FLOOD, FIRE & EARTHQUAKE RISK ASSESSMENT IN THE REGION OF ATTICA, GREECE

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ABSTRACT

Floods, forest fires and earthquakes are disastrous events as they induce fatalities, damages to the environment, properties and infrastructure, at a global level. The Region of Attica, that hosts Athens (the capital of Greece), constitutes a region with significant characteristics, such as long coastline, large inland area, various geoenvironmental units, high population density, crucial infrastructures and social economic activities. Attica Region has suffered various catastrophic events in the last decade, highlighting the flood in Mandra (2017) and the fire in Mati (2018) with 24 and 103 fatalities, respectively. In March 2021, a Programming Agreement was signed between the Prefecture of Attica and the National Observatory of Athens to conduct the research study entitled «Earthquake, fire and flood risk assessment in the Region of Attica» (Part A) in selected and most vulnerable areas, funded by the Region of Attica. In the framework of this research work state-of-the-art methodologies were developed and implemented that support multi-parameter risk assessment and management planning at high resolution (building block level). This work integrates different data sources, including remote sensing, field visits and simulations, and is characterized by considerable added value, as it supports public actors and stake-holders in decision-making and management of disastrous events.

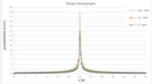
FLOOD

I. Data collection from different sources, quality control & modifications

- Relevant technical studies from competent services.
- Photo-interpretation.
- Detailed field visits according to standardized methodology and reporting template to estimate the dimensions of the technical works (such as bridges and culverts), to identify obstacles in the riverbed, to collect feedback from the residents.
- Terrain modification (DEM) with buried substreams.
- Infrastructure & services.

II. Construction of updated ombrian curves

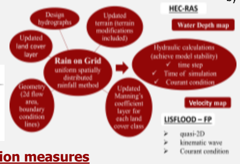
Rainfall hydrographs are derived from ombrian curves which are constructed and adapted to each river basin following a new advanced methodology [1] for three return periods (50, 100, 1000 years) according to the EU Flood Directive [2] using rainfall data from 29 stations (1860-2020).



III. Hydrologic analysis of river basin & Rainfall-runoff model (HEC-HMS)

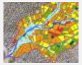
IV. Hazard – 2D Hydraulic models (HEC-RAS & LISFLOOD-FP)

Flood hydrographs are calculated by HEC-HMS. Water depth and velocity maps are produced by LISFLOOD-FP and HEC-RAS.



V. Vulnerability

Weighted estimation of:
- ✓ Population Age
- ✓ Population Density
- ✓ Building Type (construction materials and the presence of pilotis)



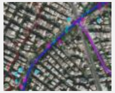
VI. Exposure

- ✓ Land Value

VII. Risk & Mitigation measures

Hazard, total vulnerability and exposure are combined to estimate flood risk. Based on the flood risk assessment and in-situ observations, critical points are identified and classified according to their risk level. Mitigation measures (refuge areas and escape routes) are proposed for the worst-case scenario.

Many high-risk points were identified in residential areas, road network and other critical infrastructures.



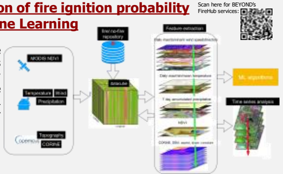
References:

1. D. Koutsoyiannis (2021). Stochastics of Hydroclimatic Extremes - A Cool Look at Risk, ISBN: 978-618-85370-0-2, Kallipos, Athens.
2. Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, Official Journal of the European Union, 6.11.2007, L 288/27.

FIRE

I. Determination of fire ignition probability through Machine Learning

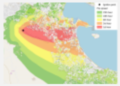
Possible fire outbreak locations were derived by BEYOND's daily fire risk forecasting ML model modified for seasonal forecasts.



II. Statistical analysis of wind characteristics

Historical time series of wind characteristics were extracted from local meteorological stations and ERA-5. Gridded data's distribution was bias-corrected through the quantile mapping method.

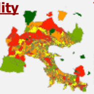
III. Hazard – Spatiotemporal Simulations



Fire spread was generated through a parameterized version in Python environment of open-source modelling software FlamMap.

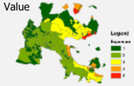
IV. Vulnerability

Weighted estimation of:
- ✓ Population Age
- ✓ Population Density
- ✓ Building Type



V. Exposure

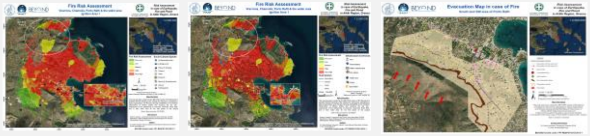
- ✓ Land Value



VI. Risk & Mitigation measures

Hazard, total vulnerability and exposure are combined to estimate fire risk. Based on the fire risk assessment and in-situ observations, critical points are identified and classified according to their risk level. Mitigation measures (refuge areas and escape routes) are proposed for the worst-case scenario.

Many high-risk areas and roads, critical points and support infrastructures were identified in residential areas.



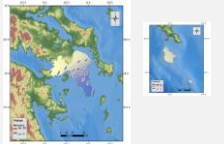
References:

1. A. Apostolakis, S. Girtsou, C. Kontoes, I. Papoutsis, and M. Tsoutsos. Implementation of a Random Forest Classifier to Examine Wildfire Predictive Modelling in Greece Using Diachronically Collected Fire Occurrence and Fire Mapping Data. Lecture Notes in Computer Science, 12573, 2021.
2. S. Girtsou, A. Apostolakis, G. Giannopoulos, and C. Kontoes. A machine learning methodology for next day wildfire prediction. In IGARSS, 2021.
3. P. Palaiologou, A. Ager, M. Nielsen-Pincus, C.R. Evers, and M.A. Day. Social vulnerability to large wildfires in the western USA. Landscape and Urban Planning, 189:99–116, 2019.

EARTHQUAKE

I. Seismic Hazard

- Probabilistic approach. Logical tree procedure.
- Estimation for 4 levels of seismic motion (T_m=95, 225, 475, 2475yr).
- Spectral values estimates at bedrock (PGA, $S_{a0.3}$, $S_{a0.6}$, $S_{a1.0}$).

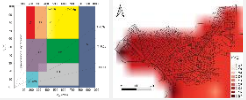


II. Geological Structure

- Databases of geotechnical surveys
- Geological mapping of urban environment
- Digitization of gathered data

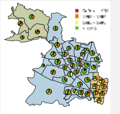
III. Subsurface Site Conditions

- Local site effects
- Soil characterization
- Seismic acceleration values at the surface level



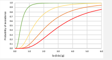
IV. Building Exposure Model

- Building data from the 2011 National Census (ELSTAT)
- Construction material, Height, Construction period, Irregularities
- Global Earthquake Model (GEM) taxonomy [1]



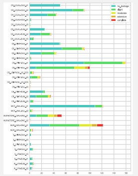
V. Vulnerability

- Probabilistic approach
- Fragility curves proposed by Martins & Silva [2]
- Four damage states defined in economic terms (repair/reconstruction cost)



VI. Seismic Risk

- Estimation of damage state distribution
- Mean damage ratio values in each building block/census sector
- Locations of predefined sheltering sites



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1. Brzev S, Scawthorn C, Charleson AW, Allen L, Greene M, Jaiswal K, Silva V. GEM Building Taxonomy Version 2.0, GEM Technical Report 2013-02 V1.0.0, GEM Foundation, Pavia, Italy, 2013
2. Martins L, Silva, V. Development of a fragility and vulnerability model for global seismic risk analyses. Bulletin of Earthquake Engineering 2021, 19: 6719-6745