Proposed methodology for urban flood-risk assessment at river-basin level: the case study of the Pikrodafni river basin in Athens, Greece

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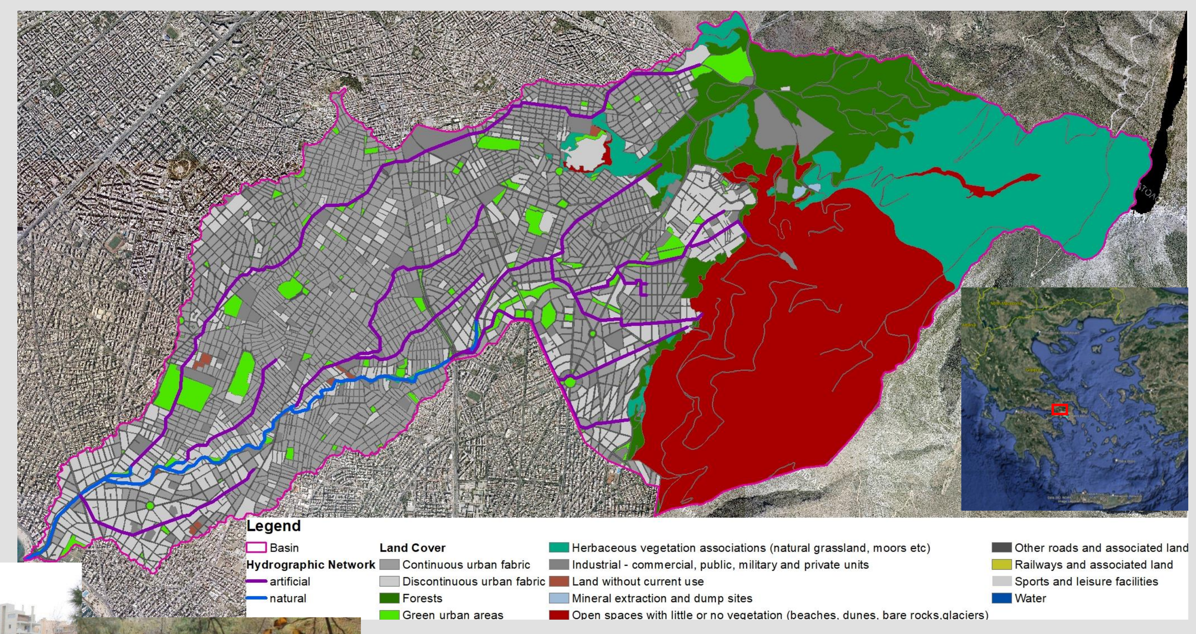
Introduction

ARIA (Attica RIsk Assessment)
Earthquake, Fire & Flood Risk Assessment in Attica Region

The need for and the complexity of flood protection works require the development of advanced methodologies for flood risk assessment, especially considering that land cover changes, climate change and human interventions in the riverbed may severely affect the river flow. In the present study, **a new methodology for urban flood risk assessment** is introduced and implemented at the Pikrodafni river basin (Athens, Greece), by analyzing the vulnerability and the exposure of the river basin of Pikrodafni's river to flood risk, in conjunction with the actual physical and socioeconomic parameters in order to propose mitigation measures. In March 2021, a Programming Agreement was signed between the Prefecture of Attica and the NOA – Part A – to conduct the study entitled ARIA «Earthquake, Fire and Flood risk assessment in the region of Attica» funded by the Prefecture of Attica. It's the first time that such a holistic approach for flood risk assessment is implemented on building-block scale in Greece. The prototype knowledge created through the project supports the Prefecture of Attica in the optimum implementation of the National Civil Protection Plan. This serves the operational needs during crisis, as well as the preparedness and the strategic decision making towards disaster resilience. All the above-mentioned factors were also confirmed and positively evaluated according to the stakeholders' feedback.

Description of study area

- Basin characterized by **high population density** (~50% of basin) & urban expansion along the riverside
- **Burnt areas** (~20% of basin) are due to forest fires, based on the burnt scar mapping time period 2015-2022 provided by FireHub Service of BEYOND Centre of IAASARS/NOA [3]
- There are many substreams which are buried and belong to the rainwater drainage network
- **Historic floods**, the most recent in 22/2/2013 many damages



Methodology and Analysis

I. Data collection & modifications

- relevant studies from competent services
- terrain modification (DEM) with buried substreams

- infrastructure & services

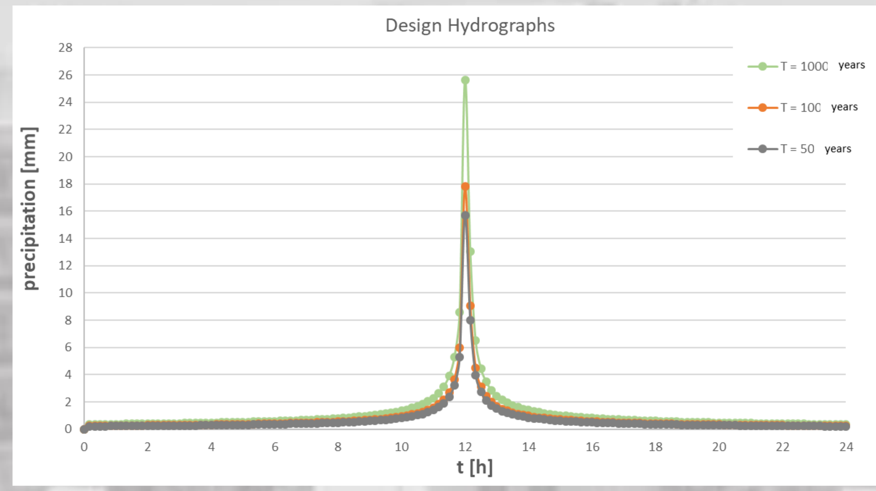
II. Methodology of field investigations

III. Precipitation from ombrian curves

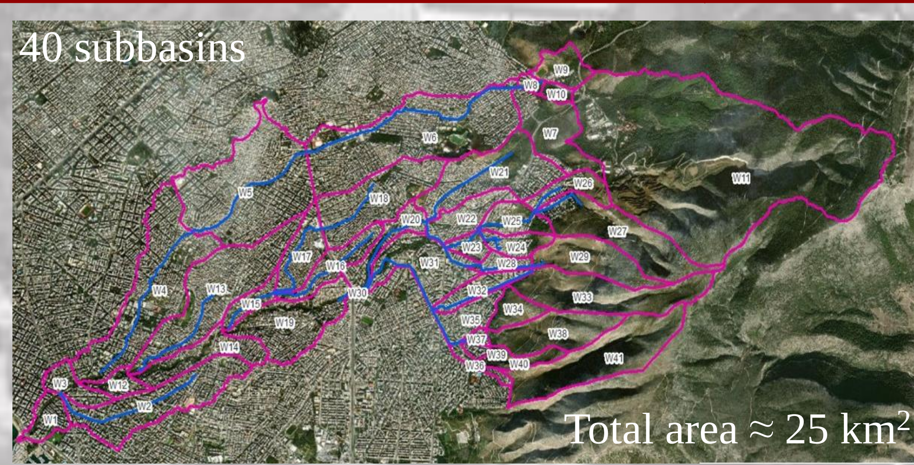
Precipitation derived from ombrian curves [4] for three return periods (50, 100, 1000 years) according to the EU Flood Directive [2] using rainfall data from 29 stations (1860-2020)

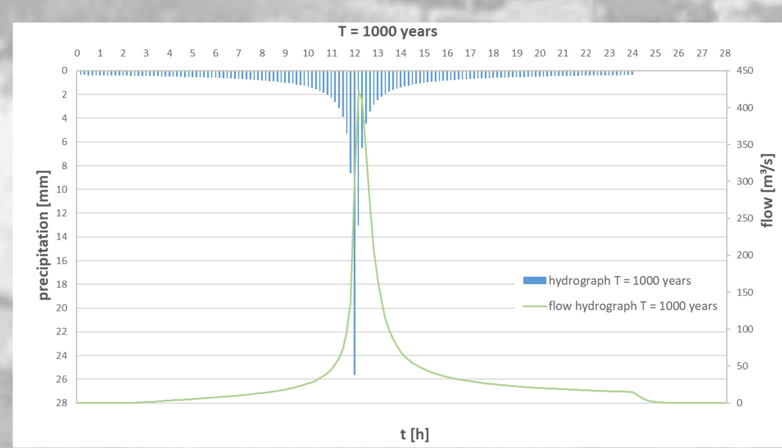
$$x = 489.22\,\frac{(T/0.07)^{0.07} - 1}{(1 + k/0.1)^{0.73}}$$

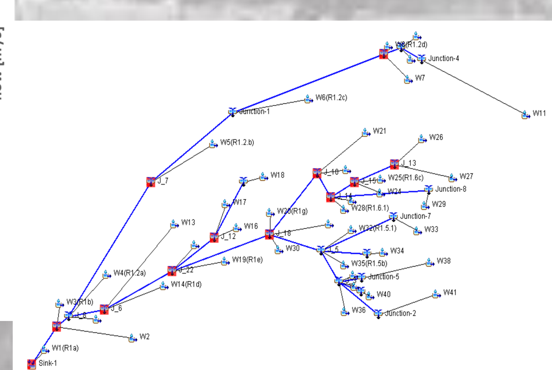
x average rainfall intensity in mm/h, k time scale in h and T return period in years



IV. Hydrologic analysis of river basin-Rainfall-runoff model (HEC-HMS







V. Hazard – 2D Hydraulic models (HEC-RAS & LISFLOOD-FP)

HEC-RAS

Design hydrographs

Updated terrain (terrain modifications included)

Updated land cover layer

Rain on Grid uniform spatially distributed rainfall method

Geometry (2d flow area, boundary condition lines)

Updated Manning's coefficient layer for each land cover class

Hydraulic calculations (achieve model stability)
- ✓ time step
- ✓ Time of simulation
- ✓ Courant condition

Water Depth map

Velocity map

LISFLOOD – FP

- quasi-2D
- kinematic wave
- Courant condition

VI. Risk assessment

Vulnerability

- Age
- Population Density
- Building Type (construction materials and the presence of pilotis

Exposure

- Land values

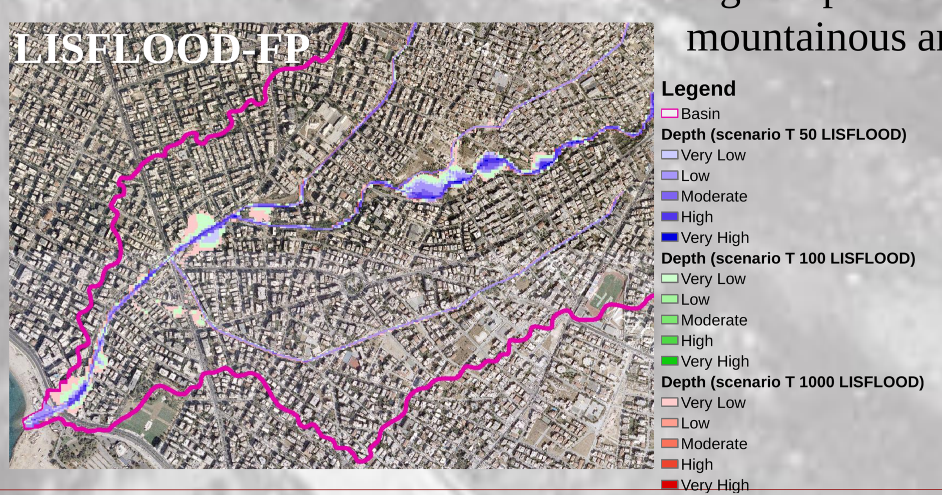
Vulnerability (Age, Population Density and Buiding type)	Flood Hazard 1	2	3	4	5
1	1	1	1	2	3
2	1	2	2	3	4
3	1	2	4	4	5
4	2	3	4	5	5
5	3	4	5	5	5

Vulnerability & Flood Hazard	Exposure 1	2	3	4	5
1	1	1	1	1	1
2	2	2	2	2	3
3	3	3	3	4	4
4	4	4	5	5	5
5	5	5	5	5	5

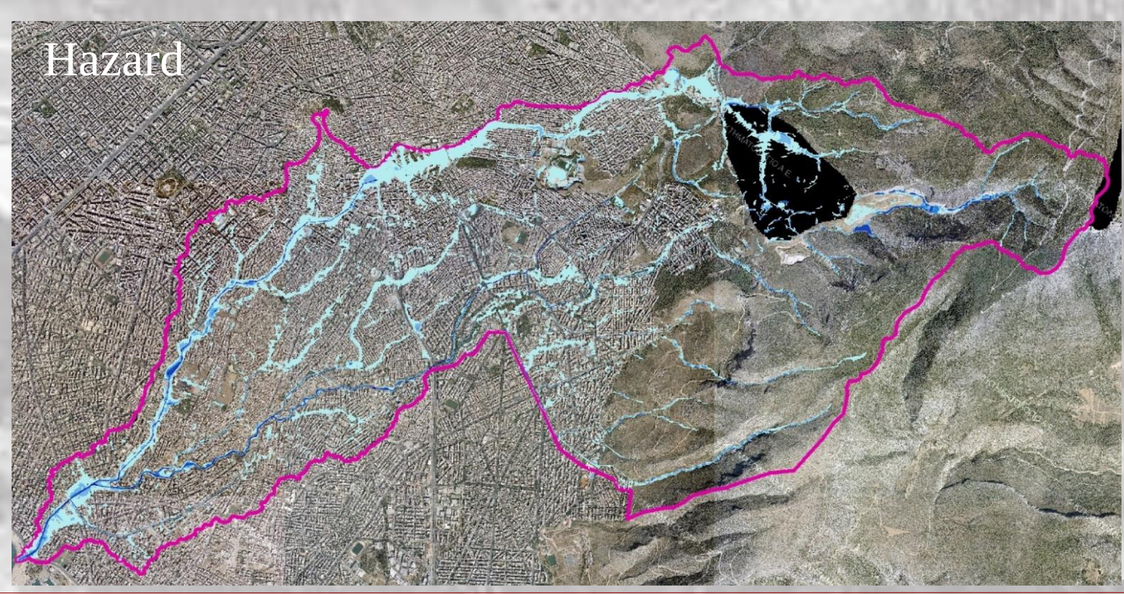
Results

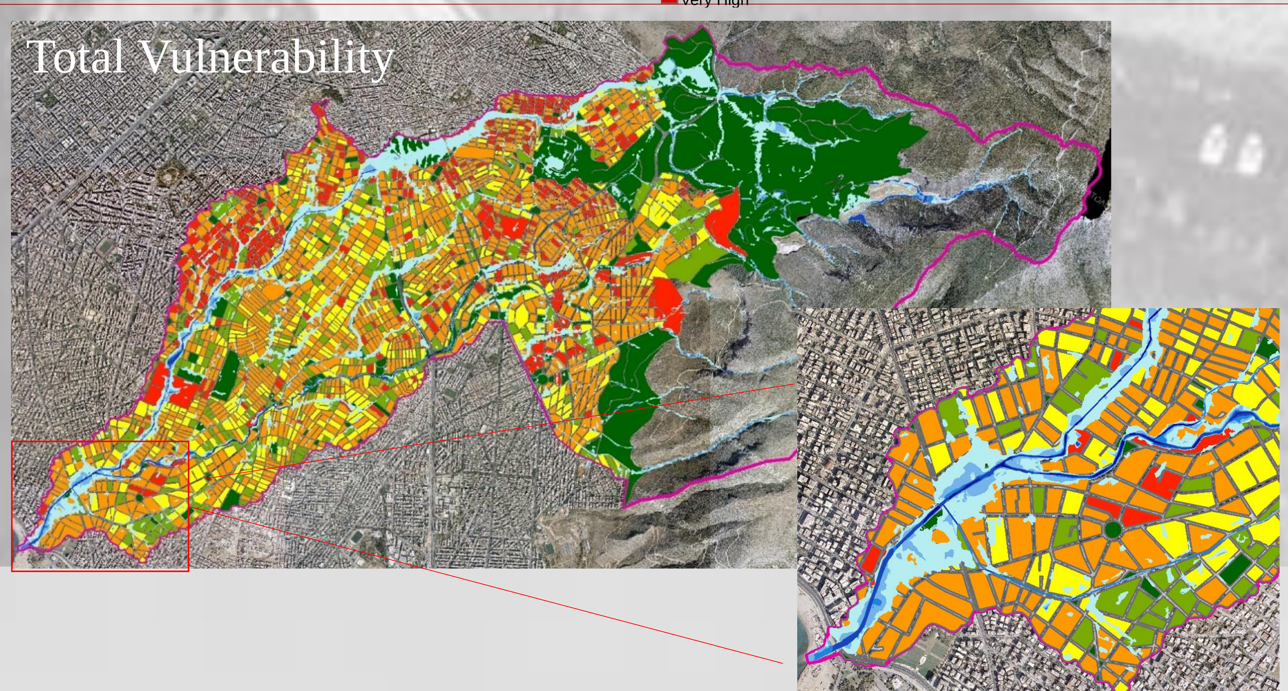
Flood modelling (maximum water depth map)

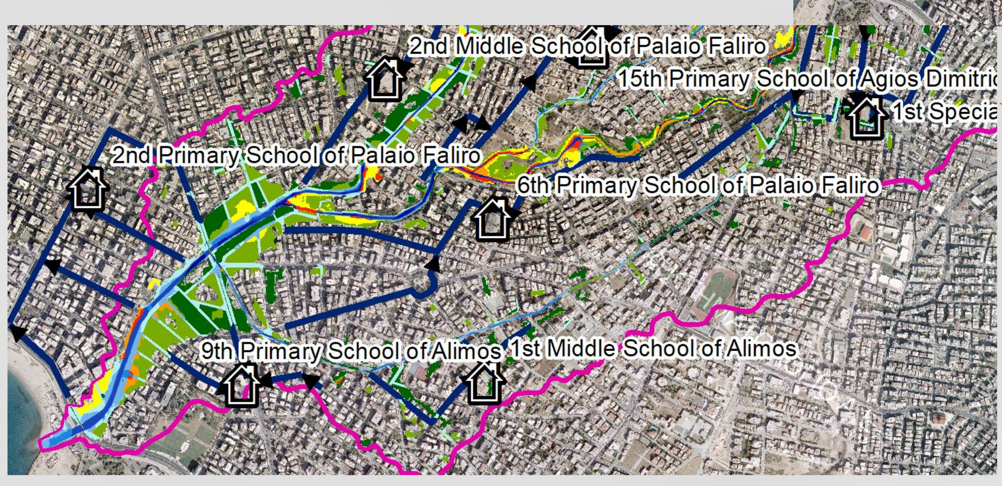
high slopes & velocities mostly in mountainous areas → low depths & limited flood extent

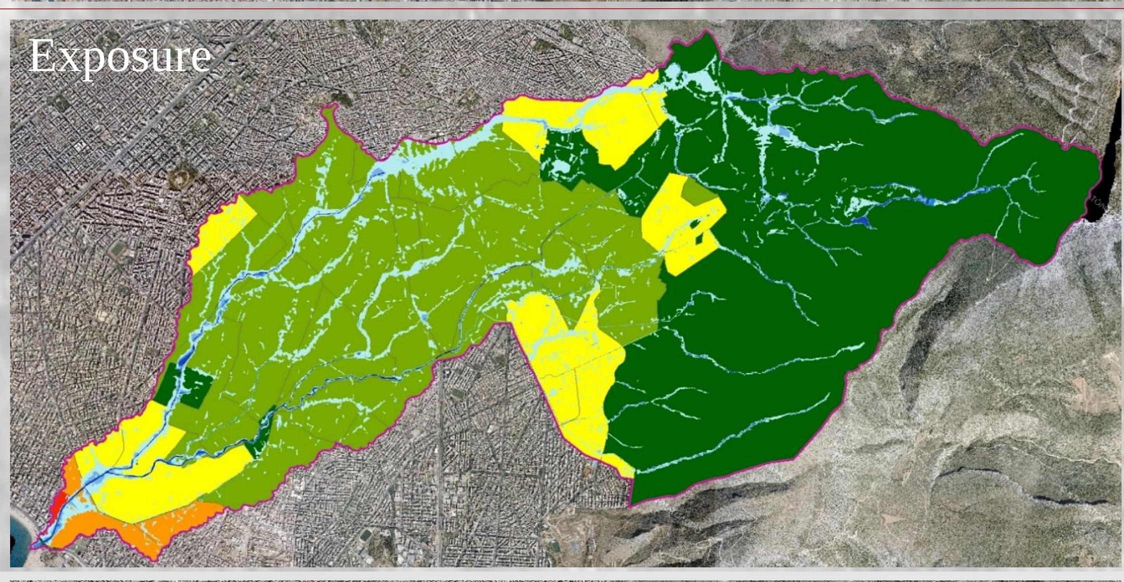


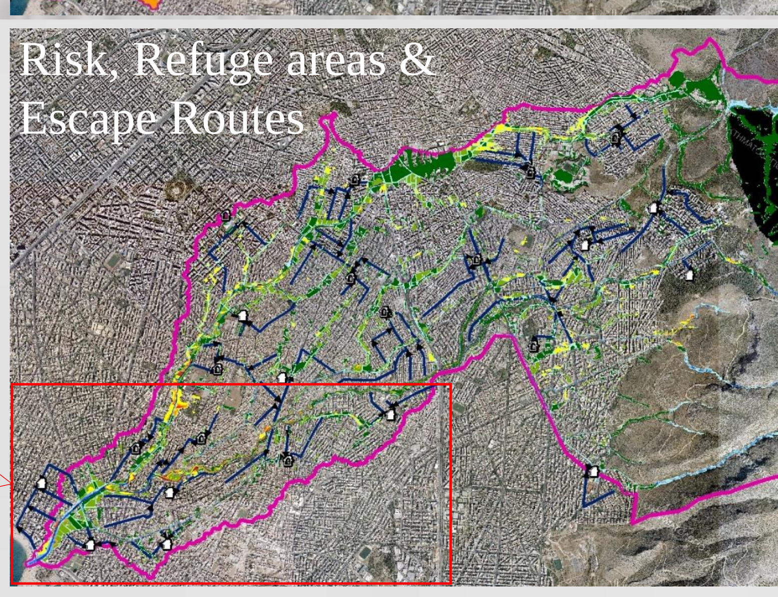
HEC-RAS (scenario T 1000 years)



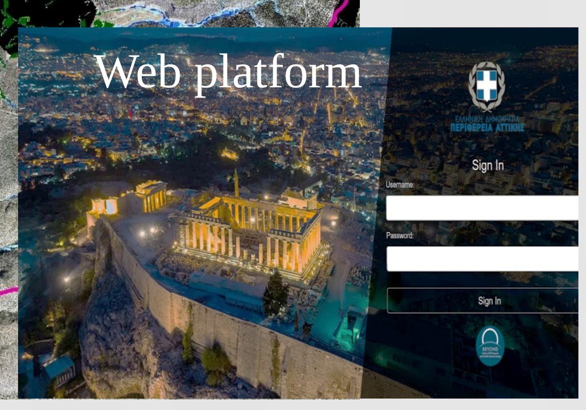








Legend
Basin
Hazard
Very Low
Low
Moderate
High
Very High
Total Vulnerability
Very Low
Low
Moderate
High
Very High
Exposure
Very Low
Low
Moderate
High
Very High
Risk
Very Low
Low
Moderate
High
Very High
Refuge Areas
Escape Routes



Conclusions

Many high-risk points were identified in residential areas, road networks and other critical infrastructure. Therefore, the **proposed mitigations measures** are:

- **structural measures**, e.g. delimitation of streams/rivers, river bed arrangement using up-to-date environmental terms, removal of constructions inside the river beds, small mountain hydro-distribution works, stream daylighting
- **non-structural measures**, e.g. special signs at high risk points, cleaning of the river bed, cleaning and maintenance of flood protection works on a regular and ad-hoc basis after each flood event, tree planting, promoting rainwater harvesting, training and raising awareness of the population, flood management exploiting the output of the projects (web platform)

Overall, it is very important to apply strategic design in order to mitigate flood risk towards the implementation of the EU Water Framework Directive [1], the EU Flood Directive [2] & the directions of the National Program of Water Resources Management and Protection [5]. Strategic design should be considered as an organized and planned response to the flood risk, with specific actions (prioritized works and measures), according to the responsibilities of each competent authority.

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