Multi-criteria analysis for the detection of the most critical UNESCO World Heritage List (WHL) sites in Europe

Abstract
A GIS-based multi-criteria analysis is implemented to identify and to rank the most critical UNESCO World Heritage List (WHL) sites at the European scale in the context of PROTHETO, a H2020 project. Two multi-criteria methods have been tested and applied to more than 300 European WHL Sites.

First, the Analytic Hierarchy Procedure (AHP) was applied to the data of the UNESCO Periodic Report, in relation to 13 natural hazards that have affected or can potentially affect the Heritage sites. According to these reports, 22% of sites are without any documented hazard and 70% of the sites have at least one hazard affecting the site. For each WHL site, the potential risk was calculated as a weighted sum of the hazards that affect the site. The weights of the 13 hazards were obtained by AHP procedure, which is a technique for multi-attribute decision making that enables the decomposition of a problem into hierarchy, based on the opinion of different experts about the dominance of hazards. The result of the AHP method consists in a map of the WHL ranked according to this potential risk, where the site most at risk results to be the Geirangerfjord and Naeroyfjord in Norway. However, the quality of these results lies in the reliability of the Periodic Reports, which are produced by different experts with unknown level of scientific background.

To test the reliability of these results, a comparison of the information of the periodic reports with available high quality datasets (earthquake, volcano and landslide) at the latter scale has been performed. Sites properly classified by the Periodic Reports range from 65% (earthquake/hazard) to 98% (volcanos, hazard), with a high underestimation of landslide hazard. Due to this high value of uncertainty, we developed a new methodology to identify and to rank the most critical WHL sites on the basis of three natural hazards (landslide, earthquake, and volcano) for which reliable European-scale hazard maps are available. For each WHL site, a potential risk was calculated as the product of hazard from the available maps and potential vulnerability. The latter is obtained considering the typology of site (e.g. monument, cultural landscape, and cultural road), the presence or absence of resilient and/or fragile, the position of the site (underground/overhead). Through this methodology, a new ranking of the European UNESCO WHL Sites has been obtained. In this ranking, the historic center of Naples results to be the most at-risk site of the European continent.

1. Risk analysis based on UNESCO Periodic Report

- Climate change and severe weather events
- Sudden ecological or geological events
- % of sites without Periodic Report
- % of sites without Hazard from the Periodic Report
- % of sites with at least 1 hazard affecting the site

Most Important Hazards: Fire (wildfire), Storms, Flooding, Earthquake, Erosion

Number of sites affected by the hazards

2. Validation of UNESCO Periodic Reports in Italy

3. Risk analysis based on PROTHETO method

a) Definition of the type of WHL site

399 UNESCO World Heritage List (WHL) sites in 40 European States

- Italy – 49
- Germany – 41
- France – 37
- Spain – 36
- Austria – 28
- Cultural
- Mixed

b) Identification of the hazards affecting the WHL sites
- A hazard level (reclassified from 0 to 1) at each WHL site has been calculated based on:
  1. Seismic Hazard Map (European seismic hazard model, EPEHR).
  2. European Landslide Susceptibility Map (ELSUS100).
  3. Hazard map of active Volcanoes in Europe

Method: Interaction between the volcanic hazard buffer and WHL site area

96% of the sites are correctly classified by the Periodic Report UNESCO for Volcanic Hazard

Method: Intersection between the landslide hazard and WHL site area

77% of the sites are correctly classified by the Periodic Report UNESCO for Earthquake Hazard

Method: Intersection between the earthquake hazard and WHL site area

56% of the sites are correctly classified by the Periodic Report UNESCO for Earthquake Hazard

Method: Intersection between the landslide hazard and WHL site area

60% of the sites are correctly classified by the Periodic Report UNESCO for Landslide Hazard

Conclusion - point 1
Periodic Reports show the actual distribution of the Hazards in Europe, but:
- Some sites are without Periodic Report.
- Periodic reports developed by each state overestimate or underestimate the risk (e.g. Ireland).

Multi-state site hazards affecting a site is associated to all the states with the same site (e.g. Spain, Denmark; Arc Sicily, with risks affected by tsunami) or overestimation

Conclusion - point 2
Discrepancy between data from Periodic Report and available high-quality datasets:
- Strong underestimation of landslide hazard.
- Data from Periodic Report not suitable for the characterization of Potential Risk of WHL sites in Europe.
- Need for a new more flexible and reliable method

Conclusion - point 3
The Historic Center of Naples is the most dangerous WHL site in Europe.
- The analysis is based only on a 1% of the WHL sites but the methodology can be extended to other hazards, as datasets become available (e.g. Flood, volcanic hazard maps).
- Earthquake dominate high risk in the Mediterranean area.
- The method is very simple consistently with the available data quality and scale