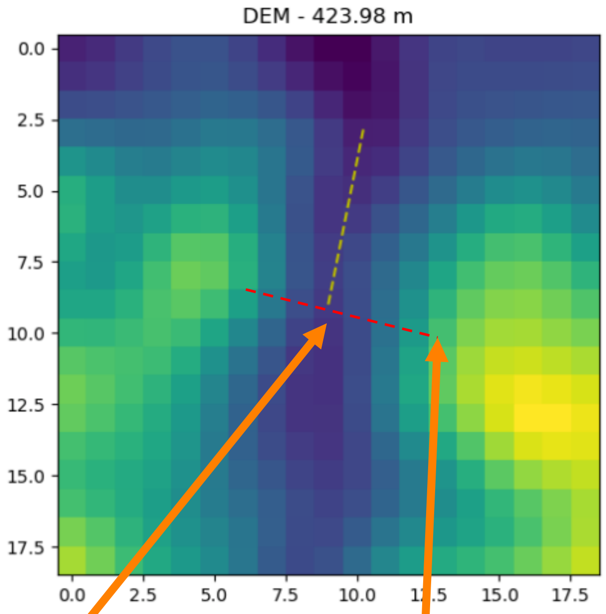


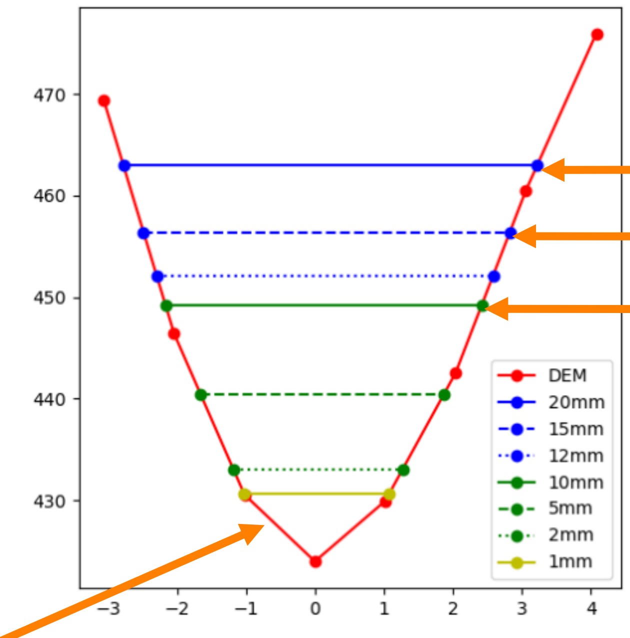
Runoff-Map

Pilot Site Choirokoitia, Cyprus

Method 2: Water runoff estimation – Calculating runoff-profiles







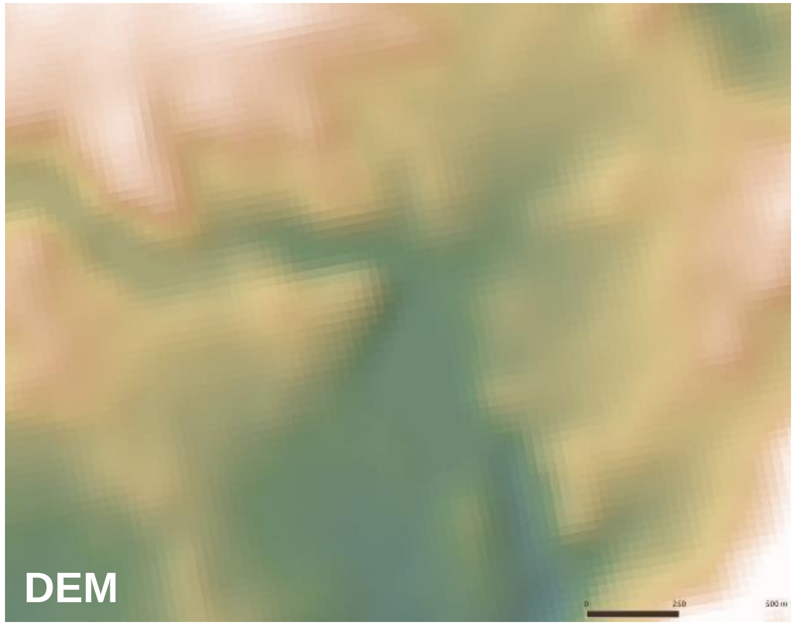
For each ridge-point in the runoff-map

Get point and runoff-direction in DEM (center)

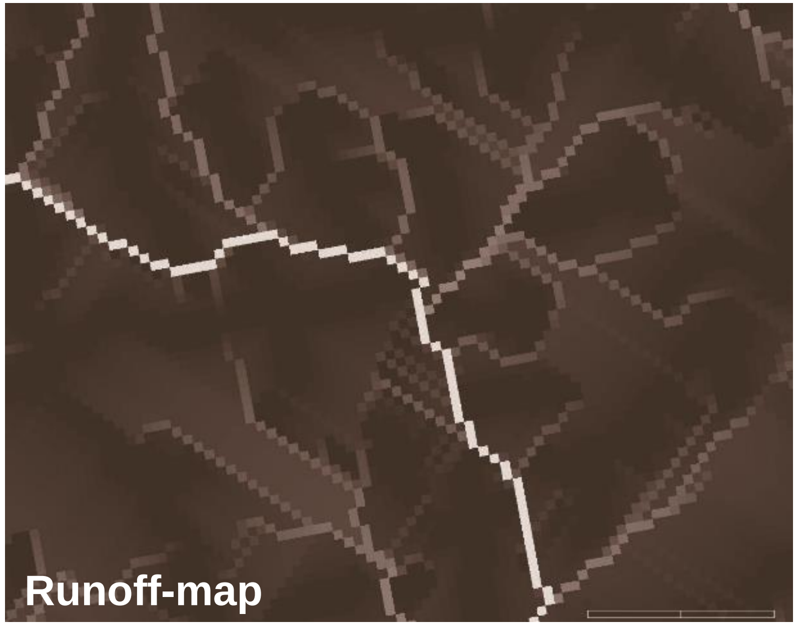
Calculate profile across runoff-direction

Fill profile with volume of „runoff“ upstream pixels (e.g. 7225) and different precipitation volumes in mm per pixel

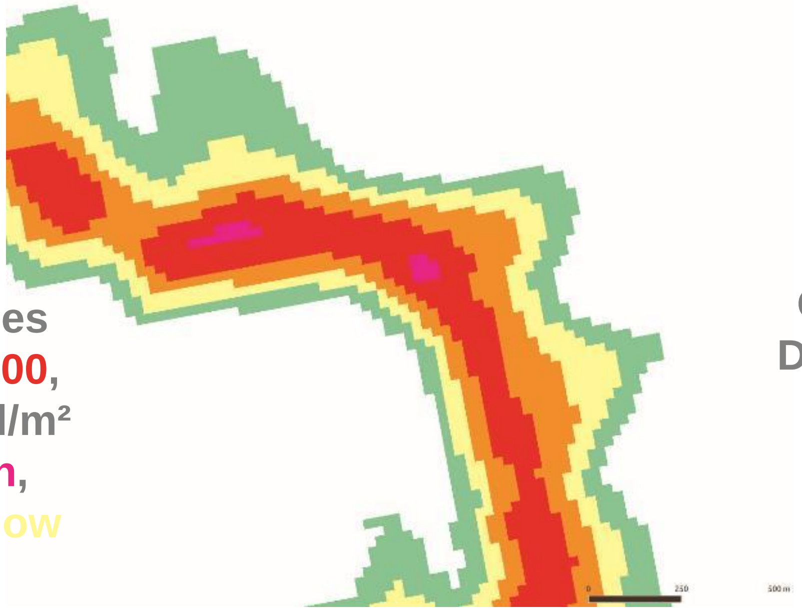
Method 2: Water runoff estimation – Create Danger Map



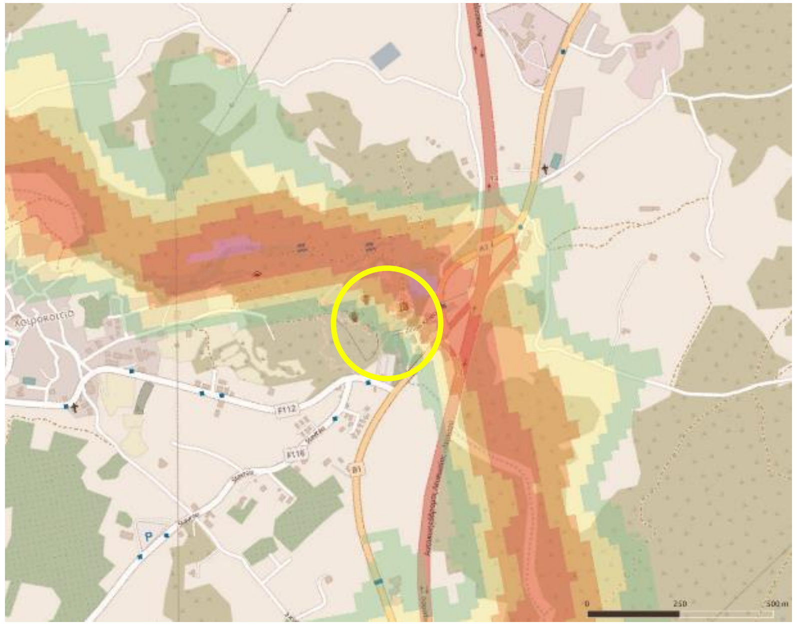
Calculate Runoff-map



Calculate flooded profiles for precipitation of 10, 100, 1000, 10000 and 100000 l/m² as danger classes high, medhigh, medium, medlow and low



Overlay these Danger Classes to OSM map



AREAS AND RESULTS

TRIQUETRA: 8 Pilot Sites in 6 European Countries

Pilot Sites endangered by strong rain


Kalopodi, Greece

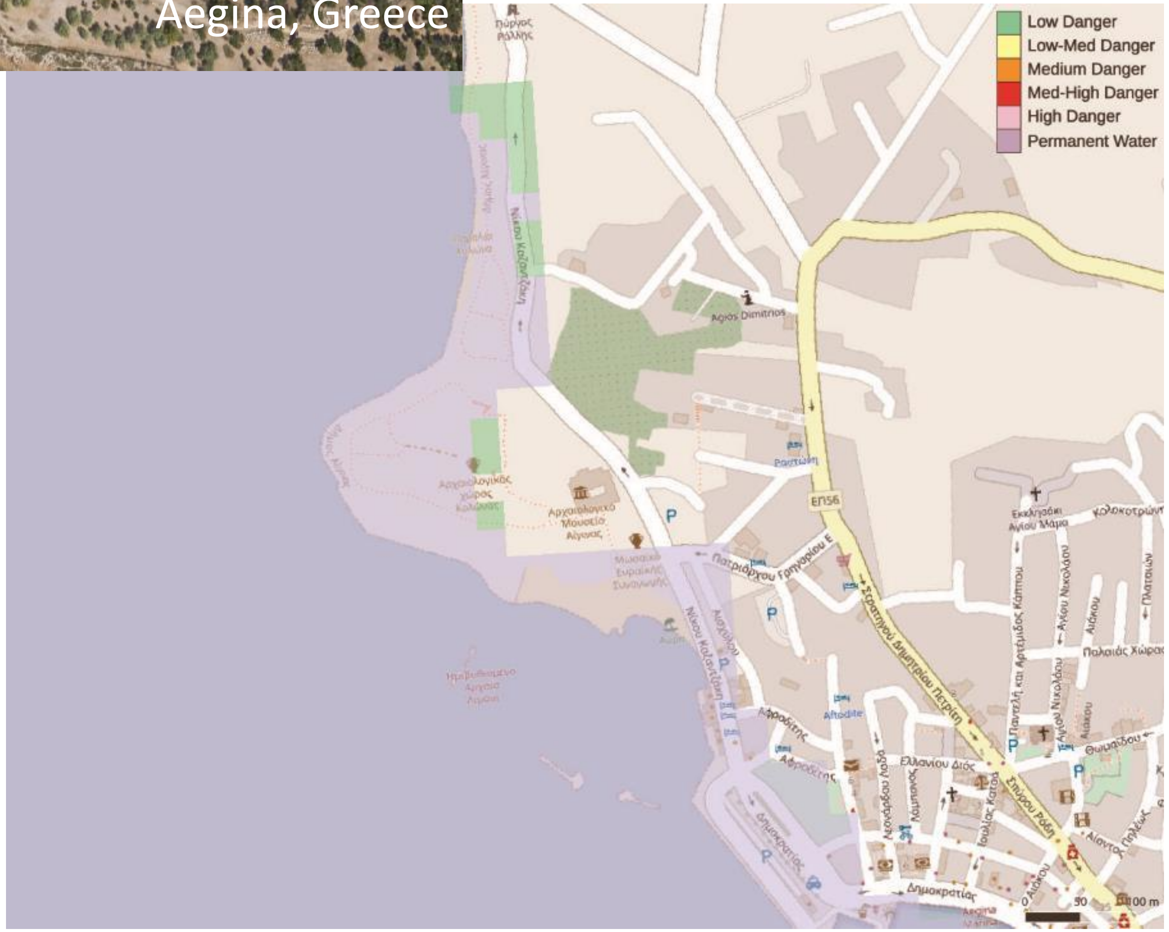

Aegina, Greece


Choirokoitia, Cyprus


Smuszewo, Poland

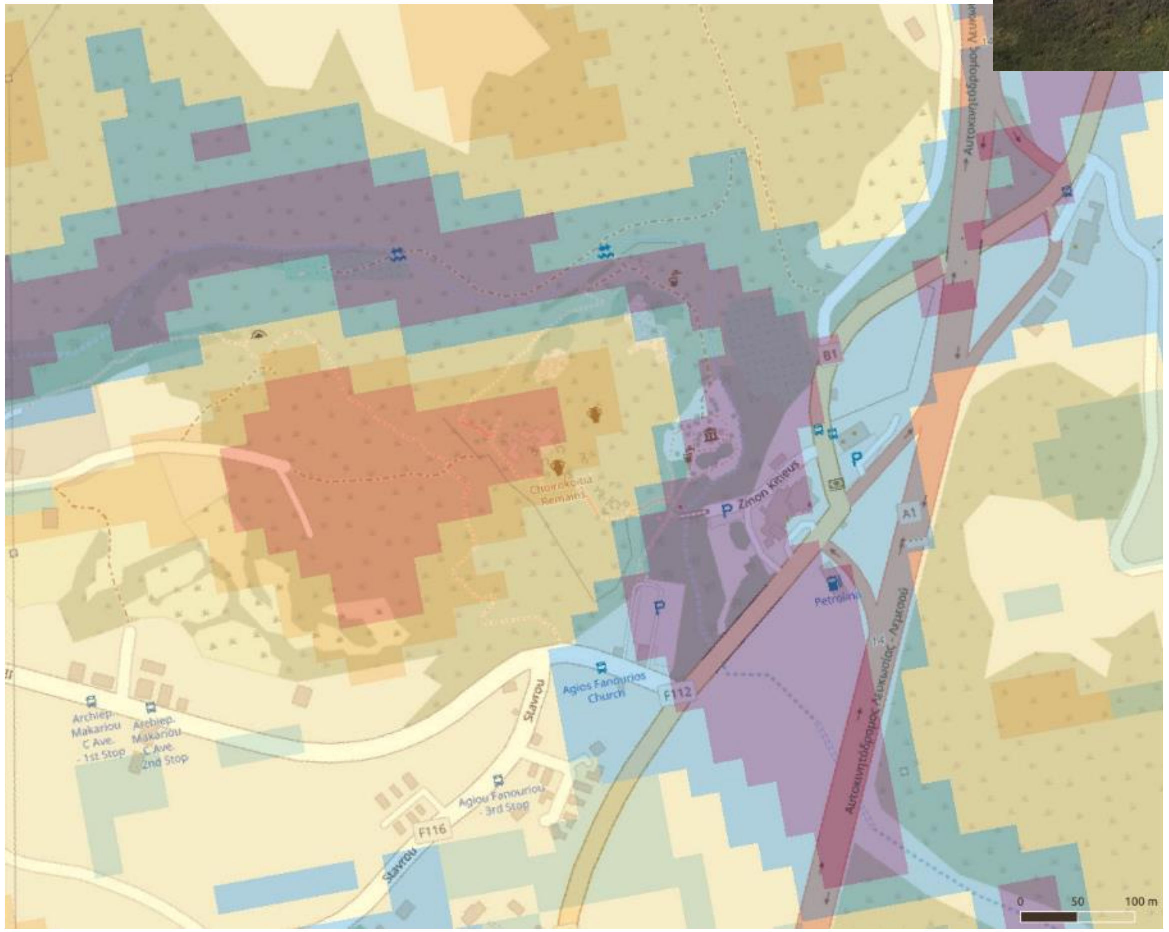
Pilot site Aegina, Greece

TPI-Danger-Map: medium danger on the coast

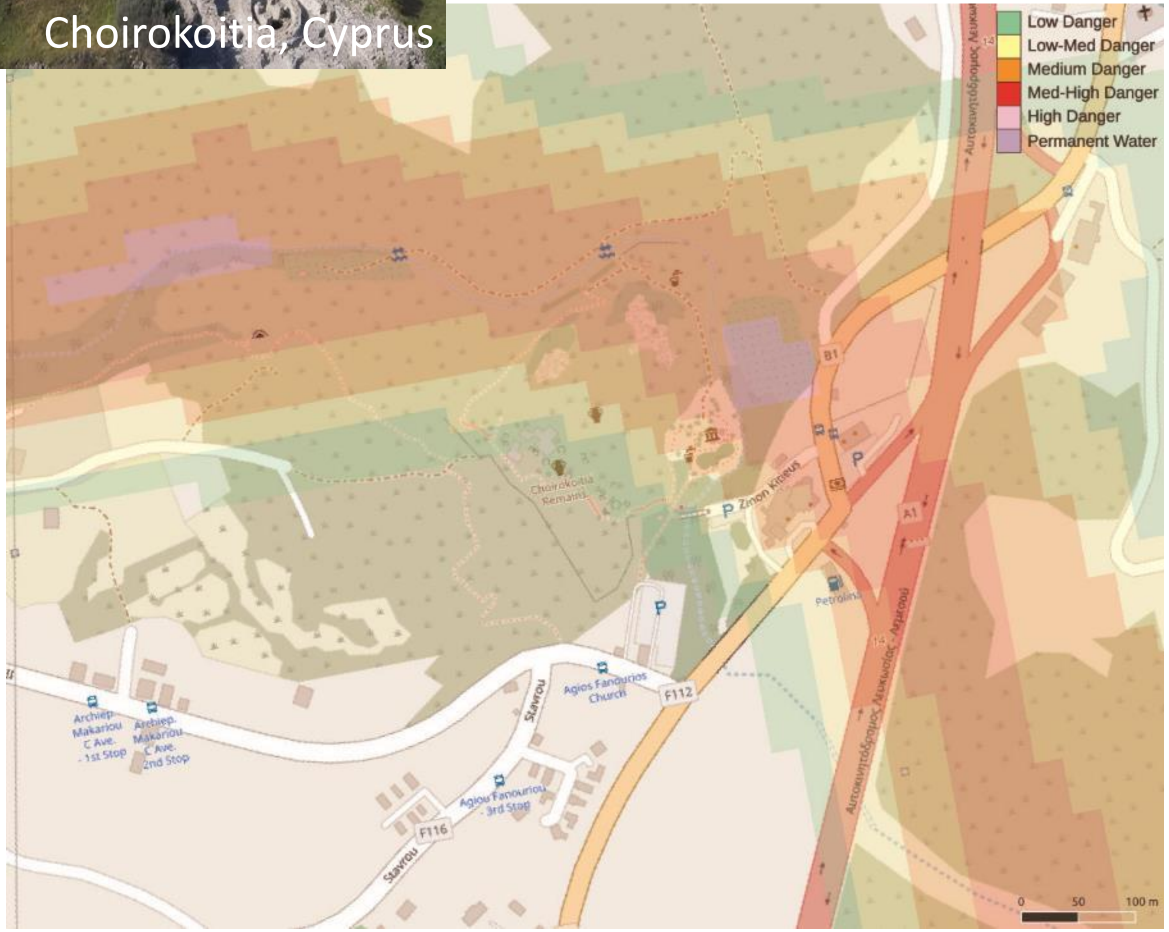


Runoff-Danger-Map: low danger on the coast

Pilot site Chorokoitia, CY

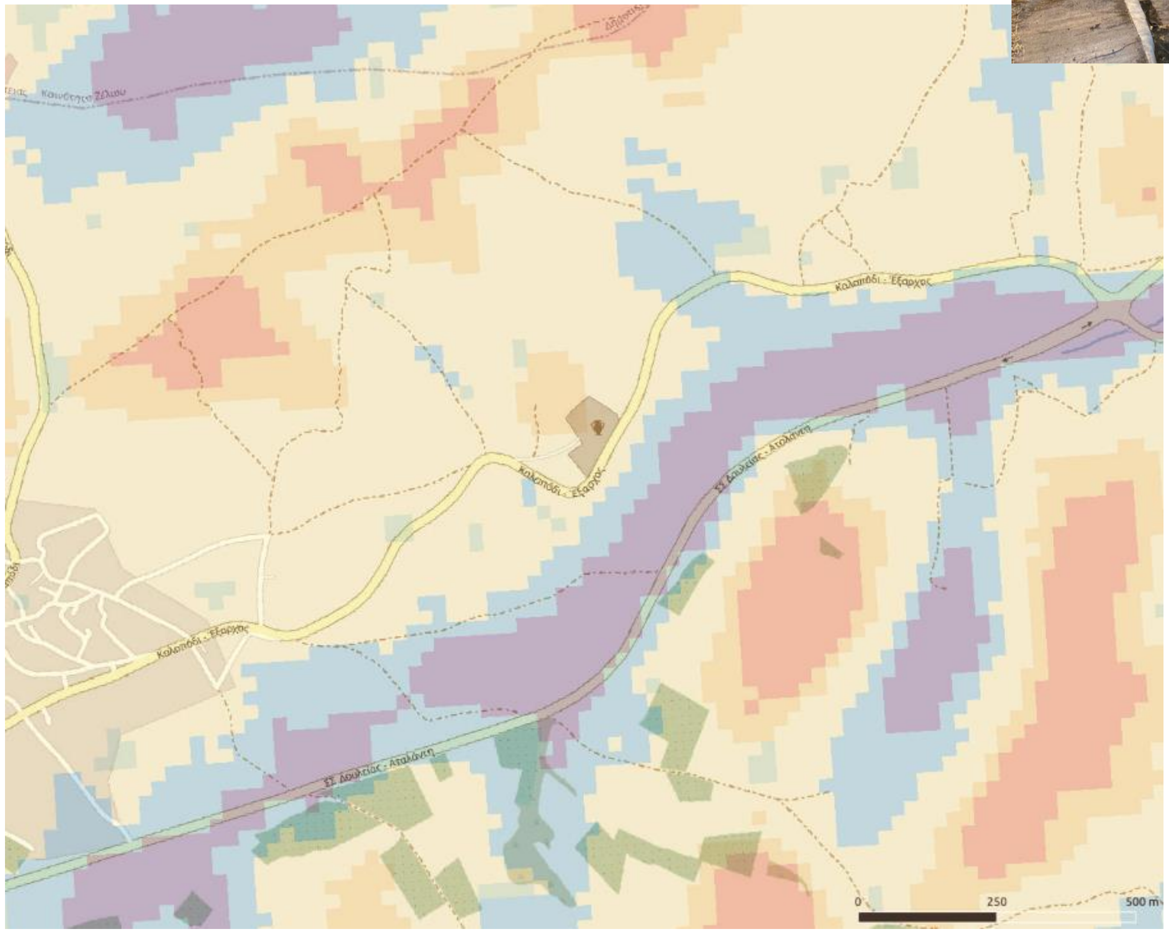


TPI-Danger-Map: medium danger in low areas

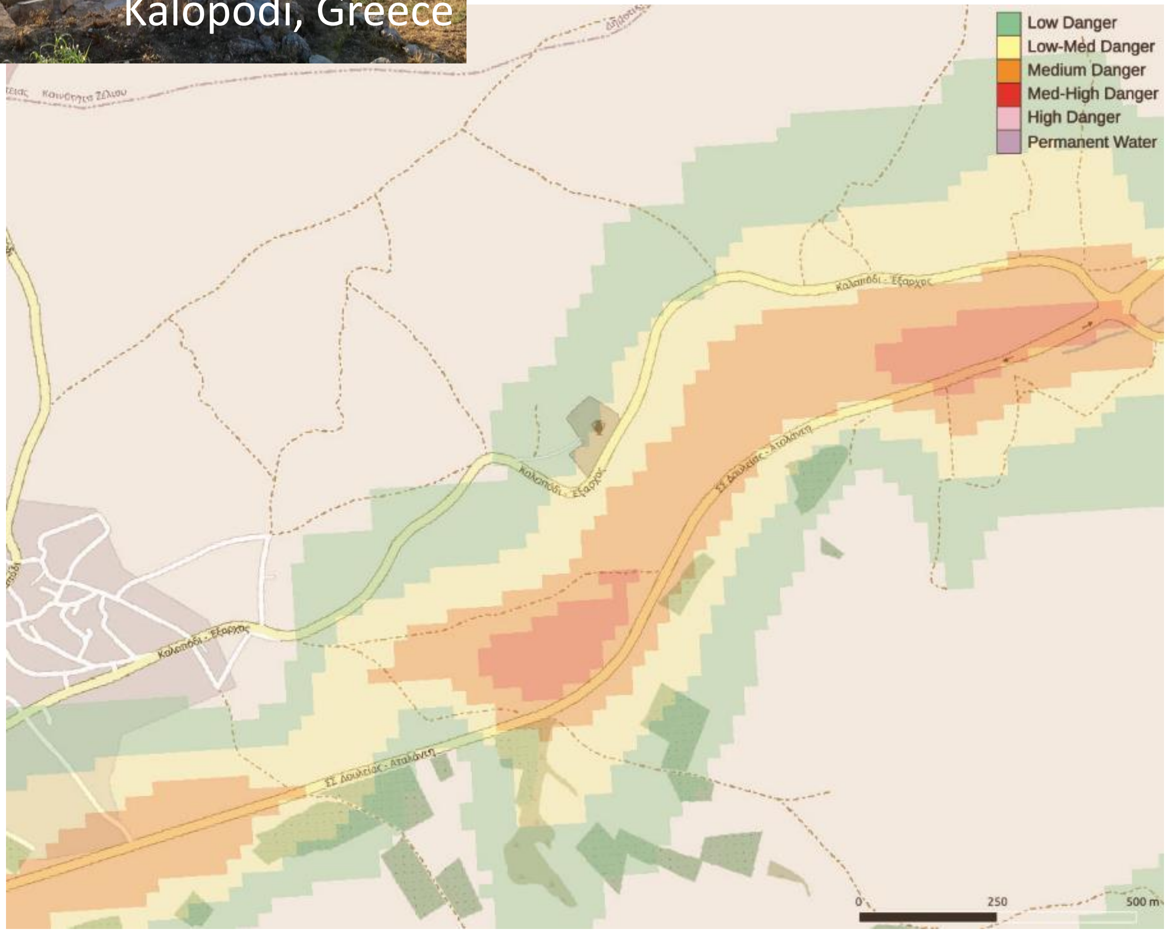


Runoff-Danger-Map: low-med danger

Pilot site Kalopodi, Greece

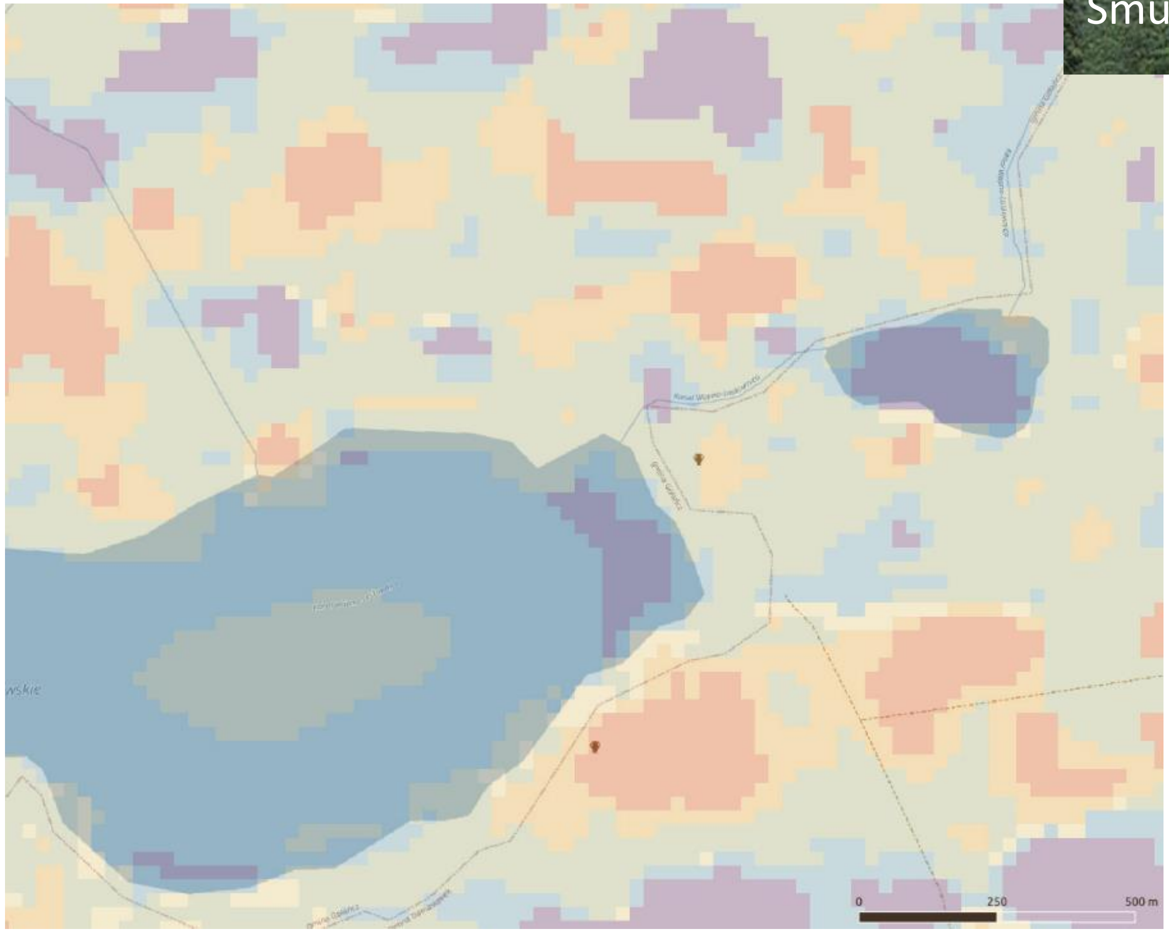


TPI-Danger-Map: no danger

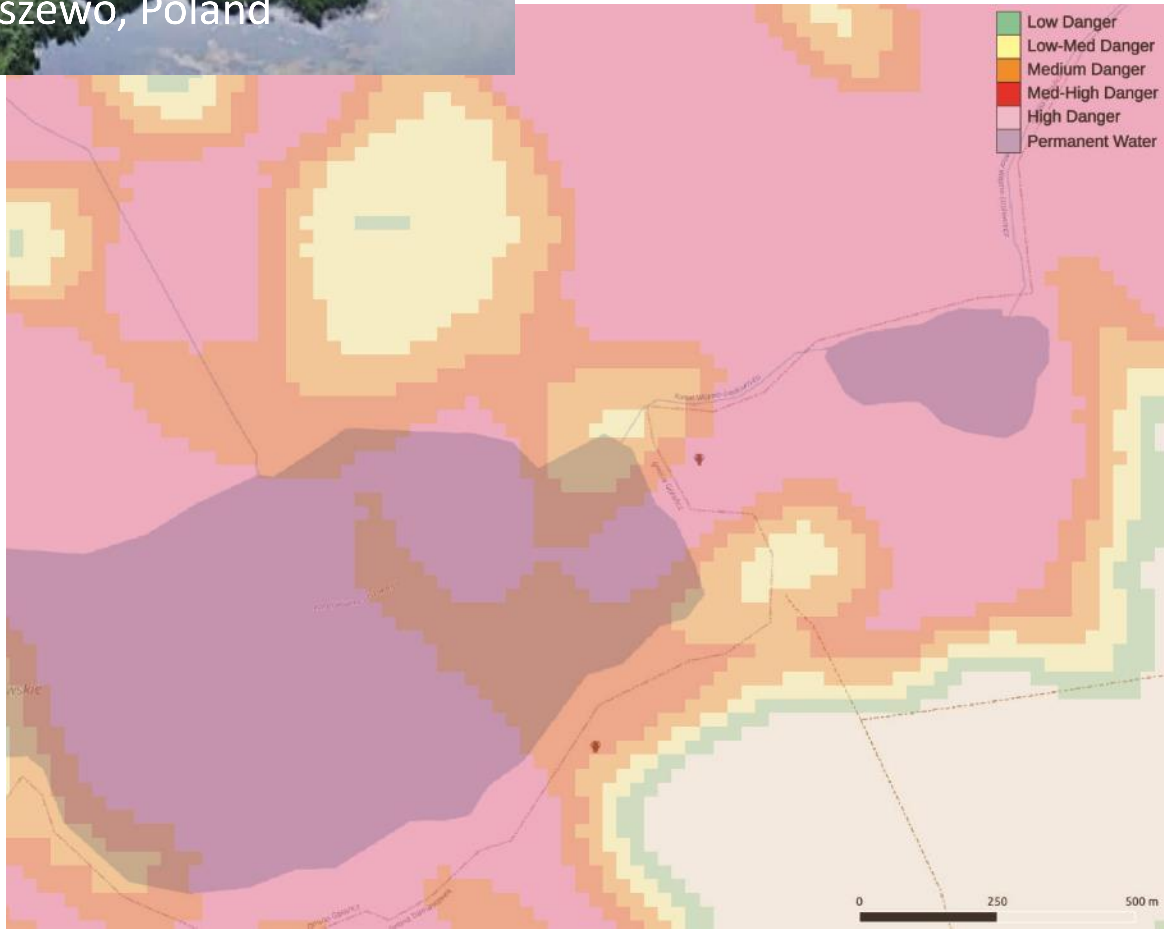


Runoff-Danger-Map: low-med danger

Pilot site Smuszewo, Poland

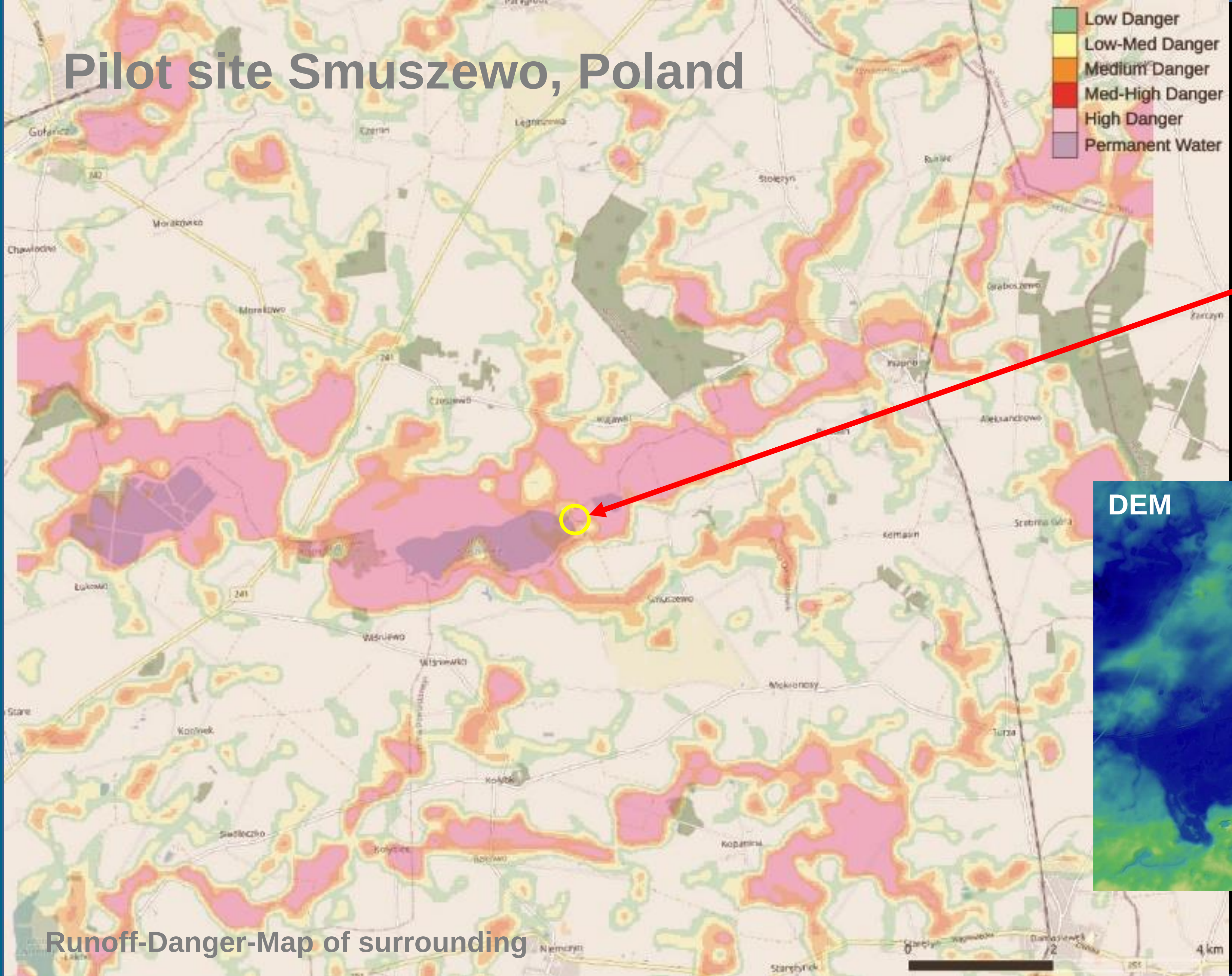


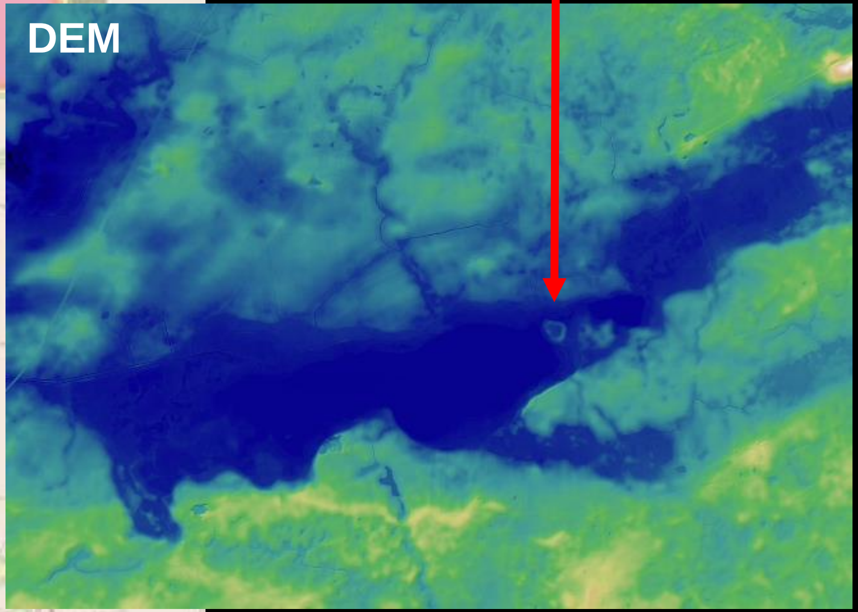
TPI-Danger-Map: no danger



Runoff-Danger-Map: high danger

Pilot site Smuszewo, Poland



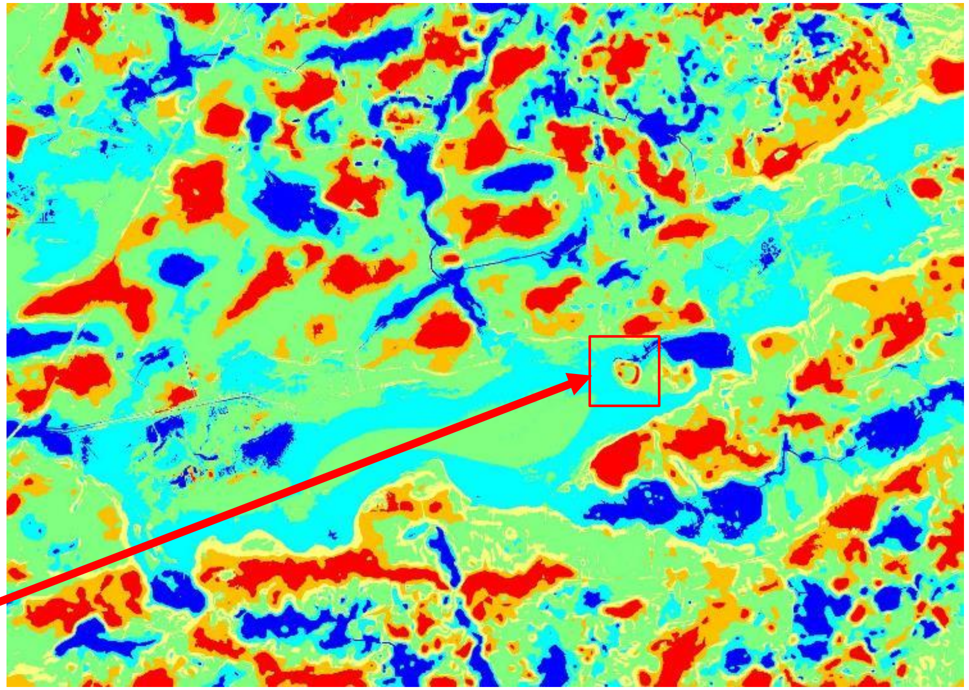


Runoff-Danger-Map of surrounding

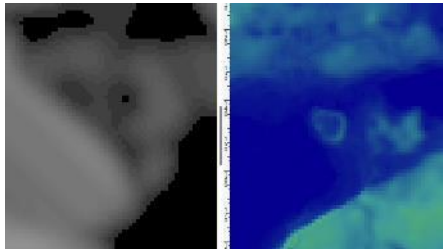
Pilot site Smuszewo, Poland

- TPI-Danger-Map calculated on high-res DEM:

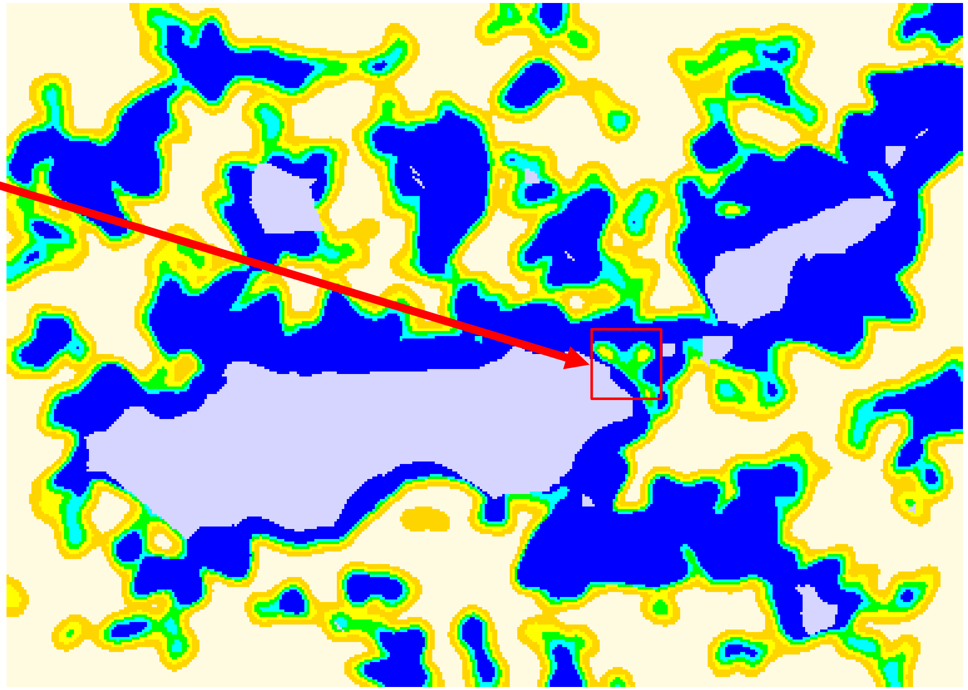
  Danger by Strong Rain as dark/light blue,
  no danger orange/red



Maximum runoff-speed in the area of interest is about 1 to 2 m/s



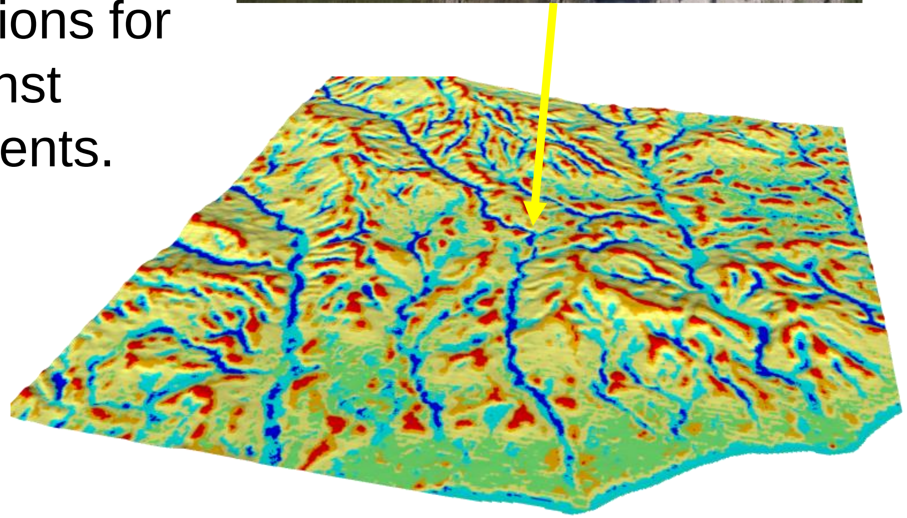
- Combined Run-off, flood and flow speed danger:
  - Light blue: Permanent water
  - Dark blue: highest danger
  - Cyan/green/orange: mid danger
  - Wheat: no danger



CONCLUSION AND OUTLOOK

Conclusion and Outlook

- In the project TRIQUETRA a strong rain danger estimation for cultural heritage sites was developed based on:
    1. the terrain in the local neighborhood
    2. estimating a maximum runoff volume from upstream areas
- The danger classification is an easy to understand visualization for laymen and administrative entities
- Combining the results enables authorities to make better decisions for conservation of cultural heritage sites and their protection against climate change induced raise of flash floods and strong rain events.
- Especially for CH sites near the sea like Aegina also the estimation of danger by sea-level-rise due to climate change, high tides and Tsunami events should be taken into account



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