

HERITAGE AT RISK

IMPROVING RESILIENCE
AND AWARENESS TOWARDS
PRESERVATION, RISK MITIGATION
AND GOVERNANCE STRATEGIES

EDITED BY
MARCELLO BALZANI,
FEDERICA MAIETTI
AND FABIANA RACO



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HERITAGE AT RISK

It is assumed that the impact of natural and man-made hazards on society in terms of damage is constantly increasing. In order to reduce the levels of potential disaster and to assess which policies and measures can generate positive impacts, it is necessary to make a careful comparison of experiences at an international scale in risk mitigation and management.

The international scenario of calamitous events that still characterise all areas of the globe is deepened together with the experiences of the earthquakes and floods that have affected the Pianura Padana area and the central regions of Italy in the last ten years, included in the training project Academy “After the Damages”. Following the results published in the first volume *Built Heritage in Post-Disaster Scenarios*, *Heritage at Risk* aims to continue the debate on recent innovations and advances in risk management to contribute to the definition of strategies and the implementation of increasingly effective tools in terms of risk mitigation.

The volume provides insights into the dynamics and negative effects of natural and man-made hazards (i.e., earthquakes, fires, floods, droughts, and volcanic eruptions), including more updated approaches to deal with post-disaster phases. The book also offers tools to deal with possible international crisis scenarios and mitigate the social impact of vulnerabilities through risk reduction.

Heritage at Risk is aimed at public administration managers, government agency representatives, international organizations, researchers, and professionals in architecture, engineering, and earth science.

Heritage at Risk

Improving Resilience and Awareness Towards Preservation, Risk Mitigation and Governance Strategies

Edited by

Marcello Balzani, Federica Maietti and Fabiana Raco

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**TECNOPOLO
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Knowing to preserve: Towards a deeper awareness of heritage identities and fragilities

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ABSTRACT: The paper summarises the After the Damages project from its conception and cultural vision to the creation of the International Academy, highlighting the topics addressed in the second and third editions and focusing in particular on the contribution of digital innovation in cultural heritage risk prevention.

Among the topics covered by the “After the Damages” advanced training project, indeed, the application of digital technologies for risk monitoring and reduction is definitely among those most under rapid evolution and development. Several recent actions and funded projects demonstrate how digital applications can be used in an increasingly targeted way to safeguard heritage in risky conditions.

Starting from the overall Summer School organization and main topics addressed during the second and third editions, some current research avenues are outlined, also reviewing the most recent scientific literature to framework relevant concepts related to risk management, preservation, awareness, identity and fragility, and the application of digital technologies in the field. The Academy, set up as a permanent organization at the end of the advanced training project, realised over three editions, demonstrates how the interdisciplinary aggregation of experts and institutions is a need in order to be able to address, on an ongoing basis, the issue of safeguarding heritage from the ever-increasing risks due to climate change and extreme events.

Among the most significant outcomes of the advanced training project and the three Summer Schools that were developed - in addition to the numerous “Focuses” and “Talks” organised in addition - is the participants’ increased awareness not only of the risk factors but also of the various tools and policies realized as best practices. A wealth of awareness and increased knowledge on the conservation of the most fragile places, to be transmitted to future generations.

Keywords: 3D survey, Digital tools, Heritage documentation, Monitoring, Risk assessment

1 INTRODUCTION

The deeper significance of the creation of the Summer School “After the Damages” first and the International Academy later, lies mainly in the opportunity to develop an interdisciplinary and international network within and beyond the high-level training project.

In its initial vision, the project was rooted in focusing on the most significant solutions and research directions on the topic of disaster response, expanding the different levels of knowledge starting from the experiences gained in the Emilia-Romagna Region on reconstruction, prevention and resilience following the 2012 earthquake. This direction remained a constant in the development of the project, but in the second and third edition it reached full maturity, expanding the topics addressed and turning the training experience into a permanent Academy.

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The very structure (Web-1) adopted for project management by the University of Ferrara as coordinator reveals the underlying cultural and educational vision. In addition to the project partners, the heads of the scientific management, and the technical-scientific committee, the Faculty Members represent twelve nations, while invited members of the scientific committee include institutions from seventeen countries from four continents.

From the outset, the careful evaluation of the scientific contents was aimed at advancing expertise in the field of risk management and mitigation - increasingly crucial on a regional, national and international level - in order to explore the most cutting-edge research trajectories on the topic and to propose methodological and operational tools as a set of skills for different professional profiles, and articulated in different training modules according to a holistic and multidisciplinary approach.

Under the “After the Damages” interdisciplinary approach to preservation, management and risk reduction, the term “resilience” – although it is definitely abused and overused in recent times – well captures the need for a more aware respect for built and social environments identities and fragilities. Resilience can be defined as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management” (Web-2).

The effectiveness of safety actions and vulnerability reduction strategies in Heritage contexts depends (also) on the awareness and the need for respect of identities.

Starting from the overall Summer School organization and main topics addressed during the second and third editions, some current research avenues are outlined, also reviewing the most recent scientific literature to framework relevant concepts related to risk management, preservation, awareness, identity and fragility, and the application of digital technologies in the field.



Figure 1. Venice, 1950-1960, Paolo Monti, Fondazione Biblioteca Europea di Informazione e Cultura (BEIC) - European Library of Information and Culture Foundation, CC BY-SA.

2 THE “AFTER THE DAMAGES” CULTURAL VISION

The catastrophic events that have affected various national and international areas and contexts (seismic events, floods and hydrogeological events as a result of climate change, but also fires that involved cultural assets such as the Notre-Dame Cathedral in Paris or the National Museum of Brazil in Rio de Janeiro), increasingly draw attention to the need to work on improving safety and reducing environmental and anthropic risk (Bonazza et al., 2018). Reducing the environmental risk (seismic, hydraulic, hydrogeological) and risks from exceptional actions, such as human influence, means acting at an interdisciplinary level on different areas that concern the concept of vulnerability and resilience, the socio-economic impact, the improvement of monitoring models, technological innovation, and the compatibility of recovery interventions.

In recent years, more attention has been paid to the study of the impacts of disaster events in general, contributing to an increased awareness – not only at the governance level, but also in academic institutions and socially – of the need to reduce the effects of potential disasters. A challenging element is therefore risk assessment and characterisation of vulnerabilities that must take into account those factors and processes that may not yet have become apparent. This is particularly relevant in highly dynamic environments, such as historical aggregates, where both socio-natural hazards and vulnerability patterns, which are constantly being updated, might undergo rapid changes in the future, in the short and medium term. Section headings organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic.



Figure 2. UNESCO, ICOMOS, European Commission, ICCROM, and United Nations publications on Climate Change effects on cultural heritage.

Starting from this assumption, the “After the Damages” project aimed to draw on some significant experiences by exploring the evolutionary trajectory and highlighting the most up-to-date results, in order to contribute to the dissemination of the potential of the post-disaster phase so as to promote more informed preventive action in pre-disaster planning (Balzani et al., 2023).

The importance of integrating uncertainty into disaster risk management has often been emphasised, especially for the historical built heritage, but still remains an issue to be comprehensively solved (Santangelo et al., 2022). In this regard, efforts have been made to help strengthen the role of relevant data collection, information processing, real-time monitoring and network infrastructure management.

The Summer School second and third editions were primarily aimed at deepening methodologies for the analysis, mitigation, and risk management, focusing on several interrelated topics, including built heritage, natural hazards, and climate change; understanding of risk, strengthening decision-making in risk management and solutions in risk reduction; data collection for the documentation of the interventions to recovery or to risk reduction; built Cultural Heritage in the Disaster Risk Management approach (Zarnic et al., 2017).

Some macro-thematic areas were identified in order to cluster the most relevant topics. The first cluster deals with intangible aspects and management tasks (governance and socio-economic aspects) including: post-disaster participatory governance tools supporting communities with a resilient attitude; local identity for the construction of intangible resilience in historic urban contexts; governance strategies aimed at environmental, social and economic resilience; community involvement to strengthen governance and stakeholder decision-making capacities in monitoring and reducing risks, towards predictive and reactive action in case of disaster.

The second cluster includes all essential actions related to pre- and post-disaster documentation (survey and data modeling, monitoring, integrated diagnostic survey, digitization of complex systems, Building Information Modeling) including: innovative methods of integrated survey by applying protocols and 3D modeling also in parametric environment (Chiabrando et al., 2028); monitoring of deformations through continuous acquisitions and longtime series, deformation monitoring by sensors.

The third cluster deals with knowledge sharing by deepening design solutions such as: tools for an aware design applied to the conservation of the historic built heritage; seismic vulnerability assessment and innovative solutions for the improvement of the anti-seismic behaviour of aggregated built heritage.

All these topics were covered through lectures by international experts and following an interdisciplinary approach, while virtual thematic visits aimed at in-depth study and discussion with experts and professionals working in the field of risk management and heritage conservation.

The training project was not limited to the delivery of lectures, but also included an active experience that the participants had to develop. The final project simulation was managed as a group work, in order to strengthen the exchange of different experiences and background, the knowledge sharing, and the multidisciplinary work among the group members, as one of the main purposes of the Summer School.

Each participant proposed a topic or thematic area among those covered by the Summer School while the scientific managers aggregated each participant in groups based on the collected proposals and selection of topics and thematic areas. Among the criteria used to create the groups, also the greatest possible differentiation between nationalities, backgrounds, professions, countries, research experiences, etc.

The final work of each group has been summarized in a power point presentation, held during the last day of the training course, focused on the general conclusion of the Summer School and the final presentations by the working teams. In this context, different visions, strategies, and considerations on the specific thematic area were put together, proposing a simulation based on a specific site (or comparing different sites' conditions), or a specific geographical area, highlighting the collective experience through the diversification of needs, requirements or approaches, overlapping of topics, issues or solutions, and including comments or “food for thought” on Summer School topics and lessons learned.

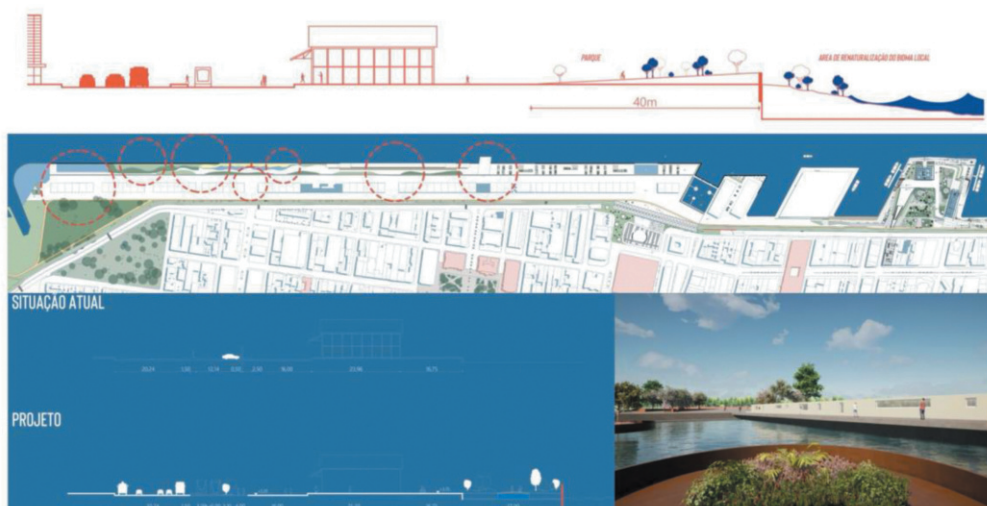


Figure 3. Preventing cities from flooding. The case of Porto Alegre and its heritage. Work of the group “SecureTeam” about “Preparedness & Mitigation for the exposed Heritage”, final presentation of the second edition of the Summer School “After the Damages”. Working group: Antonio Memeo, Mima Feltrin, Gianpiero Imbrogno, Natalia Ferrari, Anna Faiella. Tutor: prof. Haroldo Gallo.

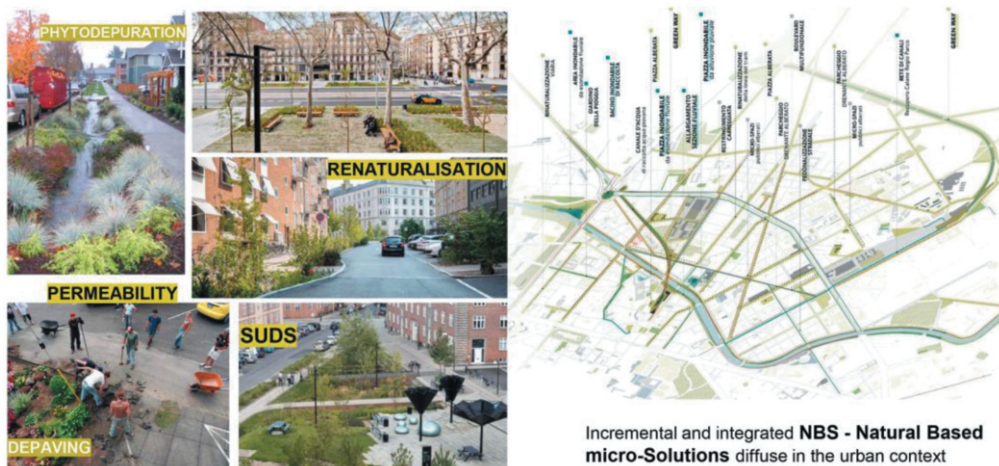


Figure 4. New Ecological Network for an adaptive urban landscapes, synoptic frame. Work of the group “#ResilienCity” about “Diffuse adaptive strategies for a resilient metropolitan City. The case study of Turin”, final presentation of the second edition of the Summer School “After the Damages”. Working group: Davide Aschieri, Chiara Donà, Stefania Farina, Ilaria Tonti, Cristhian Lao Vorobieff. Tutor: Marco Zuppiroli.

3 HERITAGE AT RISK AND DIGITAL INNOVATION

Among the topics covered by the “After the Damages” advanced training project, the application of digital technologies for risk monitoring and reduction is definitely among those most under rapid evolution and development. Several recent actions and funded projects demonstrate how digital applications can be used in an increasingly targeted way to safeguard heritage in risky conditions (Yuan et al., 2023).

The project “ResCult - Increasing Resilience of Cultural heritage: a supporting decision tool for the safeguarding of cultural assets” (Web-3), concluded in 2018, was aimed to enhance the capability of Civil Protection to prevent and mitigate impacts of disasters on Heritage sites, through the implementation of an integrated European Interoperable Database for Cultural Heritage, as a unique framework for public bodies and local authorities. The main goal was to provide a disaster risk reduction strategy identifying tailored actions and investments to improve both prevention and resilience capacities, according to the principles of Sendai Framework. The project combines the need to increase cooperation with the use of digital technologies for Heritage protection (data sharing and interoperability, protocols, best practices, alignment with EU policies/standards). ResCult also developed three case studies focusing on different types of heritage under different hazards such as flood, fire, and earthquakes, collecting data to develop an integrated European Interoperable Database for cultural heritage (Datola et al., 2024). A unique standardised-3D geographical information system (GIS), including both heritage and risk and hazard information, has been developed within the project, and validated and tested on the case studies (Colucci et al., 2024).



Figure 5. Digital knowledge and synoptic frame developed by the group “RE[CONSTRUCTING] HERITAGE” about “Crowdsourcing and digital technology for virtual and physical re-creation”, final presentation of the second edition of the Summer School “After the Damages”. Working group: Rashmi Gajare, Gustavo Mastrobuoni, Sergio Ortín Molina, Samanta Tumbarello, Mara Vertunni. Tutors: Mario Figueroa and Victoria Garcia Munhoz.

The urgency of addressing the issue of the resilience of cultural heritage to climate change and extreme events is demonstrated by the topics proposed in the Horizon 2020 Work Programme “Societal Challenges - Climate action, Environment, Resource Efficiency and Raw Materials”, including in particular the area of Cultural Heritage (H2020-EU.3.5.6. - Cultural heritage). The aim was to research into the strategies, methodologies and tools needed to enable a dynamic and sustainable cultural heritage in Europe in response to climate change, identifying resilience levels through observations, monitoring and modelling as well as provide for a better understanding on how communities perceive and respond to climate change and hazards.

Projects funded under the Horizon 2020 Framework Programme, and now concluded, such as “SHELTER - Sustainable Historic Environments holistic reconstruction through Technological Enhancement and community based Resilience” (Web-4), or “HERACLES - HERitage Resilience Against CLimate Events on Site” (Web-5) are based on data-driven knowledge, and the development of ICT platforms to collect and integrate multisource information to provide complete and updated situational awareness and support decision for innovative measurements improving Cultural Heritage resilience. The project “ARCH - Advancing Resilience of Historic Areas against Climate-related and other Hazards” (Web-6) focused on a disaster risk management framework for assessing and improving the resilience of historic areas to climate change and natural hazards through the development of tools and methodologies designed for local authorities and practitioners, the urban population, and national and international expert communities. The project “HYPERION - Development of a Decision Support System for Improved Resilience & Sustainable Reconstruction of historic areas to cope with Climate Change & Extreme Events based on Novel Sensors and Modelling Tools” (Web-7), leveraged

existing tools and services, and novel technologies to deliver an integrated resilience assessment platform, addressing multi-hazard risk understanding, better preparedness, faster, adapted and efficient response, and sustainable reconstruction of historic areas.

Among the ongoing Horizon Europe projects, “TRIQUETRA - Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage” (Web-8) aims at creating an evidence-based assessment platform allowing precise risk stratification, and creates a database of available mitigation measures and strategies, acting as a Decision Support Tool towards efficient risk mitigation and site remediation. Within the project, innovative surveying techniques are utilized, such as hydrographic surveys, multi-beam sonars, UAVs with optical, multispectral and LiDAR sensors, underwater photogrammetry, laser spectroscopy, novel simulation models and more (Ioannidis et al., 2024).

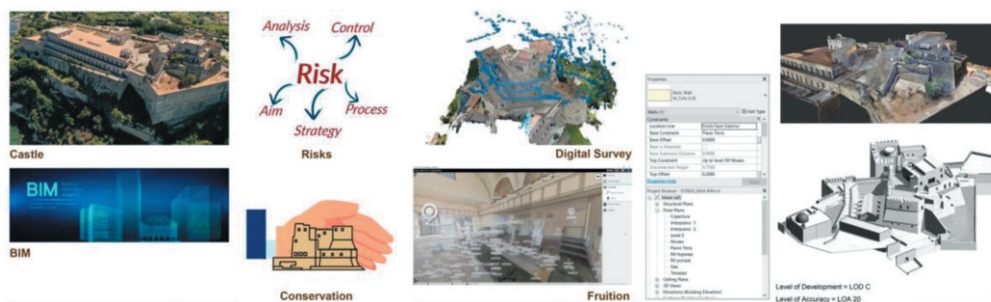


Figure 6. Synoptic frame, methodology and tools developed by the group “PC4ACH” about “Digital technologies for preventive conservation and accessibility of Cultural Heritage in post-pandemic period. The case of the Castello Aragonese of Baia”, final presentation of the second edition of the Summer School “After the Damages”. Working group: Davide Carleo, Victoria Cotella, Martina Gargiulo, Sandra Mikolajewska, Alessia Vaccariello. Tutor: Prof. Paola Puma.

The relevance of developing initiatives on the climate impact on cultural heritage also through educational actions is demonstrated by “e-CREHA - Education for Climate Resilient European Architectural Heritage”, an Erasmus+ project developed between 2020-2023 (Web-9). The initiative is aimed at providing an innovative e-learning course and methodology based upon blending learning focusing on climate-resilience for built heritage across Europe. Among the most significant points of the project, the concept of vulnerability of built heritage to climate change, and the often overlooked - in architectural education - contribution of heritage to the development of climate-adaptive strategies for a resilient society. Since Heritage contributes to social cohesion, sustainable development and psychological well-being, protecting heritage means promoting resilience.

In this general context, it is interesting to note how more and more these advanced tools and innovative digital technologies are being applied not only to individual buildings, but to aggregated historical contexts; even more relevant is the focus on small historical centres and villages (Piccinini et al., 2022). These studies highlight the need for improving cultural heritage survey and documentation practices to collect and organize data inventories relevant for risk reduction, increasing the ability to model the behaviour of cultural heritage under several actions (Romao and Bertolin, 2022).

The issue of historic centres, particularly “minor” ones, opens up consideration not only to the need to manage integrated knowledge tools for safeguarding in the case of disasters, but also to a further form of risk, that of depopulation and oblivion, if not abandonment (Maietti, 2022).

In addition to the research projects focusing on risk management for cultural heritage, of which only a few among many have been mentioned above, the scientific literature currently offers a very articulated panorama of in-depth studies on the topic, ranging from state-of-the-art analyses to the application of advanced digital tools.

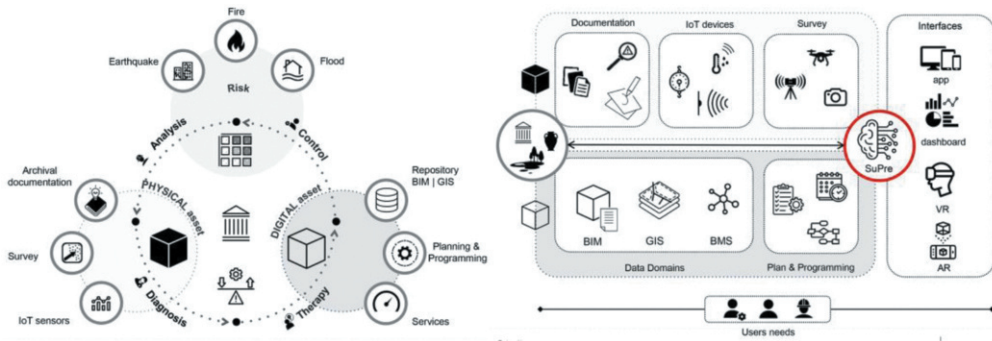


Figure 7. Methodology and tools: Digital Twin oriented to risk management and project framework developed by the group “SuPre” about “Knowledge management and damage prevention of built environment”, final presentation of the second edition of the Summer School “After the Damages”. Working group: Fabiana Guerriero, Caterina Gabriella Guida, Margherita Cicala, Matteo Del Giudice, Andrea Momolo. Tutor: Prof. Chiara Vernizzi.

One example, in this direction, is the publication, by Historic England, of annual Heritage at Risk Register (Web-10). The Register is defined as the yearly health-check of England’s most valued historic places and those most at risk of being lost forever as a result of neglect, decay or inappropriate development.

Another example is the project “Sirius” (Web-11), developed by the University of Bologna and including a “Risk Atlas”, a tool designed to monitoring Cultural Heritage as sensitive element of the urban landscape, supporting local bodies and institutions to improve evaluation of the risk factors and their mitigation before emergency occurs.

4 CONCLUSIONS

Among Heritage vulnerability to climate-related disasters is the focus of several studies and actions. It is interesting to highlight also what actual impact these research strategies have on heritage site managers and policy-making bodies (Durrant et al., 2023). Another crucial point is the need for a conscious and critical use of the technologies available today, avoiding to focus more on the instruments or tools, and less on the object to be preserved. “Nevertheless, in face of such a complex framework of know-how, increasingly advanced technologies, dedicated programs and funding, meetings and debates, the establishment of specific Institutional Bodies to manage decision-making plans and their implementation, we continue to witness the frantic chasing of emergencies after the occurrence of catastrophic events. The spectrum of risks is more and more manifesting itself in its breadth: to the evidence of the effects due to Climate Change, those deriving from hydrogeological instability, from the lack of care of the territory and coasts, the devastation of an anthropic nature due to the senseless consumption of soil, and the unsustainable pressure of an uncultured, omnivorous tourism, are added with increasing frequency” (Salonia, 2023).

As a matter of fact, there seems to be a discrepancy between studies on risks and damages, and the transfer to practical applications, concrete solutions, and decision making. The vision is toward a holistic and multidisciplinary approach, providing guidelines to a broader panel of stakeholders, including technical figures but also urban planners, conservation practitioners, cultural heritage owners and managers (Bonazza and Sardella, 2023).

This is exactly the direction of the “After the Damages Academy”, open to maximum participation from different disciplines and research areas, as well as maximum dissemination in different geographical contexts.

The Academy, set up as a permanent organization at the end of the three-year higher education project, demonstrates how the interdisciplinary aggregation of experts and institutions is

a need in order to be able to address, on an ongoing basis, the issue of safeguarding heritage from the ever-increasing risks due to climate change and extreme events.

Among the most significant outcomes of the advanced training project and the three Summer Schools that were developed, the participants' increased awareness not only of the risk factors but also of the various tools and policies realized as best practices. A wealth of awareness and increased knowledge on the conservation of the most fragile places, to be transmitted to future generations.

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