FOREWORD

by

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THE TRIQUETRA PROJECT

Cultural Heritage (CH) encompasses all tangible and intangible elements of culture and society that are considered valuable. It shapes individual and collective identities, provides evidence of historical events and contributes to societal wellbeing through engagement and interaction. However, the safeguarding of CH is becoming increasingly challenging, particularly in the face of Climate Change (CC). Many CH monuments and sites are constantly exposed to environmental stressors, and in several cases, they are subjected to extreme conditions exacerbated by CC. This exposure renders them vulnerable to a variety of risks, including land deformation, flooding, acid rain, erosion and other hazards. These threats are intensifying, driven both by climatic shifts and anthropogenic pressures, putting CH assets at significant risk of damage or even total loss. Although extensive research has been conducted on the protection of cultural heritage, there remains a critical gap in systemic, multi-hazard approaches at regional and European levels that can efficiently identify, assess and mitigate risks to ensure the highest possible level of preservation.

The TRIQUETRA project ("Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage") proposes a technological toolbox and methodological framework for tackling CC risks and natural hazards threatening CH, in the most efficient way possible. TRIQUETRA was launched in January 2023, funded by the Horizon Europe programme (GA No. 101094818). The project aims to create a comprehensive decision support framework for risk identification, quantification and mitigation concerning endangered CH sites across Europe. TRIQUETRA is coordinated by the National Technical University of Athens (NTUA) and brings together 21 partners from Greece, Germany, Italy, Cyprus, Poland, Austria and Switzerland. The consortium includes 6 public entities, 4 SMEs, 7 university research groups and 4 research institutes, ensuring a rich combination of scientific, technological and cultural expertise.

The TRIQUETRA project takes its name from the concept of a "trifecta" approach to CH risk management, reflecting its focus on three interconnected steps: risk identification, risk quantification and risk mitigation (Fig. 1).
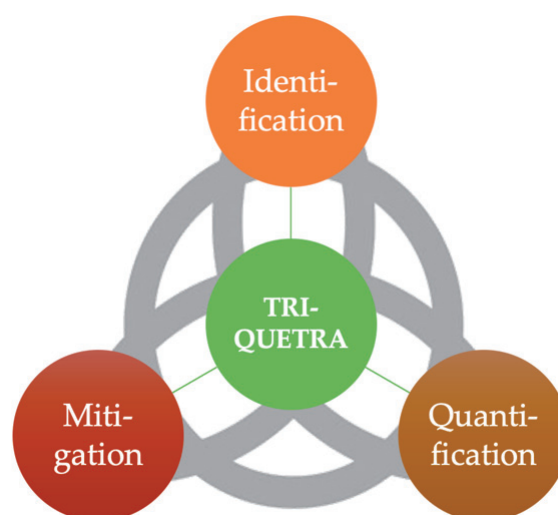

Fig. 1 - The TRIQUETRA approach

Within TRIQUETRA, a wide spectrum of hazards that threaten CH is addressed. These include climate-related hazards, extreme water, snow and ice hazards, geological and geophysical hazards as well as chemical and biological hazards. In addition, TRIQUETRA also investigates the damage and failure modes of CH structures and how multi-hazard compound and cascading effects can accelerate deterioration. Identifying and quantifying the risks corresponding to all these hazards is essential for developing effective mitigation strategies.

A key element of the project is the development and testing of innovative technologies, including a Flash LiDAR system for 3D mapping of underwater heritage sites, a novel mid-infrared spectroscopic sensor for real-time in-situ water quality monitoring, advanced remote sensing methodologies and nanotechnology-based protective coatings. Moreover, TRIQUETRA actively promotes citizen engagement through a dual-purpose mobile application, combining crowdsourced monitoring with Augmented Reality (AR) functionalities.

The TRIQUETRA Decision Support System (DSS) constitutes the main technological output of the project. It is a modu-

lar web platform designed to support evidence-based decision-making for the identification, quantification and mitigation of risks affecting CH sites. The core structure of the DSS consists of three main components:

- The Risk Severity Quantification Module, which enables the identification and evaluation of different kinds of hazards to the pilot CH sites of the project.
- The Mitigation Measure Selection and Optimisation Module, which provides tailored recommendations for risk mitigation based on site-specific parameters, combining literature-based solutions with expert-driven mitigation strategies.
- The Knowledge Base Platform (KBP), which acts as the central data repository of the TRIQUETRA project, integrating a dual system: a bibliographic database, containing scientific references and best practices, and a geospatial WebGIS interface that visualizes site-specific data.

Furthermore, the DSS incorporates some additional auxiliary tools, such as a Digital Twin visualization environment and an AI-based forecasting tool.

TRIQUETRA's methodologies and technologies are tested and validated across eight pilot sites, namely Kalapodi (Greece), Ventotene (Italy), Aegina Island (Greece), Choirokoitia (Cyprus), Epidaurus (Greece), Roseninsel (Germany), Argilliez (Switzerland) and Smuszewo (Poland), covering a diverse range of environmental conditions, materials and CH typologies.

For more information, visit: https://triquetra-project.eu/