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SCIENZE E MATERIALI DEL PATRIMONIO CULTURALE

**CULTURAL HERITAGE  
FACING CLIMATE CHANGE:  
EXPERIENCES AND IDEAS  
FOR RESILIENCE AND ADAPTATION**

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

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## Abstract

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. This contribution 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.

## Résumé

Le patrimoine culturel n’occupe pas encore une position centrale dans les documents politiques nationaux et internationaux actuels sur le changement climatique. Au niveau national, des essais sporadiques récents pour intégrer le patrimoine culturel dans des politiques nationales et internationales plus larges ont été faits. Cette contribution illustre la «Stratégie Nationale Italienne d’Adaptation au Changement Climatique» en se focalisant sur les conséquences concernant le secteur du patrimoine culturel. En particulier, les résultats inclus dans les documents technico-scientifiques produits en 2014 et en relation avec la protection du patrimoine culturel sont discutés.

**Key-words:** extreme events, climate parameters, priority, monitoring, safeguarding, measures, plan.

**Mots-clés:** événements extrêmes, paramètres climatiques, priorité, surveillance, sauvegarde, mesures, planification.

## 1. Introduction

In spite of the resources committed up to now in Europe, both at research and policy level, to strengthen Cultural Heritage protection towards environmental impact, the recently published document “Getting cultural heritage to work for Europe” by the EU clearly states that further steps are needed in order to ensure the sustainable management and conservation of Cultural Heritage sites, structures and artefacts in facing climate change, particularly extreme events. Disasters and catastrophes pose risks not only to the conservation of the Cultural Heritage assets with its cultural, historic and artistic values, but also to the safety of visitors, staff and local communities living on the site or in neighbouring areas. Additionally, they cause undoubtedly negative consequences for the local economies due to the loss of tourism revenues, and for the

livelihoods of local people who are dependent on it. The risk is amplified in hazard prone areas with Cultural Heritage properties, where population growth is generally higher than the average. On its turn, expansion of cities in coastal areas and/or in flood plains, coupled with inappropriate building practices and an overburdened infrastructure contribute to a further increase of the risk putting tremendous pressure on heritage sites, especially on those located in urban vulnerable areas. Moreover, climate change is contributing towards increased intensity and frequency of hydro-meteorological events, such as heavy rainfall, wind-storm, heat waves and droughts. Cultural Heritage is put at risk not only by impending disasters, but very often also by emergency and post disaster recovery actions. Severe damage is often inflicted to the cultural property during disaster response and also during the restoration and remedy phases, due to lack of preparedness

TEMPERATURE	WATER	WIND	POLLUTION
<ul style="list-style-type: none"> <li>• Temperature range</li> <li>• Freeze-thaw cycles</li> <li>• Thermal shock</li> </ul>	<ul style="list-style-type: none"> <li>• Precipitation Amount</li> <li>• Total number of rainy days</li> <li>• Extreme rain</li> <li>• Consecutive number of rainy days</li> <li>• Mean RH</li> <li>• RH range</li> <li>• RH shocks</li> </ul>	<ul style="list-style-type: none"> <li>• Wind speed</li> <li>• Wind driven rain</li> <li>• Wind speed counts</li> <li>• Wind driven sand</li> </ul>	<ul style="list-style-type: none"> <li>• SO<sub>2</sub></li> <li>• HNO<sub>3</sub></li> <li>• O<sub>3</sub></li> <li>• Rain pH</li> <li>• Particulate matter</li> </ul>

1. - List of main climate parameters involved in damage processes occurring on heritage materials grouped in temperature, water, wind and pollution derived parameters.

*Liste des principaux paramètres climatiques impliqués dans les processus de dommage existant sur les matériaux du patrimoine regroupés en paramètres dérivant de la température, de l'eau, du vent et de la pollution.*

in emergency situations and to misdirected actions taken during post disaster emergency and rehabilitation phases. The reasons might be among others the lack of proper attention and funds, the bureaucracy barriers and the hazardous situations, which make Cultural Heritage assets not accessible to rescue teams.

Moreover, it has to be underlined that existing measures on climate change adaptation aiming at Cultural Heritage safeguarding are still not exhaustively integrated in strategies and plans at national level. Current policy documents linking climate change and Cultural Heritage are almost exclusively drafted by heritage organisations and institutions (see, for instance, the Policy document on the impacts of climate change on world heritage properties of the UNESCO World Heritage Centre). An indicative example of the lack of integration of Cultural Heritage into wider policies on climate change is the most recent report of the Intergovernmental Panel on Climate Change on Impacts, Adaptation and Vulnerability (IPCC, 2014). Cultural Heritage is only mentioned in footnote 59, which acknowledges the need for understanding the direct and indirect economic impact of the loss of Cultural Heritage as a result of climate change. At national level, sporadic

recent attempts to integrate Cultural Heritage into the wider national and international policies have been made. The Italian National Strategy for Adaptation to Climate Change represents an encouraging example in this direction.

## 2. The Italian National Strategy for Adaptation to Climate Change

The Italian National Strategy for Adaptation to Climate Change consists of three technical-scientific documents published in 2014 that constitute an updated basis on the technical knowledge of the impact of climate change and its vulnerability and provide a strategic perspective on adaptation:

- Strategic document “Elements for a National Strategy for Adaptation to Climate Change” (Castellari *et al.*, 2014a);
- Technical-scientific Report “State of scientific knowledge on impacts, vulnerability and adaptation to climate change in Italy” (Castellari *et al.*, 2014b);
- Technical-legal Report “Analysis the EU National legislation relevant to impacts, vulnerability and adaptation to climate change” (Castellari *et al.*, 2014c).

The strategy has been developed through a highly multidisciplinary approach and a coordinated action of different actors, such as scientific national experts, operational bodies (Civil Protection, rescue services) and policy and decision makers at national, regional and local level.

The process of the strategy development, coordinated by the Italian Ministry of the Environment and Protection of Land and Sea with the technical and scientific support of the Euro-Mediterranean Centre on Climate Change (CMCC), foresaw a stakeholder involvement since the very beginning with ad hoc consultations with Ministries and Regions and an on line public consultation with citizens from 30 October 2013 to 20 January 2014. The preparation of the structure and contents of the documents started in July 2012 with the support of 232 experts.

The main general objectives of the national strategy are the following:

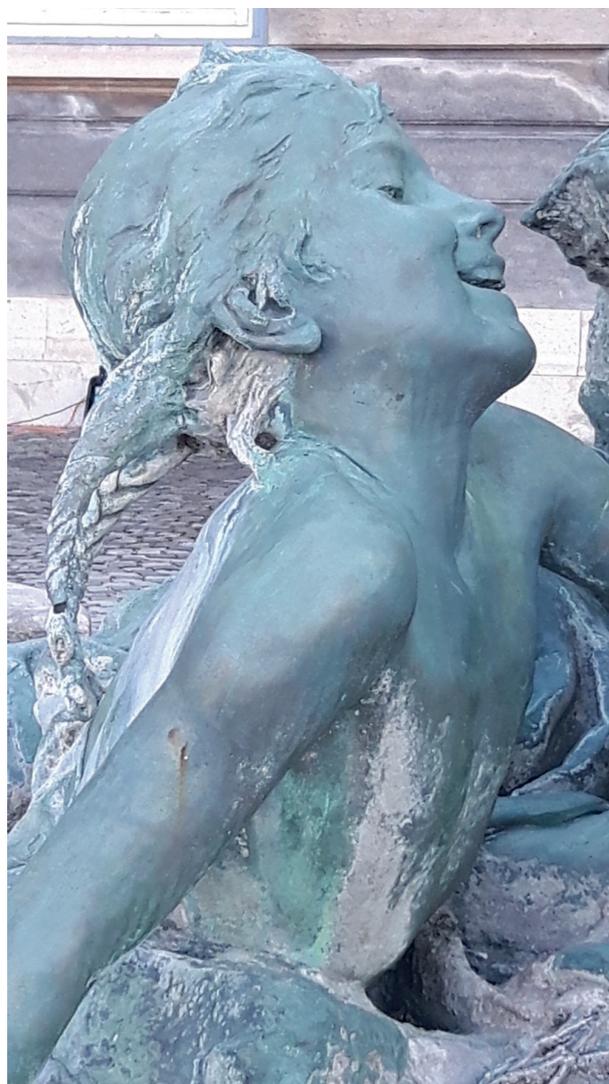
- Assessment of the impact of climate change on diverse social-economic sectors and natural systems.
- Reduction of risks induced by climate change.
- Identification of a set of actions for adapting to and facing the impacts.
- Improvement of adaptation capacities of natural, social and economic sectors.
- Take advantage of the opportunities derived by new climatic conditions.

Cultural Heritage is included among the different sectors under risk taken into consideration.

### 3. State of scientific knowledge on impacts, vulnerability and adaptation to climate change - Cultural Heritage

The Technical-scientific Report “State of scientific knowledge on impacts, vulnerability and adaptation to climate change in Italy” highlights first of all that the assessment of the impact of climate change on Cultural Heritage is based on the identification of climate parameters with priority in causing damage on Cultural Heritage located outdoors (built heritage, monumental complexes, archaeological sites, etc.) and indoors (museums, churches, hypogea, etc.) (fig.1).

This identification derives mainly from the results achieved within EU FP6 Project “Global climate change impact on built heritage and cultural landscapes - Noah’s Ark” (2004-2007) (Brimblecombe *et al.*, 2006, Sabbioni *et al.*, 2010). This project coordinated by CNR-ISAC had for the first time produced a Vulnerability Atlas and Guidelines for Cultural Heritage protection towards climate change. The Noah’s Ark coupled climatology with conservation science expertise, acquired a unique know-how in delivering future forecast of Cultural Heritage vulnerabilities induced by outdoor-indoor climate



2. - Undesired corrosion on bronze due to the synergic effect of temperature, relative humidity and deposition of SO<sub>2</sub> and particulate matter.

*Corrosion indésirable sur le bronze due aux effets synergiques de la température, de l'humidité relative et du dépôt de SO<sub>2</sub> et de particules.*



3. - Black, grey and white areas on carbonate stone due to the combined impact of precipitation, gaseous pollutants and carbonaceous particles.

*Zones noires, grises et blanches sur une pierre calcaire dues aux impacts combinés des précipitations, des polluants gazeux et des particules carbonées.*

changes, including extreme weather related events (Sabbioni *et al.*, 2010).

In addition, the report contains an identification of the main damage processes, occurring on heritage materials mainly outdoors located, that are expected to undergo modifications in the future due to climate change: i) corrosion on metals (fig. 2); ii) mechanical damage and fungal growth on wood; iii) surface recession, blackening, thermal stress, frost weathering, salt crystallization, biodegradation on stone, brick and mortars (figs. 3 and 4).

The expected changes for each deterioration process are clearly described on the basis of the available scientific literature on the topic (Bonazza *et al.*, 2007; Bonazza *et al.*, 2009a; Bonazza *et al.*, 2009b; Bonazza & Brimblecombe, 2016; Brimblecombe & Grossi, 2009; Grossi *et al.*, 2011; Gomez-Bolea *et al.*, 2012; Sabbioni *et al.*, 2010).

It should be underlined that vulnerability and risk assessment is given based on the approach adopted within the Noah's Ark project, that considered a synergic action of different climate and pollution parameters occurring over time on architectural surfaces and provided a quantitative evaluation of the effects of "slow" climate changes through the use of damage functions.

A major concern on the effects of disasters and natural hazards (such as floods, landslides and heavy rain) is evidenced for the built heritage in general and cultural landscape, while the conscious adoption of an environmental monitoring is proposed as a fundamental tool for preventive conservation of collections in museums.

Concerning the still existing gaps within the current state of knowledge in relation to the impact of climate change on Cultural Heritage, a major concern is the lack of an exhaustive set of observation data from environmental monitoring, that is necessary for a proper correlation of the damage with changes in climate. Additionally, the need of the implementation of damage modelling aiming at the production of future scenarios at local scale based on quantitative evaluation and vulnerability indicators is evidenced. Finally, the development of multi-risk scenarios for complex systems (i.e. urban historic centres, archaeological sites, cultural landscape) is recognized as a priority.

#### 4. Elements for a National Strategy for Adaptation to Climate Change - Cultural Heritage

The strategic document "Elements for a National Strategy for Adaptation to Climate Change" proposes, as main action to be undertaken for facing the impact of climate change on cultural heritage, the integration of the management plans (existing ones or under definition) with measures of preparedness, recovery and response to emergency specifically dedicated to Cultural Heritage safeguard. This can be achieved either by adding specific sections concerning adaptation to climate change or inserting appropriate measures in existing sections through a review of directives and management plans already adopted.



4. - Effect of rising damp and salt crystallization on brick masonry.  
*Effet des remontées capillaires et des cristallisations salines sur une maçonnerie en briques.*

General short (by 2020) and long (over 2020) term “soft” recommendations are also given aiming at increasing the awareness on impacts, vulnerability and adaptation measures:

- Dissemination of existing knowledge (by 2020).
- Adoption of continuous environmental monitoring (by 2020).
- Collection of data to support decision making process both at national and regional level (by 2020).
- Execution of routine maintenance in order to decrease as much as possible invasive interventions of restoration (by 2020).
- Assessment of priorities in relation to the state of conservation of artefacts and in response to climate/pollution changes (by 2020).
- Assessment of the conservation of the artefacts in relation to the detected environmental conditions (by 2020).
- Understanding the environmental, economic and social context of the heritage assets under risk (by 2020).
- Promotion of different strategies for long-term financing of maintenance actions (over 2020).

Finally, specific short and long term “grey” adaptation actions for heritage materials (stone/wood/metals), built heritage, objects in museums and landscape are proposed.

## 5. Conclusion

On the basis of the developed National Strategy of Adaptation to Climate Change, a National Plan for Adaptation is currently under implementation. The Plan foresees the determination of macro-regions with diverse degree of vulnerability and the identification of measures to be adopted for facing the risks imposed by climate change on different sectors (including Cultural Heritage). A cost/benefit assessment concerning the adoption of each proposed measure is provided, alongside a plan of monitoring and evaluation of the process by the use of performance indicators.

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## References

BONAZZA, A., BRIMBLECOMBE, P., GROSSI C.M., SABBIONI C. *Carbon in black crusts from the Tower of London.*

- Environmental Science and Technology, 41, 2007, pp. 4199-4204.
- BONAZZA, A., MESSINA, P., SABBIONI, C., GROSSI, C.M., BRIMBLECOMBE P. (2009a). *Mapping the impact of climate change on surface recession of carbonate buildings in Europe*. Science of the Total Environment, 407, 2009a, pp. 2039-2050.
- BONAZZA, A., SABBIONI, C., MESSINA, P., GUARALDI, C., DE NUNTIIS, P. Climate change impact: mapping thermal stress on Carrara marble in Europe. Science of the Total Environment 407, 2009b, pp. 4506-4512.
- BONAZZA, A. BRIMBLECOMBE, B. – *Climate and the changing appearance of buildings. Cultural heritage from pollution to climate change*. Ravello, Edipuglia, 2016, pp. 27-34 (Centro Universitario Europeo per i Beni Culturali, Scienze e materiali del patrimonio culturale, 11), ISBN 978-88-7228-801-6.
- BRIMBLECOMBE, P., GROSSI, M.C., HARRIS, I. *Climate change critical to cultural heritage*. Heritage Weathering and Conservation, Taylor and Francis, London 2006, pp. 387-393, ISBN 0415412722.
- BRIMBLECOMBE, P., GROSSI C.M. *Millennium-long damage to building materials in London*. Science of the Total Environment, 407, 2009, pp.1354-1361.
- CASTELLARI, S., et al. *Elementi per una Strategia Nazionale di Adattamento ai Cambiamenti Climatici*. Ministero dell’Ambiente e della Tutela del Territorio e del Mare, Roma, 2014a, 239 p. ISBN 9788887728071.
- CASTELLARI, S., et al. *Rapporto sullo stato delle conoscenze scientifiche su impatti, vulnerabilità ed adattamento ai cambiamenti climatici in Italia*. Ministero dell’Ambiente e della Tutela del Territorio e del Mare, Roma, 2014b, 878 p. ISBN 9788887728095.
- CASTELLARI, S., et al. *Analisi delle normative comunitaria e nazionale rilevante per gli impatti, la vulnerabilità e l’adattamento ai cambiamenti climatici*. Ministero dell’Ambiente e della Tutela del Territorio e del Mare, Roma, 2014c, 155 p. ISBN 9788887728088.
- GÓMEZ-BOLEA, A., LLOP, E., ARIÑO X., SAIZ-JIMENEZ, C., BONAZZA, A., MESSINA, P., SABBIONI, C. *Mapping the impact of climate change on biomass accumulation on stone*. Journal of Cultural Heritage 13, 2012, pp. 254-258.
- GROSSI, C.M., BRIMBLECOMBE, P., MENÉNDEZ, B., BENAVENTE, D., HARRIS, I., DÉQUÉ, M. *Climatology of salt transitions and implications for stone weathering*. Science of the Total Environment 409, 2011, pp. 2577-2585.
- IPCC. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 2014, 151 pp.
- SABBIONI, C., BRIMBLECOMBE, P., CASSAR, M. *The Atlas of Climate Change Impact on European Cultural Heritage. Scientific Analysis and Management Strategies*. London, Anthem Press, 2010, 146 p. ISBN 9781843317982.