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Editorial

Natural Events Threatening the Cultural Heritage: Characterization, Prevention and Risk Management for a Sustainable Fruition

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1. Aims and Content of the Special Issue

The Special Issue entitled "Natural Events Threatening the Cultural Heritage: Characterization, Prevention and Risk Management for a Sustainable Fruition" is primarily focused on the natural threats affecting cultural heritage. This, as a part of human history, deserves protection and appropriate management strategies to ensure its continuity the future generations' fruition. Heritage sites are exposed to the impacts of natural and human-triggered catastrophic events, which threaten their integrity and may compromise their value. With specific reference to territories hosting examples of cultural heritage, the main risk factors include a wide spectrum of hazards, from geological to climatic. In this frame, this Special Issue collects six scientific studies on the investigation of either potential or occurred natural events and their related implications on the sustainable fruition of the affected sites. Their geographical provenance, in terms of the authors' affiliation, is Italy (four articles), Italy–Mexico (one article) and China (one article). The topics involve the instability of rock slopes threatening tourist locations and archaeological sites, the disaster risk management of cultural heritage and risk mitigation measures as well as a landslide susceptibility assessment.

2. Overview on Published Contributions

The article *Geomechanical Characterization of a Rock Cliff Hosting a Cultural Heritage through Ground and UAV Rock Mass Surveys for Its Sustainable Fruition* [1] deals with the combination of conventional rock mass surveys, performed according to the specifications provided by the International Society for Rock mechanics (ISRM) [2] and airborne photogrammetry for the characterization of unstable rock masses threatening the fruition of a popular tourist destination in Sicily (Italy), where the tourist path to a Saracen Castle, crossing a heavily fractured carbonate cliff, is often affected by the transit of falling rock volumes. The use of an unmanned aerial vehicle allowed for overcoming the poor accessibility of the area, thus providing the possibility of collecting rock mass data for the reliable and representative rock cliff characterization. The results, supported by rockfall trajectory simulations, were used to suggest the most suitable risk mitigation measures to ensure the sustainable fruition of the analyzed cultural heritage.

The paper entitled *Rockfall Threatening Cumae Archeological Site Fruition (Phlegraean Fields Park—Naples)* [3] focuses on the rock mass characterization at Cumae, one of the most important archaeological sites in Italy, whose fruition suffers from rockfall hazard. The susceptibility to rockfall of a sector of the Cumae Mount was analyzed by a GIS-based approach supported by a geomechanical and structural analysis of a dense point cloud built from a ground-based photogrammetric survey. The collected data allowed the authors to perform a stereographic stability analysis, taking into account the main discontinuity sets, and to achieve a rockfall susceptibility zonation, which returned a high level of risk as the detected susceptibility interacts with both the Cumana station and the railroad.

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Citation: Mineo, S. Natural Events Threatening the Cultural Heritage: Characterization, Prevention and Risk Management for a Sustainable Fruition. *Sustainability* **2023**, *15*, 2318. https://doi.org/10.3390/su15032318

Received: 16 January 2023
Accepted: 21 January 2023
Published: 27 January 2023

In the article *Study on the Influence of Water–Rock Interaction on the Stability of Schist Slope* [4], the microstructural evolution characteristics of schist a during water–rock interaction was studied by using low field nuclear magnetic resonance (NMR) and electron microscopy. This rock type is involved in landslides of social concerns, threatening also the priceless cultural heritage resources in China. The achieved results show that the long-term interaction of rocks with solutions characterized by different properties affects both the peak strength of schists and their failure mode. Moreover, low-intensity rainfall for prolonged periods causes the dissolution of mineral particles and cementitious materials between particles, bringing changes in the pore structure of schist, thus leading to a progressive development of micro-cracks, which adversely affects the rock mechanical behavior.

The paper *Investigating the Integration of Cultural Heritage Disaster Risk Management into Urban Planning Tools. The Ravenna Case Study* [5] aims to provide an insight into the role that urban planning tools have when attention is paid towards improving the resilience of historical areas, coping with climate change through improvements in the disaster risk management of cultural heritage sites. For this purpose, the authors considered a cultural heritage site (Santa Croce Church) and an archaeological area located in the city of Ravenna (Italy) as a case study involving earthquake, subsidence and flooding as the main hazards, along with climate change as the amplifying factor of those existing hazardous phenomena. A six-phase cultural heritage management protocol is proposed, demonstrating how a collaboration between different sectors and institutional bodies leads to an improved ability to deal with disaster risks.

The article *Flood Susceptibility and Sediment Transport Analysis of Stromboli Island after the 3 July 2019 Paroxysmal Explosion* [6] is about the investigation on the effects that wildfires could have on the increase in the hydraulic hazard (related to floods from streamflows in volcanic areas). The authors chose Stromboli Island (southern Italy), already affected by eruption-induced wildfires, as the test site based on the hypothesis that the change in the land use caused by the fires could increase the surface runoff due to rainfall and generate the erosion and re-mobilization of the eroded material. Different rainfall scenarios were numerically simulated, and flood discharge rates were calculated for both pre- and post-eruptive scenarios. The achieved results show that the risk of flooding on the island is low to moderate and that the absence of vegetation, consequent to a fire occurrence, could cause a considerable re-mobilization of the sediment and/or soil, which could have effects on the inhabited areas of the island.

In the paper *Application of Bioengineering Techniques as Geo-Hydrological Risk Mitigation Measures in a Highly Valuable Cultural Landscape: Experiences from the Cinque Terre National Park (Italy)* [7], the use of bioengineering techniques is reported as a geo-hydrological risk mitigation measure. The study area is located in the Cinque Terre National Park (northwestern Italy) which is included on the list of World Heritage Sites by UNESCO and was severely affected by the consequences of an extreme rainfall event in 2011. The authors inventoried and mapped 14 bioengineering works, pointing out that the slopes impacted by shallow mass movements were stabilized by means of grading works and through crib walls, while transversal and longitudinal measures were used for the stabilization of the stream channel. The results of this study highlight that no environmental monitoring or maintenance procedures were performed; moreover, no vegetational studies were considered to select the most appropriate plant and grass species to be used according to the floral and vegetational features of the study area. This implies that planted or sown species may not be suited for the environmental features of the study area, adversely affecting the successful use of bioengineering. As a final remark, this study highlights that multidisciplinary approaches have a great importance in the design procedures of bioengineering techniques.

3. Discussion and Perspectives

The papers published in the frame of this Special Issue point out the impact that natural events have on the sustainable fruition of cultural heritage and tourist areas. With specific reference to the content of the papers discussed herein, the threat arises from both extreme and ordinary events, mainly connected to the geomorphological evolution of the territory hosting a cultural heritage, even under the effect of a continuously changing climate. Most of the contributions are focused on landslides and floods. In the first case, the risk arising from rockfalls is not limited to the site itself, where the safety and protection of visitors must be ensured, but also to the access infrastructure where visitors converge [8]. In this frame, the published papers underline the utility of combining conventional and remote surveying methodologies to achieve a reliable characterization of the unstable rock slopes threatening the fruition of historical and tourist sites [1,3]. Moreover, it was further proven that the interaction between rocks and water (rainfalls) leads to the worsening of the rock's mechanical and physical properties [4], stressing how rock weathering processes are a fundamental part of the geological cycle [9]. On the other hand, floods can represent a relevant risk in volcanic areas, where the occurrence of explosive eruptions may trigger wildfires, causing accelerated erosion phenomena, due to the increased surface runoff and the development of soil water repellency [10,11]. The paper which focused on the flood susceptibility at the volcanic island of Stromboli [6] well-addressed this issue, highlighting that the fire caused an increase in the discharge rates of a superficial runoff. Such a study represents a useful reference for territorial planning and risk management. In this latter frame, cultural heritage risk management protocols would represent a useful tool to be integrated in urban planning procedures [5], while the definition of the guidelines on the best practices to be adopted for specific remediation works should be implemented [7].

In a society where the technological development runs after natural changes, a balance between human presence and nature should be established, with the aim of preserving the heritage for the future generations in the awareness that natural phenomena cannot be avoided, although their effects can sustainably be prevented.

Acknowledgments: The Academic Editor of this Special Issue would like to thank all the publishing authors who have contributed to the development of scientific knowledge on the proposed topics, along with all the Reviewers, who have worked to ensure the scientific quality of the published papers.

Conflicts of Interest: The author declares no conflict of interest.

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