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Editorial

CONFRONTING CLIMATE CRISIS: A CALL FOR SUSTAINABLE AND ADAPTIVE HERITAGE CONSERVATION

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ABSTRACT

This special issue addresses the urgent threat of climate change to cultural heritage and presents a range of strategies for mitigation and adaptation. The research highlights the diverse impacts of rising temperatures, increased humidity, and extreme weather events on archaeological sites, historic buildings, museums and galleries. The papers provide evidence for a much-needed paradigm shift in the management of heritage conservation signifying a move away from habitual practices with narrowly focussed conceptions of risk towards sustainable and context-specific approaches. Case studies from Greece, the UK, the Philippines, and Egypt demonstrate the importance of localized solutions, the development of data-driven risk assessments, including environmental monitoring systems and the adaptive reuse of heritage structures. The studies also emphasize the critical need for carefully targeted climate control measures and a rejection of a default energy-intense climate management model based on outdated approaches and badly adapted control measures. The collection of papers in this volume, advocates for community engagement and collaboration among stakeholders to promote shared responsibility for heritage preservation. The findings reveal that conventionally used nominal standards are not universally applicable and call for more evidence-based approaches to collection care. By embracing these contextual strategies, the heritage sector can enhance its resilience, move away from traditional conventions and ensure the considered preservation of cultural heritage for current and future generations.

KEYWORDS: Climate, heritage, museum, sustainability, environment, evidence-based, decision-making.

1. INTRODUCTION

The escalating climate crisis poses an unprecedented threat to cultural heritage sites and collections worldwide. As evidenced by the research presented in this special issue, the impact of rising temperatures, changes in humidity and extreme weather events, demands immediate action. The articles in this volume highlight the need for a paradigm shift in heritage conservation, moving beyond habitual practices towards sustainable, adaptive, and context-specific strategies.

The volume offers a series of linked research papers, each offering distinct case studies but unified by seeking data and solutions to understand and address the challenges of climate change on cultural heritage. This edition contains studies spanning diverse geographic contexts, different operating models, different collection types and different institutional frameworks yet nonetheless they offer a comprehensive view of strategies and tools for sustainable conservation. The papers address the common themes of this special issue and do so by describing practical examples and evidence-based approaches. For too long the major sectoral approach to environmental management has been governed by an oversimplistic adherence to a set of standards for environmental care developed primarily in the UK and USA in the 1970s. These approaches were explicitly developed in response to operating context, often well-resourced institutions in temperate climates, yet by convention, comparison and a misperception of what might be considered to be 'best practice' became a set of instructions to be adhered to regardless of context.

The advent of more climate conscious approaches, the resource challenges from less well funded institutions attempting to match these often Eurocentric approaches saw increasing dissatisfaction with the approach. Institutions could ill-afford expensive control measures, equipment could not deliver this consistently and systems that had been developed to deliver conditions suitable for European collections were imposed on materials which had been manufactured, used, survived and collected in other climates. The calculations of typical moisture content and materials dimensions should have been reviewed in the light of each climate but instead became a global hegemony of a default safe, energy intense solution set for temperate climates and stone buildings.

In devising appropriate climate strategies conservators, engineers, architects and facilities managers can approach risk in one of two ways. Either risk could be minimised and climates created which protect most of the materials of cultural heritage most of the time. Such climates default to known safe conditions based on research and observations of conditions in which collections are stable. As a narrowly focussed approach this worked if resources were plentiful. The impact on buildings, budget and ultimately climate, have caused raised many questions as the papers in the journal elucidate. The default safe position can be tested: moving from a focus on a conservative approach to what is known to be safe to an approach that seeks achievable solutions, setting conditions at the boundaries of risk points. Such an approach takes a broader view of acceptable practice which includes a tolerance of risk which offsets other benefits such as energy efficiency, comfort or sustainable practice. To take this informed view researchers must consider those boundary points, and it is precisely these context-led evidence-rich approaches that are contained in this special edition.

2. RESEARCH PAPERS IN THIS VOLUME

The challenges are immense. **Archaeological sites** are vulnerable to a range of climate-driven hazards, including heatwaves, droughts, floods, and wildfires. The site of Olympia in Greece, a UNESCO World Heritage site, faces increasing risks from extreme temperatures, heavy rainfall, and prolonged dry periods, all of which threaten its structural integrity and visitor safety. Mavrakou et al. (2025) using Olympia as a case study, develop a comprehensive methodology for assessing climate change-related risks to archaeological sites. Their research uses climate projections from the Euro-CORDEX program and applies the IPCC AR6 risk framework to assess climate-related risks at UNESCO World Heritage sites enabling detailed, localized assessments of climate impacts, which facilitates the development of long-term adaptation strategies. The method quantifies hazards, exposure, and vulnerability through climatic and non-climatic indicators, enabling comprehensive risk assessment. The case study presented highlights threats such as heatwaves, droughts, and sea-level rise. By identifying site-specific risks, this framework facilitates the development of tailored adaptation strategies, enhancing resilience against climate-induced threats. Its universal applicability makes it a valuable tool for quantifying current vulnerability and projecting future climate hazards. It also demonstrates the use of localized risk assessments, and the integration of climatic and non-climatic indicators, thus ultimately informing safeguarding of archaeological sites worldwide.

Similarly, **historic buildings** in urban environments are at risk from water damage, temperature fluctuations, and air pollution. They are also at risk from inappropriate development responding to the abstract implementation of generic modules for environmental management. The case study of 60 Goodramgate in York, UK, illustrates the need for

proactive management and the use of environmental monitoring to understand and mitigate the impact of dynamic conditions while still maintaining the relevance and functionality of heritage spaces. Lingle et al. (2025) focus on sustainable approaches to preserving historic buildings in York. York, boasts a rich built heritage that necessitates sustainable management strategies to ensure longevity. Researchers at the University of York and the York Conservation Trust explored collaborative methodologies that integrate social, material, and historical contexts. The research explores how to embed decision-making processes that prioritise sustainability and examines the potential for adaptive reuse of heritage buildings, which fits the goal of increasing the resilience of the cultural heritage conservation sector. The use of environmental monitoring to understand the current conditions of a historic structure to inform decisions about modifications, and the use of a minimally interventive approach to preservation, aligns with the special issue's focus on smart systems for monitoring, and the life cycle assessment and energy consumption of conservation practice. Data collected for a year after lime rendering restoration, correlated with structural assessments and historical insights informed adaptive reuse and maintenance. This minimally interventive approach showcases the potential for balancing heritage preservation with climate resilience, setting a precedent for urban historic environments amid global climate uncertainty.

At Ranger's House, an English Heritage historic building in the UK, the vulnerability of Limoges enamel to high and fluctuating temperature was addressed through localized cooling. Luxford et al. (2025) investigated the effectiveness of cooling systems for controlling object temperature, using the Limoges enamel collection at Ranger's House as a case study. Environmental data indicated that chillers effectively minimized diurnal temperature spikes and maximum temperatures, reducing the risk of physical damage of sensitive objects. The data also enabled researchers to pinpoint the extreme weather conditions that created a specific vulnerability for the Limoges. Instead of working to default safe conditions which were increasingly difficult to deliver in extreme weather events, the team identified the highest risk conditions specific to the collection enabling an informed discussion about mitigation measures. The study addresses the practical challenges of using active climate control in historic spaces and highlights the need for sustainable solutions, thus directly addressing the theme of life cycle assessment and energy consumption of conservation practice. It also illuminates the importance of understanding material response to high temperature. Increased relative humidity posed a secondary risk, necessitating energy-intensive controls. As global temperatures rise, the frequency of hot days is expected to double, compelling researchers to explore more sustainable methods. Recommendations include alternative cooling technologies and targeted environmental controls to ensure that energy costs and the consequent carbon footprint was directed at known requirements of object safety.

Museum collections are susceptible to deterioration due to high temperatures and humidity. The National Museum of the Philippines faces challenges particularly with mould growth and mechanical failure in its collections, and the Lopez Museum and Library also deals with the challenges of managing hygroscopic materials in such conditions. These institutions are now actively looking for ways to reduce their reliance on energy-intensive climate control systems and find more sustainable approaches to collection care. Building an understanding of solutions draws on evidence from monitoring, materials response as well as historical patterns of behaviours and the needs of museum visitors (Villanueva, 2025).

Calanno and Tse (2025) examine the challenges of preserving museum collections in tropical climates, using the National Museum of the Philippines as a case study. This paper addresses the need for context-specific approaches to conservation, highlighting how traditionally used guidance for environmental conditions in museums and galleries may not be suitable for all climates. It considers both the material responses to changing climate, particularly with respect to temperature and humidity, and the implications for conservation. Environmental monitoring at the National Museum of the Philippines revealed that relative humidity often exceeds 70%, causing biodeterioration and structural damage to organic collections. During the pandemic, reduced mechanical climate controls led to lower humidity fluctuations, providing insights into passive climate management's potential. The study emphasizes the need to rethink museum environments in hot, humid climates and explores the use of passive climate strategies. The research also touches on energy consumption, highlighting the high energy demands of mechanical HVAC systems.

The Lopez Museum and Library in the Philippines exemplifies the challenges tropical climates pose to hygroscopic materials like paintings and paper. Traditional air-conditioning incurs high energy costs and emissions but cannot be simply dispensed with as this would risk both collection care and visitor comfort with significant impact on the sustainability of the institution. Villanueva (2025) describes the development of sustainable environmental guidelines for collections in the tropics, using the Lopez Museum and Library in the Philippines as a case study. The paper

highlights how a one-size-fits-all approach to climate control can be both ineffective and unsustainable and advocates for a context-focused approach that considers material properties, historical environmental data, and object use. Flexibility in conservation practices is prioritised to ensure sustainability without compromising preservation concerns. This approach underscores the need to reimagine the strict implementation of environmental guidelines originally developed for temperate climates, paving the way for context-sensitive solutions. It also aligns with the goal of developing smart systems for the monitoring and control of factors influencing preservation and addresses the need to reduce the conservation sector's carbon footprint by providing a case for more appropriate, less energy intensive climate control.

Museums in Egypt face similar challenges of finding suitable and sustainable solutions for collection protection and visitor comfort. The Grand Egyptian Museum and the Egyptian Museum in Cairo face rising temperatures, dust storms, and urban pollution. Elkhial (2025) explores strategies to mitigate these risks, focusing on newly built, historical, and older museum infrastructures, for the sustainable protection of Egypt's vast cultural heritage. Her study directly addresses the aim of increasing the resilience of the cultural heritage sector, by assessing preventive conservation practices in museums facing the impacts of climate change such as rising temperatures. She proposes an integrated framework that combines preventive conservation with climate change adaptation strategies, including the use of data-driven approaches to inform decision-making such as risk assessment, environmental monitoring, and community engagement. Preventive conservation practices implemented over two decades reveal varying levels of effectiveness in addressing climate-induced threats. Critical gaps include infrastructure limitations and inadequate decision-making processes. Recommendations include enhancing conservation policies, improving museum infrastructure, and adopting climate-adaptive practices. These findings contribute to global discussions on protecting cultural heritage amid climate challenges.

3. DISCUSSION: COMMON THEMES AND FUTURE DIRECTIONS

Across these studies, several recurring themes and strategies emerge for heritage preservation in the face of climate challenges. Museums and Galleries worldwide operate guidelines which are described as international standards or 'best practice' but which were derived from circumstances in temperate climates and well-resourced institutions. Attempting to copy practice devoid of context is not universally applicable. Instead, a comprehensive understanding of each site considering its social value, specific environmental context, and the material properties of the objects within its care is essential. The case studies presented demonstrate a move towards context-specific strategies that consider each material's environmental history, condition, and institutional programming.

Several key themes emerge offering a pathway for future action:

Localized Risk Assessments: The importance of site-specific risk assessments that consider the unique environmental, historical, and cultural contexts of each site cannot be overstated. This requires a comprehensive understanding of both climatic and non-climatic factors.

Localised Environmental Management: Adapting global guidelines to specific climates, particularly in tropical and arid regions, ensures relevance and sustainability.

Integrated Approaches: Combining material data, historical insights, and modern technologies supports informed decision-making and adaptive reuse.

Adaptive Reuse and Resilience Building: Heritage buildings should be adapted for contemporary use, prioritising minimal intervention to preserve their original fabric and character whilst enabling sufficient evolution to ensure relevance. Environmental monitoring helps to inform decisions regarding any necessary modifications. Tailored adaptation strategies, supported by robust environmental data, enhance heritage sites' resilience to climate and economic uncertainties.

Environmental Monitoring and Smart Systems: The use of reliable sensors and data analysis is critical for understanding the impacts of climate change and developing effective mitigation strategies. This includes the use of data loggers, and other technologies to monitor temperature, humidity, and other environmental factors.

Sustainable Energy Solutions: The heritage sector must prioritize energy efficiency, explore renewable energy options and actively seek to reduce its carbon footprint. The reliance on energy-intensive climate control systems should be reduced through the adoption of passive climate strategies and consideration of the life cycle of conservation practices. Minimizing energy-intensive controls through passive methods and strategic building designs reduces carbon footprints without compromising conservation.

Collaboration and Knowledge Sharing: The integration of conservation expertise, scientific research, and stakeholder input is critical for making informed decisions. Sharing knowledge and best practices across institutions and regions enhances the sector's capacity to respond to climate risks. Interdisciplinary

collaboration among conservation scientists, policymakers, and local communities fosters innovative solutions and shared responsibility.

Community Engagement: Involving local communities, policy makers, and the public in conservation efforts is vital for raising awareness and fostering a sense of shared responsibility.

Evolution of standards: Moving from the conception of standards as a set of fixed values that govern practice, to standards which guide approaches to decision making will ensure that practices are adapted and adopted in sympathetic ways worldwide. This can help to diminish colonial practices of insisting on European or north American models which are masked in the language of standardisation.

4. CONCLUSIONS

The papers together demonstrate the importance of sustainable, adaptable, and context-specific approaches to cultural heritage conservation in the face of climate change. These studies underscore the urgency of adopting proactive strategies to protect global cultural heritage in an era of accelerating climate crisis. By embracing these informed approaches, the heritage sector can move towards a future - where cultural heritage is preserved and enjoyed for current and future - with clear reference to the impact of this work on the possibilities and opportunities for future generations. These papers do not offer a simplistic call to remove climate control, the papers demonstrate that this would impact both on preservation and the quality of user experiences but instead demonstrate that evidenced and informed strategies can serve the needs of collections, communities and climate. This special issue serves as a call to action, urging researchers, policymakers, and practitioners to work together in the face of this global challenge. The research presented here offers a valuable foundation for addressing pragmatic challenges in cultural heritage conservation due to climate crisis, for the selective and considered use of resource for benefits that have clear social and scientific benefits. The complexity and interlinked nature of climatic and non-climatic factors means that adaptive management strategies that prioritize resilience, collaboration and continuous monitoring, are essential.

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