

International Workshop on Cultural Heritage Facing Climate Change: Experiences and Ideas for Resilience and Adaptation

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Compilation of abstracts

BIANCONI Patrizia, Rome. *JPI on Cultural Heritage (JPIH), Italy*

The joint programming initiative on cultural heritage and global change

(JPI CH) is one of the 10 initiatives launched in 2009 by the Council of the European Union with the scope of promoting all actions that can foster research and research planning both in academics and business domains. The aim is to face global challenges by defining a European common research area where R&D activities are channelled through innovation knowledge transfer.

In particular, JPI CH is been working on developing this common area of research on Cultural Heritage that is to be intended as comprehensive field including three main dimensions: tangible, intangible and digital. The main objective of JPI CH is to promote the safeguarding of Cultural Heritage in its broader meaning: climate change, protection and security, uses of cultural heritage by society. The strong relationship between Cultural Heritage, technological innovation and economic development allows for further considerations within the European framework of challenges and competitiveness.

BRATASZ Lucas, New York. *Institute for the Preservation of Cultural Heritage, Yale University, USA.*

Impact of climate change on clay and organic materials

Global climate change impact on cultural heritage objects has been much researched in recent years. Several risks leading to the degradation of objects in outdoor and indoor exposure have been considered encompassing chemical, biological, physical, structural and mechanical processes. However, there is no consensus between professionals how to assess risk of mechanical damage to heritage objects caused by the environmental fluctuation.

This presentation aims at analysis of the potential impact of climate change on the mechanical damage in two cases: clay containing sandstone (CCS) and wooden objects, especially panel paintings. CCS deteriorated due stresses generated by swelling and shrinkage of the clay in response to changes in the material moisture content. Measurement of acoustic emission shows that process of deterioration is related to accumulation of large number of independent micro-damages. Therefore, actual risk induced by climate change can be relatively easily estimated by summing up impact of individual events. Similarly to CCS, painted wood is composed of materials which swell or shrink differently in response to the sorption and desorption of moisture caused by relative humidity variation. When the moisture-related stress goes beyond a critical level, the paint layer can crack or delaminate. Process of paint fracture stabilizes due to effective stress reduction by opening joints. Therefore, process of cracking and delamination is threshold based not cumulative one. In such case, prediction of risk is particularly difficult to assess as it critically depends on environmental history of the object.

BONAZZA Alessandra, Bologna. *Institute of Atmospheric Sciences and Climate, National Research Council (ISAC-CNR), Italy*

Cultural Heritage in the Italian National Strategy for Adaptation to Climate Change

Cultural heritage does not still occupy a central position in current national and international policy documents on climate change. At national level, sporadic recent attempts to integrate cultural heritage into the wider national and international policies have been made. The presentation will illustrate the “Italian National Strategy for Adaptation to Climate Change” focusing on the outcomes related to the cultural heritage sector. Particularly the results included within the three technical-scientific documents produced in 2014 and connected with cultural heritage protection will be discussed.

BRIMBLECOMBE Peter, Hong Kong. *School of Energy and Environment, City University of Hong Kong*

Small changes in climate - large impacts on heritage

In the last 10 years our understanding of climate change has improved through the availability of higher resolution climate models, both in the temporal and spatial domain. Temperature is generally well predicted as is absolute humidity, but there are greater difficulties with rainfall which may be strongly influenced by storm tracks and related synoptic issues. Nevertheless there is now a better understanding of the way in which small changes in climate may cause large changes in the rate of damage to heritage materials and wider effects of the appreciation of cultural sites. Amplification can occur through changes in phase or the mediation of biological processes. In this presentation output from climate models and recent meteorological observations will be compared with evidence of broader environmental change, rates of damage and shifts in seasonality. These provide hints that some changes in the impact of shifts in climate on heritage can already be observed.

CAMUFFO Dario, Padua. *National Research Council, Institute of Atmospheric Sciences and Climate, Padua, Italy*

Climate-related challenges for Venice: lessons from the past, solutions for the future?

Venice is a unique coastal city of the UNESCO' world list of cultural heritage. In its long and well documented story, it had, and continues to have, a number of climate related challenges, e.g.: sea-level rise and building submersion, increase of flooding storm surges, cold spells and frozen lagoon water, lightning and fires. So far, the research has been able to reconstruct the above challenges for over one millennium and even more. The sea level has been reconstructed from tide gauge record (available since 1871), visual arts (i.e. Canaletto, Bellotto: XVII century, and Veronese: 1571), sea-stair proxy (available since 1350) and geo-archeological observations (available since 200 AD). Flooding storm surges have been reconstructed from archive documents and tide gauge record. Cold spells and frozen lagoon water have been reconstructed from weather logs (available since 1716), visual arts and archive documents. Also lightning and fires are equally well documented.

- How long MOSE will prevent from floods, considering the land subsidence and the sea level rise accelerated in times of global warming?
- The ice slab floating on the lagoon may be reduced by increasing the inflow of tidal mild waters? Is this an effective protection for wild animals living in the lagoon marshes?
- The particular structure of the city, with narrow canals and streets makes difficult firemen interventions. Why not to apply a network of fire hydrants?

CASCINI Leonardo, Salerno. *University of Salerno. ICOMOS, Italy*
Protecting the Cultural Heritage from water-soil interaction related threats

This presentation introduces the ongoing research activities carried out within the framework of the project “Protecting the Cultural Heritage from water-soil interaction related threats” funded by the Italian Ministry of Education, Universities and Research within the 2015 call for the Research Projects of National Interest (PRIN). Following an introduction on the natural and human induced hazards that affect the Italian territory, a specific focus is devoted to introduce the problem of the interaction between the hazards and the cultural heritage. Then, the PRIN project is introduced, briefly presenting goals and scope of the project, its main tasks and the overall adopted methodology, that is essentially based on a multi-disciplinary, multi-risk and multi-scale approach. A set of collaborative case studies is presented and two examples are provided as demonstrator of the proposed research approach to practical engineering problems.

COLLARO Carolina, Naples. *University of Beyreuth, Italy*
Maya’s heritage conservation avoiding « collapses»

The scientific literature has long been interested in hypothetical and fascinating theories of the "collapse" of Mayan civilization. As it is known, many cities were abandoned, even suddenly, leaving even ceramic furnishings in place. So more than a collapse, we can talk about a series of cyclical collapses, which induced the Mayans to abandon, and then return, to the sites built. Some authors sustain that sudden drought provoked sites’ abandonment, other theories argue that climate change even was a major external cause. Anyway these theories cannot explain the motives of these repeated abandonments alone. Beyond the importance of continuing to study the reasons for these abandonments, even with a greater impetus for Paleoclimate research, we are rightly asked how to avoid further collapses in the future. What we are concerned about is the abandonment of the places that are still digging and of the many others that still have to come to light. Our study focuses on the Mirador area in the Peten region, bordering on Mexico and not far from Belize. The Mirador is a kaleidoscope of sites linked together by "causeways" or large arteries that reach 800 mt in length and 40 in width, now completely legible despite the forest, thanks to the wise use of LIDAR. The site is immersed in the tropical forest, one of the few tropical forests left untouched in the world. This is an opportunity to preserve both an archaeological heritage and a natural heritage together. However, the remarkable biodiversity patrimony is constantly being endangered today by several factors: illegal logging, narcotics, extending agriculture, fires, and deforestation. The goal is to find a way out to the many fires, to protect biodiversity by addressing non-conflict tourism flows, and to make proposals that take into account the challenging local context: an expanding agriculture, drug smugglers that discourage access routes planning, Illegal logging, deforestation. One priority is the need for up-to-date climatic data to adequately protect these important findings and to prevent further degradation. The paper will argue the reasons to deepening into climate change research, hereto considered as a driver of environmental and cultural change which could compromise the sustainable development.

DALY Cathy, Lincoln. *School of History and Heritage, University of Lincoln, United Kingdom*
Informing Heritage Policy in an Uncertain Climate; Reflections from Ireland

Cultural heritage policy is likely to be most effective when it is well informed. When creating strategies for climate change adaptation therefore, the degree of uncertainty in future modelling poses a substantial challenge. This paper offers a brief exploration of this and other barriers to policy development as raised by professional respondents from fifteen different countries. Efforts to

tackle the issue within the Republic of Ireland are explored as a case study. Research and policy developments over the last decade in Ireland are chronicled including the implications of the recently adopted Climate Change Bill. The Irish example demonstrates how uncertainty, future discounting, politics and financial instability impact on the translation of research into policy.

DE MENNA Emanuela, Brussels. *DG Research & Innovation, European Commission, Belgium*
EU R&I and adaptation policies for cultural heritage. What results and what perspectives for the future?

The presentation will focus on the contribution of EU R&I to adaptation policies for cultural heritage and in particular on research results and impacts on policies and societal needs. It will include past and ongoing EU research projects, R&I strategic programming and policy initiatives and actions. The objective is to foster the discussion on knowledge and tools needed but also on strategies, barriers and bottleneck for the implementation and uptake of research results and for broadening stakeholder and users' engagement. The presentation will firstly make a reference to ongoing EU R&I projects on adaptation/prevention, preparedness and response to climate related events. Secondly it will introduce EU projects on adaptation targeting specifically cultural heritage, considering also the legacy coming from more than 20 years of research in the field. Thirdly it will briefly explain ongoing EU R&I policy initiatives and actions in the field (workshops, exhibitions, 'Fairs' etc.) including the upcoming creation of a Community of EU innovators on cultural heritage to be launched during the European Year of Cultural Heritage 2018. All initiatives will presented in the frame of a renewed and forward looking EU R&I policy agenda, named 'Heritage Alive', aimed at valorising cultural heritage as a living strategic resource for people and societies, in line with the EU and international policy context.

DI STEFANO Maurizio, Naples. *International Council on Monuments and Sites, Italy*
Cultural heritage in the context of a changing climate

The alarming perspective of severe climate changes, causing increasingly frequent catastrophic events - such as floods, hurricanes, avalanches - requires a reflection about the consequences for cultural heritage. In fact, the destructive power of these natural disasters often seems to be human-induced destruction driven, due to myopic patterns of settlement, urbanization and land use. As a consequence, climate changes are in the list of the 17 Sustainable Development Goals of 2030 Agenda - the transformative plan signed in 2016 to address urgent global challenges over the next 15 years - requiring urgent action needed not only to combat climate change and its impacts, but also to build resilience in responding to climate-related hazards and natural disasters. According to its mission to promote the conservation, protection, use and enhancement of monuments, building complexes and sites, ICOMOS International Council on Monuments and Sites appointed a Scientific Committee on Risk Preparedness (ICORP) to develop basic and applied research activities about the impact of catastrophic events on cultural heritage.

Focusing on prevention and management of the risk since Aquila earthquake, ICOMOS works side by side with the Blue Shields, supporting UNITE4HERITAGE campaign and creating important opportunities for confrontation, development and deepening of research topics of particular importance for the analysis of major, natural and anthropic risks, in particular in the field of conservation and restoration of cultural and landscaping heritage, with the development of guidelines for the safeguarding of cultural heritage damaged by natural and man-made phenomena consistent with the objectives of prevention and risk preparation.

FORNARO Gianfranco, Napoli, IREA - CNR

Integrated monitoring from wide-area surveillance to in-situ sensing and characterization for increasing CH resilience to CC and supporting decisions: the HERACLES approach

HERACLES (HERitage Resilience Against CLimate on Site) main objective is to design, validate and promote responsive systems/solutions for an effective resilience of CH against climate change effects, considering as a mandatory premise a holistic, multidisciplinary approach through the involvement of different expertise (end-users, industry/SMEs, scientists, conservators/restorers and social experts, decision, and policy makers). This will be operationally pursued with the development of an ICT platform able to collect and integrate multisource information in order to effectively provide complete and updated situational awareness and support decision, including new solutions for maintenance and conservation. It will be validated in two challenging test beds, key study cases for the climate change impact on European CH assets (Italy- historical town of Gubbio and Greece-Heraklion and Knossos). The strength of HERACLES solutions is their flexibility in evaluating a big quantity of different information that can be changed and tailored to the specific CH assets needs, guaranteeing in that way a general applicability. (Grant Agreement number: 700395)

GOMEZ-BOLEA Antonio, Barcelona. *University of Barcelona, Spain*

Biodeterioration vs bioprotection of stone monuments under warmer atmosphere

More or less evident, biofilms are present in all stone surfaces exposed to the environment. Biofilms are complex communities of microorganisms that grow, in balance with external conditions, and present a dynamic of succession between the different organisms that compose them. We can identify organisms, which are permanently part of the community, belonging to archaea, bacteria, cyanobacteria, algae, black yeast, filamentous fungi and lichens. We must understand the bio-protection as the result of a positive balance between bio-deterioration and erosion. In lichens, when they are alive, it has been found that can act protectively by absorbing moisture into its thallus and buffering the surface from thermal stress causing temperature fluctuations. Even after death, the patina they left, continues to protect the surface of the rock from erosion by the chemical-mineral transformation process. In carbonate rocks, which are easier to dissolve than acid rocks, is where the role of bio-protection by crustose lichens may be more important, both epi- and endolithic. Lichens can be described as a microecosystem in which bacteria, cyanobacteria, algae and fungi coexist. Biofilms and lichens live in balance with the environment, and we can consider them as the result of the equilibrium of multiple interfaces formed by factors derived from lithosphere, atmosphere, hydrosphere and the anthroposphere. Whenever one of these factors changes, by instance, the temperature as a consequence of global warming, there are changes as well in biofilms or lichens. Each specie composing the biofilm (or lichen) has different ecological amplitude, particularly the maximum temperature that it can resist is different. Furthermore, there is a limit in which one specie (or organism) will be replaced by another one. For example in arid regions, the extreme temperature act as a limiting factor for the life of lichens, even endolithic ones. In these regions of southern Europe is where the protective cover of lichens possibly disappears. Consequently, it is urgent to select emblematic monuments from this region for biomonitoring their stones surfaces.

IWASZKIEWICZ Casimir, London. *Consultancy Solutions Within Reach Ltd, United Kingdom*

Climate change adaptation in the cultural heritage sector: strategies for decarbonisation and renewable energy

The presentation, Climate change adaptation in the cultural heritage sector - Strategies for Decarbonisation & Renewable Energy, outlines the drivers for change and potential solutions. It will illustrate this with reference to policies, examples of early stage progress in the cultural heritage sector, other sectors and developments in management, technologies and decision making factors that encourage long term success.

KORKA Elena, Athens. *Antiquities and Cultural Heritage of the Hellenic Ministry of Culture and Sports, Greece*

Natural disasters and risks in World Heritage monuments of Greece

Risks from natural disasters always have been a major concern because they can cause extensive damage to World Natural and Cultural Heritage. This is particularly so today because many natural disasters are brought about, or increased, by climate change throughout the world. Reducing and managing the risk of man-made and natural disasters are major challenges before the world community. Disasters are the consequences of uncontrolled human activity and poor environmental management, bringing damage to World Heritage monuments inevitably exposed to these dangers. The international organizations such as UNESCO, ICOMOS, IUCN, ICOM and others, have adopted principles and strategies for the management of risk reduction which should be applied to every site or monument and training should be provided for the personnel in charge.

LEFÈVRE Roger, Paris. *Professor emeritus, Paris-Est Créteil University, France*

Cultural Heritage in the French National Adaptation Plan to Climate Change

Only Italy and France include Cultural Heritage in their respective National Adaptation Plans to Climate Change. In France there are 44 000 historical monuments and gardens, archaeological sites, museums and collections. Among them 42 monuments, sites and cultural landscapes are inscribed on the UNESCO World Heritage List, 5 being threatened by sea level rise. The 2nd French National Adaptation Plan to Climate Change (2017-2020) is in progress and has at the time six chapters: 1- Governance and Steering; 2-Knowledge and Information; **3-Prevention and Resilience**; 4- Environment; 5- Economy; 6-International Action. **Prevention and resilience** comprises: 3a - Tools of Prevention and 3b - Transformation of Territories in which Cultural Heritage is included. The **general strategies** for adaptation of Cultural Heritage to Climate Change consist in: 1- Research policy; 2-Fundamental and applied research; 3-Education and training; 4-Public policy and economy. The **specific strategies** of adaptation of Cultural Heritage to Climate Change respond to temperature increase, sea level rise, climate and pollution outdoors and indoors, continental water.

LEISSNER Johanna, Brussels. *Fraunhofer Sustainability Network, Belgium*

EU project Climate for Culture (2009-2014) on the impact of Climate Change on cultural heritage buildings

Climate change is one of the most critical global challenges of our time. For many decades a huge number of scientists from all over the world have been researching this topic and developing complex climate models which are suitable for making future climate projections. Within the integrated European-funded project Climate for Culture (2009-2014) a multidisciplinary research team consisting of 27 partners from the EU and Egypt has performed research to estimate the

impact of climate change on the indoor environments in historic buildings and their vast collections as well as on the future energy demand in Europe and the Mediterranean. It identified the damage potential of changing climate for the cultural heritage most at risk and developed mitigation strategies. The main innovation was to use a combination of simulation and modelling tools to predict more accurately the influence of changing outdoor climate on the indoor and microclimate in historic buildings until 2100. Further, future energy demand for climatisation of historic buildings was calculated. By using an automated procedure an assessment of the damage potential in various climate zones was performed. For this purpose, the regional climate model REMO with a high resolution of 10x10 km was developed for the entire the European and Mediterranean area and coupled with newly developed whole building simulation tools. For the climate modelling two moderate emission scenarios were chosen: A1B and RCP4.5 which assume that CO2 emissions will be mitigated by introducing new energy technologies by the end of the century.

MIKKONEN Tuija, Helsinki. *Ministry of the Environment, Finland*

Some Nordic Aspects concerning Cultural Environment as a Resource in Climate Change Mitigation and Adaption

One of the main goals of the Finnish Cultural Environment Strategy (2014-2020) is how to recognize the ways the cultural environment helps in mitigating climate change and in adaptation to it. The Strategy underlines the importance of good management of the cultural environment in mitigation. If we take systematically care of our built heritage and landscape according to the principles of sustainable development it can help us in mitigation of climate change.

In 2013-2014, a Nordic research group carried out an interesting project about the interaction of climate change and cultural environment. The participants of the project came from Finland, Sweden, Norway, Iceland and Denmark. The project was called Cultural Environment as Resource in Climate Change Mitigation and Adaption (CERCMA), and it focused on the positive influence of cultural environment protection for climate change mitigation and adaptation. The project dealt with building conservation, planning of built heritage areas and management of cultural landscape. The main questions were, how energy efficiency repairs may be best combined with the preservation of traditional skills and building materials; how traditional planning density and scale as well as the preserving of historic green areas may contribute to sustainable community planning; and how cultural landscape may support alternative modes of energy production.

NETO Filipa, Lisbon. *Directorate General for Cultural Heritage, Portugal*

Listening to the STORM – a preliminary survey to identify needs in risk management policies for cultural heritage endangered by natural hazards

STORM Project has the aim to develop an integrated approach for a better management of the risks that endanger cultural heritage, through the creation of tools and instruments designed to assist in decision making during crisis or natural catastrophes, most of them caused by climate changes, along the distinct phases of prevention/mitigation, preparedness, response and recovery. STORM integrates 20 partners from seven different countries (Germany, Austria, Italy, Greece, Portugal, United Kingdom and Turkey) and an international organization (ICCROM), encompassing a multidisciplinary team. In order to achieve the proposed goals, five sites covering a varied range of building materials, chronologies, artefacts and risk scenarios have been selected for pilot testing, Tróia (PT); Manchester (UK); Center of Rethymno (GR); Ephesus Theater (TR); Diocleciano bath's (IT). In the first 6 months of the project, a preliminary survey has been made to gather information regarding the legal frameworks for cultural heritage risk management and civil protection, as well as procedures in place adopted mainly in the sites. With this information it was possible to identify the

most significant gaps and needs, at a national and European level. Some countries have recognized the necessity for a greater awareness of governments and communities towards this cause, as well as for the development of scientific research and technological tools contributing to a better knowledge of cultural heritage associated risks and vulnerabilities. One of the final goals of STORM will be to develop recommendations to enhance existing policies, cooperation schemes, and integrated mechanisms of prevention, preparedness, response and recovery of the cultural heritage endangered by natural hazards and climate change.

ROSSONI-NOTTER, Elena et al¹, Monaco. *Musée d'Anthropologie préhistorique de Monaco*
Cultural Heritage and Climate Change through Paleolithic researches: an example from the Liguro-provençal area.

Cette présentation intéresse plus particulièrement les sites paléolithiques et coupes-témoins quaternaires du littoral liguro-provençal. Les données interdisciplinaires, préhistoriques et géologiques, recueillies permettent de dater et éclairer les processus paléoclimatiques et paléoenvironnementaux locaux depuis 1 million d'années. Elles s'intègrent dans un projet d'analyses plus large « Karstodyssée », porté par E. Gilli de l'Université de Paris 8 (France), et relatif à l'étude des marqueurs eustatiques, tectoniques et tsunamiques dans les karsts littoraux méditerranéens français de l'Eémien à l'Actuel. L'objectif principal de cette collaboration est d'inventorier, identifier, dater et géoréférencer les différents témoins géomorphologiques et biologiques des sites littoraux régionaux, notamment ceux des niveaux marins assignables à l'Eémien afin de mieux appréhender et caractériser l'amplitude maximale de ce dernier interglaciaire (125 000 ans). Les résultats obtenus, basés sur des données archéologiques, naturalistes et biochimiques, pourront par leurs précisions et spécificités servir de base à une réflexion plus ample sur les niveaux marins liés aux cycles de réchauffement, et de points-repères pour des fourchettes de hausse et de variations prévisibles, contribuant ainsi aux recherches dédiées aux enjeux climatiques d'aujourd'hui et de demain.

SABBIONI Cristina, Bologna. *Institute of Atmospheric Sciences and Climate–CNR ISAC, Italy*
Cultural heritage in a context of a changing climate: aims of the workshop

The presentation aims at introducing the Workshop on “Cultural Heritage facing climate change: experiences and ideas for resilience and adaptation” summarising the big questions on which it is based and structured. The Workshop intends to set the point for launching a common message for the future.

SAINSARD Jean-Michel, Paris. *Ministère de la Culture et de la Communication, France*
Le jardinier et le projet, pour une adaptation aux changements climatiques

Percevoir le changement climatique comme un couperet est une vision réductrice du jardin en tant qu'oeuvre. Même si elle est en soi inquiétante, la disparition de certains végétaux ne peut être considérée comme insurmontable à la survie des jardins. A la différence de l'espace forestier, il faut se souvenir que, dans un jardin, les enjeux sont avant tout paysagers. Certes, une replantation a un coût important, mais il ne faut pas méconnaître la dimension expérimentale du jardin, et les essais à multiplier. Les paysagistes sont ainsi amenés à repenser les jardins, à créer d'autres formes qui enrichissent le jardin d'autres significations. L'histoire des jardins, les structures encore en place confirment que la recherche n'est pas nouvelle. L'expérience de végétaux devenant inadaptés,

¹ Co-authors: O. NOTTER, E. GILLI, P. SIMON, S. SIMONE

obligeant à reprendre des structures entières, nous rappelle que la réponse est toujours dans le projet, que le jardin historique se compose aussi du paysage alentour, d'axes, de pleins et de vides, du bâti, des usages et pratiques, de l'économie. Cela nécessite de grandes capacités d'ouverture intellectuelle et de pédagogie pour remettre en question certaines formes et compositions historiques. Nous choisissons donc d'être optimistes, de nous penser à l'aube d'une nouvelle pensée du jardin historique, qui fait confiance à la capacité du vivant à s'adapter, au projet et à la gestion jardinière.

SCIACCHITANO Erminia, Brussels. *Directorate-General for Education, Youth, Sport and Culture, European Commission, Brussels*

Progress towards evidence-based policy making. There is need to better exploit the information / knowledge provided by European research and translate it into concrete action.

Need promote research capable to support systemic action, in order to support the improvement of European cooperation on risk analysis, assessment and management.

Facilitate synergies among competence centres in Europe and existing tools (risk maps, informative systems), and legislative framework.