Flood Vulnerability Modelling for Large Scale Risk Assessment of Cultural Heritage: An Application to Portuguese Churches

Rui Figueiredo[a,*], Xavier Romão[a], and Esmeralda Paupério[b]

[a] CONSTRUCT-LESE, Faculty of Engineering, University of Porto
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal

[b] Construction Institute of the University of Porto
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal

[*] Corresponding author. Email: ruifig@fe.up.pt

ABSTRACT

Flood risk is expected to increase worldwide in the coming decades due to various socio-economic and environmental factors, including climate change. Minimizing flood risk across large geographical regions requires robust risk management decision-making, which must necessarily be supported by risk assessment studies. These combine flood hazard data for a region of interest with information on exposed assets and models of their vulnerability (i.e. the impact they are expected to undergo as a function of flood actions), and allow computing consistent risk metrics.

While the preservation of cultural heritage against flooding has received ample scientific attention, most studies tend to focus on single specific assets. At present, there is a lack of methods in the literature to quantify the vulnerability of large sets of cultural heritage assets. This considerably hampers the development of meaningful risk assessment studies at large scales, for example, at the country level.

The lack of flood vulnerability models for cultural heritage risk assessment at large scales can be justified by various underlying difficulties [1]. Firstly, empirical approaches commonly adopted for other asset types, such as residential buildings, are not applicable, because they require large datasets of observed damage and/or losses, which are not available for cultural heritage assets. Secondly, there is no agreed upon method to quantify their value and, consequently, their degree of damage or loss. Thirdly, cultural heritage assets differ considerably among themselves even within common typologies, which complicates the development flood vulnerability models that can be applied to groups of similar assets.

This study aims to address the above issues by proposing a new framework to assess the flood vulnerability of cultural heritage assets. The proposed framework is based on a so-called synthetic modelling approach, whereby hypothetical flood scenarios are simulated and the corresponding potential damage is estimated through an expert-based what-if analysis [2]. This comprises three main steps: 1) cultural heritage assets within a region are divided into classes based on their main common features; 2) all components that may constitute each asset class are identified; 3) levels of vulnerability to flooding are established for each component (i.e. how damaged each component is expected to be when in contact with flood water). Due to its modular structure, this modelling approach is flexible and adaptable to the level of available information on the exposed assets, which can vary significantly based on the application context. The modelling framework is illustrated through a risk assessment of churches in Portugal at both regional and national scales.

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