Proactive Climate Adaptation Strategies for Italian Built Heritage: Developing Risk and Adaptive Systems Maps

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Introduction

The ongoing threat of climate change to the material integrity and structural stability of our built heritage underscores the necessity for adaptation strategies alongside traditional mitigation efforts. While mitigation has dominated climate change research and policy discussions, the imperative to anticipate new risks, mitigate existing ones, and enhance the resilience of built heritage against environmental degradation is increasingly recognized. This recognition is evidenced by international interest in European projects such as NOAH's ARK (Cassar et al. 2010), Climate for Culture (Frauenhofer Institute n.d.), KERES (Fraunhofer Institute n.d.). Despite this, climate adaptation planning for cultural heritage remains largely reactive, lacking the proactive approach needed to enhance its resiliency.

When developing a restoration project for a historical building, designers (architects or engineers) need to follow a knowledge path to ensure quality restoration interventions (Pugliano 2023). Understanding the heritage building is crucial for making the right intervention decisions. Currently, the knowledge path focuses on the past and present of the heritage asset but does not consider its future. However, in a more unstable climatic future, it is essential to consider this aspect to enhance the asset's resilience (García 2019; Chmutina et al. 2020; EU Open Method of Coordination (OMC) group of Member States' experts on 'Strengthening cultural heritage resilience for climate change' 2022). There is no official specialist yet in the knowledge path who can make climatic projections of degradation indexes in heritage assets. These indexes are known as climate-heritage indexes.

Methodology

This paper aims to fill this gap and provide a scientific foundation for formulating effective policies and protective measures for built heritage in the Italian context, which is rich in heritage buildings. This study focuses on climate-heritage indexes derived from climatic variables such as temperature, relative humidity, precipitation, and wind. These indexes were computed based on the regional climate projection for Italy (VHR-PRO_IT), produced by CMCC and covering 1989-2050 (CMCC Foundation n.d.). The climate projection dataset, developed within the Highlander project at approximately 2.2 km resolution (i.e., Convection Permitting Scale) by dynamically downscaling the CMCC-CM global model, adopts the IPCC RCP4.5 and RCP8.5 scenarios (Raffa et al. 2023). The spatial horizontal resolution features 2.2 km and an hourly time resolution. As suggested in the study by Raffa (Raffa et al. 2023), bias adjustment was performed before post-processing the climatic data for use in this heritage building adaptation study to correct systematic biases against observations. Secondly, the climate-heritage indexes were generated using the Climdex-kit (Campalani 2022) which combines CDO (climate data operators) and Python functionalities. Once the projected risk maps for the Italian area were obtained, they were analyzed, and an Adaptive Systems Map was produced. This map features possible adaptive systems applicable to heritage buildings in the Italian context according to the necessary deterioration risks identified from the risk map. The choice of adaptive systems is based on a review of previous studies (Blavier et al. 2023).

Results

Although the research is ongoing and results are not yet available, the study proposes a range of adaptive systems tailored to preserving built patrimony in the face of climate change challenges. Preliminary observations suggest that climate-heritage indexes can effectively highlight areas at risk, providing a basis for developing targeted adaptation strategies. The integration of high-resolution climate projections and detailed heritage assessments is expected to yield actionable insights for policymakers. This methodology sets a precedent for future studies in other countries as well.

Conclusions

Since this study is based on a single model of climate projections, it is not possible to consider the uncertainties in the evaluation of the climate-heritage indexes. Therefore, this study provides an initial evaluation, which needs to be reinforced by future studies. However, this research also supports the transition from a reactive to a proactive approach in climate adaptation planning for cultural heritage. By establishing a scientific foundation for the development of effective policies and protection strategies, this research will help pave the way to ensuring the preservation of built heritage for future generations. The use of advanced climate modelling and heritage-specific indexes exemplifies the application of technology in the realm of cultural heritage, offering a robust framework for future research and policy formulation. This methodology for constructing an Adaptive Systems Map can serve as the

basis for other regional studies. Furthermore, the outcomes are anticipated to significantly impact the field by providing a clear, evidence-based path toward enhancing the resilience of cultural heritage assets against climate change.

KEYWORDS: Historical Buildings, Climate Change, Adaptation, Heritage-Climate Indexes, Preservation

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