Heritage Conservation & Regeneration

FP9 2021-2027 POSITION PAPER

Contribution from ECHOES Cluster

1. Introduction

Only well-preserved artifacts can be made accessible to create social inclusion, a fundamental (and globally overlooked) process in order to improve the quality of life and enhance the economic value of European Cultural Heritage.

European Cultural Heritage is bold, inspirational, and with a wide societal relevance. Cultural heritage, landscapes and intangible heritage are European common goods and narrate our past and shared future. As a matter of fact, Europe hosts the largest share (45%) of heritage sites inscribed on the World Heritage List (485 to date, out of 1073 in total). European museums preserve artworks, whose amplitude finds no comparison worldwide.

This unique patrimony must be experienced, lived and transmitted to future generations. In fact, when Cultural Heritage (meaning the actual objects, monuments, landscapes) is accessed and experienced in "shared" environments, it brings citizens together, ameliorate our lives and well-being. In synthesis it creates social inclusion, an invaluable yet globally overlooked process that improves society and prevents alienation and social fractures (two fertile grounds for several rising social issues).
Besides its enormous social value, European Cultural Heritage is a production factor and an investment opportunity that boosts Europe's global competiveness. In terms of jobs, European cultural and creative industries provide work for nearly 2,5 times more people than automotive manufacturers and 5 times more than the chemical industry[1]. By attracting millions of visitors each year, Europe's cultural heritage generates an estimated European annual revenue of €335 billion (2014), and about 10 million jobs. Tourism indirectly generates more than 10% of the EU's GDP and provides about 12% of the labor force (EU business 2014). Moreover, the market for art was about 90 billion euro in 2016 (auctions and fairs), and the art market directly supports some 2.8 million jobs.

The best way to realize these benefits is to increase the access to cultural heritage. However, the original artifacts can be accessed by citizens and tourists only if properly conserved, which is not an easy task.
Cultural Heritage is affected by numerous degradation processes, caused by environmental factors, anthropic actions (pollution, wrong conservation practice), and microorganisms. The problem is amplified by the huge number of Cultural Heritage objects that are in need of interventions, and by the very nature of the art materials that have been employed in the artistic production since the early 20th century: in many cases, artists used (and still use) materials derived from the industry, which were not meant to last and are prone to fast (and often autocatalytic) degradation processes. Information and Communication Technologies (ICT) are surely useful to favor the fruition and the management of Cultural Heritage resources, however they cannot replace the direct enjoyment of the actual objects by the citizens/tourists. ICT and Digitalization can even hinder social inclusion, when the objects are merely reproduced in isolated contexts (e.g. individual laptops and smartphones in private environments) rather than directly observed, enjoyed and discussed in open, common environments (museums, collections, schools, squares, education centers, etc.). This concern is reported in the literature, for instance according to Tribe and Mkono[2], in the ICT age tourists may sometimes "prefer the virtual to the real"; moreover, Ritzer and Liska[3] argued that "post-tourists" might prefer digital connectivity, simulation and distraction over an authentic experience.

[1] Creating growth. Measuring cultural and creative markets in the EU. EY, 2014
[2] J. Tribe, M. Mkono. "Not such smart tourism? The concept of *e-lienation*". Annals of Tourism Research 66 (2017) 105-115.
[3] Ritzer, G., & Liska, A. (1997). McDisneyization and ''Post-Tourism'': Complementary perspectives on contemporary tourism. In C. Rojek & J. Urry (Eds.), Touring Cultures: Transformations of Travel and Theory (pp. 96–109). London: Routledge.

Effective strategies are thus needed to ensure the long-term conservation of irreplaceable Cultural Heritage resources. Not only remedial conservation is the only way to make degraded artifacts accessible again, it also has an economic value: the market for conservation is estimated at ca. €5 billion per year, and it could increase by a significant factor in next years due to the wider use of nanomaterials.

Given the vast amount of works of art produced through the ages, and the continuously increasing production from contemporary artists, it is fundamental to develop systems and methodologies for the conservation of artifacts with the following features: feasible, not time-consuming, affordable to end-users, and safe to the operators and the works of art.
A clear direction has been outlined, and it's targeted, measurable and time bound: by 2030, a 75% time reduction, and a 50% cost reduction for restoring and making accessible artworks, while ensuring elevated standards of protection and quality of interventions.
Achieving this target would mean opening up huge amounts of collection objects, which still wait in deposits to be displayed, together with heritage sites that currently cannot be visited. Furthermore, the mission targets self-excluded groups (different educational levels also displayed the highest rates of people not having visited any cultural sites at all[4]) and aims to bring the involvement of people in different cultural activities up to 50% more. Heritage appreciated in person and on the ground will foster local economies and tourism.

[4] Cultural Statistics. 2016 edition. Eurostat, 2016

2. Remedial conservation: medicine for Cultural Heritage. Needs and goals.

The ICOM-CC resolution adopted at the 15th Triennial Conference held in New Delhi in September 2008, defines Conservation as "all measures and actions aimed at safeguarding tangible cultural heritage while ensuring its accessibility to present and future generations". Accessibility means the possibility to access and enjoy not only the conceptual value of the artwork (i.e. by using ICT technologies such as 3D reconstruction) but also the actual object. Therefore, a fundamental need in conservation of Cultural Heritage is to repair and restore the degraded artworks (see for instance Figure 2.1). The huge number of artifacts in European and global Cultural Heritage (see Table 2.1) poses a significant challenge to conservation approaches. Such a vast patrimony cannot be preserved with conventional conservation methods without risking short- or long-term drawbacks (from detrimental interventions), or lengthy and expensive processes.

Table 2.1 Number of objects in museums and collections (both EU and global)

MUSEUMS	MODERN/CONTEMPORARY WORKS OF ART
MOMA	150,000
MUSÉE D'ART MODERNE DE LA VILLE DE PARIS	10,000
CENTRE G. POMPIDOU -LE BEAUBOURG	100,000
MAV/VAL - MUSÉE D'ART CONTEMPORAIN DU VAL-DE-MARNE	2,000
TATE	CA. 1,000 ON DISPLAY
MUSEO NACIONAL CENTRO DE ARTE REINA SOFÍA	10,000
RIJKS MUSEUM OF AMSTERDAM	30,000

Figure 2.1 Representative examples of Cultural Heritage objects, where degradation processes hinder the enjoyability and accessibility of the artifacts: (Left) Beato Angelico wall paintings (Florence, Italy). The center image shows the paintings after the removal of salts and consolidation of the painted layer were carried out. (Right) Degraded sculptures in Templo Mayor (Mexico City, Mexico).

Conservation methods and materials must have the following fundamental requirements, set and optimized through the intense cooperation between Natural Sciences and Social Sciences and Humanities (SSH, in charge of defining ethical guidelines and conservation needs):

a) Effective methods must be selective, i.e. they must remedy degraded portions of the artifacts, without altering the rest. Conventional methods are often non-selective, e.g. when a varnish is simply applied to coat the surface of an artifact, leading to short- or long-term alterations through aging.
b) Methods must not be time-consuming. The use of non-selective and incompatible restoration materials results in the need of continuous treatments, which prevent the exposition and fruition of the artifacts. Selective methods allow focused treatments and avoid drawbacks, quickly making degraded artifacts accessible again. Preservation in museums with a large number of works cannot be reasonably approached with time-consuming methodologies.
c) Methods and materials must be environmental friendly and must not impact the health of the operators (restorers, curators). Conventional solvents used in the restoration practice have toxicity issues, while advanced systems proposed in the last decade (e.g. responsive gels used for cleaning) have no or minimal impact.

To address these requirements, a new scientific framework is necessary. Although the conservation of cultural heritage involves a different code of ethics, it can be compared to medicine, where artifacts are analogous to patients and conservators are similar to doctors. Accordingly, diagnosis, treatment and prevention are relevant activities where Science is contributing: Diagnosis is covered by the development of Diagnostics for the investigation of works of art; Prevention consists in preventive conservation measures (where the art objects are not directly treated); Treatment consists in remedial conservation, i.e. the "therapy", the final action, and the "drugs" used are new smart materials and methods coming from groundbreaking technologies.

Both diagnostics and preventive conservation are at their mature stage:
Diagnostics have been largely developed and explored in the last decades, and numerous techniques are currently available to investigate the composition and degradation of artifacts. Current perspectives in diagnostics regard the evolution of optical systems and solid-state sensors, which will soon make possible to carry out most of the current investigations on artifacts (e.g. Raman, FTIR, etc.) using portable devices directly integrated with smartphones. Regarding preventive conservation, efforts are currently being dedicated to the development of effective solutions that must be affordable even to Small and Medium-sized Museums, where expensive systems for the control of atmosphere would not be feasible. Low-cost tools/solutions, and solutions able to monitor both individual and groups of similar artifacts are necessary implementations.

However, in order to maintain the actual Cultural Heritage objects, remedial conservation is essential.

The European projects in the framework of the 7th and H2020 research programmes **NANORESTART**, **NANOFORART**, **INNOVACONCRETE**, **NANO-CATHEDRAL**, **NEMOSINE**, **HEROMAT**, **NANOMATCH** generated new groundbreaking materials and methods (so far more than 70 new materials, 36 from CSGI) based on nanoscience for the conservation of our Heritage (see Fig. 2.2).

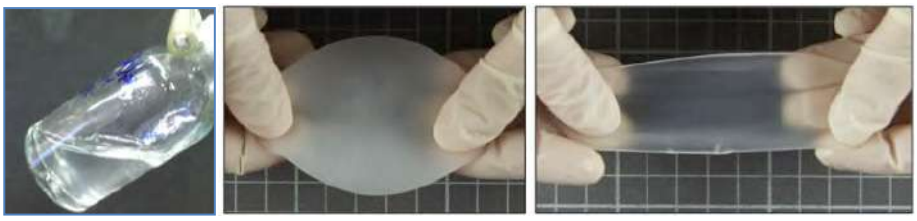


Fig. 2.2 (Top row) An example of the cleaning gels developed in the H2020 project NANORESTART. (Center and bottom rows) Some of the masterpieces cleaned using the gels: paintings by Jackson Pollock ("Alchemy", "Two", Peggy Guggenheim, Venice), Pablo Picasso ("The Studio – L'Atelier", Peggy Guggenheim, Venice), and Roy Lichtenstein ("Whaam!", Tate Modern, London).

Despite the progress that has been made, there is the need to further develop materials and methods for remedial conservation through realistic Research & Innovation actions. Research in materials science is also fundamental to develop resilient (or easily degradable, when dictated by artistic purposes) art materials.

The first goal is thus to carry out Research and Innovation activities across the entire innovation chain, which is essential to reduce time and costs for making artworks accessible. In particular, at high TRL (Technology Readiness Level), it is mostly SMEs and end-users (conservators) that play a fundamental role. Collaboration and feedback loops between basic research (such as chemical and physical research on material characterization and development of advanced materials), applied research (such as non-invasive diagnostic systems for cultural heritage, impact of climate change, new models for sustainable tourism, industry 4.0 shift for elaborating innovative strategies for safeguarding, restoring and transmitting cultural heritage for a deeper experiential knowledge by the public, development of environmental- and user-friendly methods for the selective preservation of large amounts of artworks), and social and cultural innovation (such as mutual exchange between different cultures and social cohesion thanks to values and messages cultural heritage delivers, source of inspiration for contemporary thinkers and artists), entrepreneurial innovation (such as cultural and creative industries, monitoring artifacts/context interaction, advanced exhibition systems, smart showcases), will be essential. Such knowledge-based research and innovation could work in conjunction with regulatory and governance actions to see that the mission target is reached.

The second goal involves raising the awareness of citizens on the importance of Cultural Heritage and of developing new tools for its preservation. The large impact of the new methodologies for preserving Cultural Heritage can be expressed considering the audience reached by one of the latest projects dedicated to the development of new materials for restoration, NANORESTART (H2020). In the first two project years, more than 19 million estimated people were reached over the world as general public, civil society and policy makers through:

- Exhibitions (e.g. "From Kandinsky to Pollock. The Art of the Guggenheim Collections"; Palazzo Strozzi, Florence, Italy, 19 March 2016 – 24 July 2016)
- TV and Radio Iinterviews (e.g. BBC Radio 4, BBC World Service, SVT - Swedish National TV, Radio 24, China Time News, ANSA Europe, ABC TV news (USA), etc.)
- Workshops and trainings (e.g. at the Pratt Institute - USA, Universidad de Costa Rica, UFRGS – Brazil, Cuzco University -Perù, The Solomon Guggenheim Collection – USA, Centro Conservazione e Restauro La Venaria Reale – Italy, Universidad Militare Nueva Granada – Colombia, etc.).

Although Member States of the European Union are responsible for preserving cultural heritage, the Union also has the obligation towards its citizens to ensure that Europe's heritage is safeguarded and enhanced (Innovation in Cultural Heritage Research For an integrated European Research Policy, 2018). To this purpose, the European cluster **ECHOES** (**http://www.echc.eu**) has been recently launched, in order to strengthen and make sustainable the new conservation developments. The mission of ECHOES is the enhancement of all actions addressed to the conservation and valorization of Cultural Heritage in all its forms and material.

3. Research topics and expected impacts

3.1 Resilient art materials: expanding the lifetime of cultural heritage

Contemporary Cultural Heritage (CH), also encompassing design, fashion, etc., is often produced by artists using materials derived from the industry, which are not meant to last. Therefore, given the societal and economic importance of CH, it is necessary to implement the materials actually coming from both the manufacturing and design industry, in order to achieve durable materials for specific purposes.
The development of durable materials needs to be tackled through the formulation of composites with specific functionalities to address the degradation processes that commonly affect contemporary art and design items. The newly developed and validated art materials must be validated according to existing international standards methodologies (when applicable), such as ISO, CEN TC 346 and other standards. In any case, however, the new materials must comply with the best practices and recommendations agreed with conservation institutions/museums, such as ICOM-CC, UNESCO, IIC, INCCA, and ICCROM. This research topic is expected to have a large impact on a number of industrial application (plastics, textiles, coatings, adhesives, etc.), where the production of high-quality goods (i.e. lifetime, durability, performance) is a fundamental goal to make EU competitive at a global scale.

Priorities:

- Low impact and sustainable processes for the production of new and highly resilient materials for cultural and artistic heritage.
- Efficient, reliable and cost-effective predictive models and simulation to evaluate the long-term behavior and durability of the new materials.
- Standardization of the materials production processes and the certification of their environmental impact and life cycle assessment.
- Promotion of a SME driven industry for the provision of art, design, and fashion materials.

3.2 Durability in conservation materials for cultural heritage

TOPIC DESCRIPTION

Specific Challenge

It is a daunting challenge for European society to preserve its unique Cultural Heritage (CH). In recent decades, the alarming growth of environmental pollution in European cities has seriously affected the conservation and maintenance of monuments, historic buildings and other CH elements. The continuous and tedious restoration works negatively affect to social and economic activities promoted around CH. Nowadays, nanotechnology has become a popular tool to produce advanced materials, even in cultural heritage field. Specifically, nanomaterials giving new properties to conservation products, such as self-cleaning, depollutant or repellence has been produced and some of them are, even, commercially available. Most of these nanomaterials, which are in the form of nanoparticles (TiO_2, SiO_2..) dissolved in water or organic solvents, shows great performance. However, the durability of these materials has hardly evaluated. The main problem of nanoparticles application regards the formation of a thin coating with low adhesion to the substrate, promoting a low durability. For this reason, the development of long-lasting solutions based on nanotechnoloy (i.e. functionalized nanoparticles integrated in a matrix capable of penetrate in the pore structure of substrates and subsequently, adhered to CH materials) is a promising approach to be investigated in cultural heritage field. Namely, in most cases the materials have the same (or very similar) composition and physico-chemical properties than those of the artifacts, therefore their durability is expected to match that of the works of art in pristine conditions. Whenever this cannot be achieved, the goal is the development of materials whose application is, as much as possible, reversible.

Scope

The following elements should be addressed in the project:

- Innovative solution(s) (materials and/or techniques) for Cultural Heritage conservation with improved durability regarding to the market solutions. In addition, these solutions should fulfill the performance required for their specific applications. The development of multifunctional treatments is strongly encouraged.
- Parameter relevant in durability should be evaluated both theoretically and in real conditions (monuments and historic buildings).
- Production of a pre-normative to validate the durability of conservation materials for cultural heritage. Specifically, the implementation of standards for comparing accelerated ageing tests with real situations is required.

  A significant contribution of Social Sciences & Humanities (SSH) disciplines should be included in the proposals in order to apply appropriate conservation methodology and to respect the authenticity and integrity of CH elements. In addition, a traditional requirements of CH treatments, reversibility, should be discussed in the context of durability. Moreover, to carry out a global dissemination, international cooperation is strongly encouraged, in particular, with relevant international organizations.

  Projects are expected to contribute actively to on-going activities of ECHOES cluster (Enabling Cultural Heritage. Oriented European Strategies), EMMC (European Materials Modelling Council) and other EU funded clusters.

  The implementation of this topic should start at TRL4 and target TRL6. Thus, a previous research about the solution(s) proposed in the project is required.

  In order to assure the market uptake of the propose solution(s), the participation of companies leading the conservation market is also encouraged.

Expected Impact

- Practical and affordable materials/technique solutions in terms of durability, performance, cost and/or complexity of application.
- Effective market uptake of the proposed solution(s) five years after the end of the project.
- Implementation of standards to measure durability of conservation materials in the CH field.

3.3 Written documentation and Graphic Art: preservation of a patrimony to enhance social cohesion

Documentary and graphic art represents a large part of the 20th and 21st century cultural heritage. This vast patrimony conveys a significant ensemble of ethical and societal values and ideas, representative of different cultures and social fabric, which contribute to form the identity of people. Letters, drawings, posters, magazine, music sheets, photographs, cardboards, are all examples of precious objects that are found both in the collections of the most important museums and in the daily life of citizens.
The possibility to fully valorize this patrimony and enhance its role in favoring social cohesion resides in the accessibility of the actual objects in "shared environment" (museum, libraries, collections, schools, academia, cultural associations and other social circles), rather than digital reconstruction or the use of social media.
Accessibility and fruition of the objects are strictly connected to their conservation status. Unfortunately, the degradation of these materials is often fast (e.g. 10-30 years) and follows an autocatalytic process, which makes preventive conservation only partially effective. Therefore, effective and durable solution for the remedial conservation of such artifacts are required.

Priorities:

- Low impact, sustainable, and cost-effective solutions for the intervention on written documentation and graphic art.
- Efficient, reliable and cost-effective models to predict the degradation processes of the relevant artefacts.
- Efficient, reliable and cost-effective predictive models and simulation to evaluate the long-term durability of the newly developed conservation methods.
- Standardization of the materials and methods used for the remedial conservation
- Certification of the environmental impact and life cycle assessment of the new materials.
- Promotion of the citizen awareness about the conservation challenges and the need to valorize of documentary heritage as a tool for social cohesion.

3.4 Innovative solutions for preventing water-based decay of cultural heritage building materials.

TOPIC DESCRIPTION

Specific Challenge

European cities hold an abundance of monuments and heritage site, which are unique in the world. Water is considered the most important decay agent for Cultural Heritage (CH) building materials, either by causing direct damages (freeze/thaw cycles, solubilization of minerals), or by acting as a vehicle for other agents such as soluble salts, pollutants and living entities. Thus, a great number of products, preventing water ingress in building materials, has been commercialized in recent years. However, this products boom has not been commonly accompanied from a suitable knowledge of physical-chemistry basis controlling wetting behavior of building materials. For instance, two completely different phenomena such as hydrophobicity and water-repellence are commonly mistaken by market, and even by many researches. Therefore, a deep study of wetting phenomena and repellence, involving an exhaustive investigation of behavior of surfaces under study (i.e. identification of Cassie-Baxter or Wenzel state), play an important role in order to develop the suitable treatment for CH building materials. In addition, the diffusion of this knowledge to cultural heritage stakeholders such as monuments owners, authorities, restorers and architects is a critical step to achieve a suitable application of these products.

Furthermore, the aforementioned decay agents (pollutants, salts or living entities) tend to act simultaneously, giving rise to synergistic effects that, in turn, greatly accelerate the degradation of the affected materials. Prime examples of this synergistic action are the deposition of pollutants, which provide organic matter for heterotrophic microorganisms, or the formation of black crusts composed of particle matter and algae or lichens. In order to protect building materials, treatments, such as hydrophobic and antifouling treatments, are usually applied separately, thus increasing the operational costs and causing potential incompatibility issues. For this reason, the development of multifunctional treatments, combining hydrophobic, self-cleaning and biocide activity is a promising approach.

Scope

The following elements should be addressed in the project:

3.4.1 Innovative solution(s) (materials and/or techniques) for preventing water-based decay of CH building materials. The development of multifunctional treatments including hydrophobic, repellent, self-cleaning and anti-fouling performance is encouraged.

3.4.2 The solution(s) should be based on physical-chemistry basis controlling wetting behavior of building materials.

3.4.3 Multi-scale modeling should be employed to predict performance of the implemented solutions.

3.4.4 The durability of the solution(s) proposed is other key parameter to be validated.

3.4.5 The proposed solutions should fulfill requirements demanded for cultural heritage elements. A significant contribution of Social Sciences & Humanities (SSH) disciplines should be included in the proposals in order to assure the correct fulfillment of conservation criteria and to respect the authenticity and integrity of CH elements. In order to carry out a global dissemination, international cooperation is strongly encouraged, in particular, with relevant international organizations. Projects are expected to contribute actively to on-going activities of ECHOES cluster (Enabling Cultural Heritage. Oriented European Strategies), EMMC (European Materials Modelling Council) and other EU funded clusters.

The implementation of this topic should start at TRL5 and target TRL7. Thus, a previous research about the solution(s) proposed in the project is required.

In order to assure the market uptake of the propose solution(s), the participation of companies leading the conservation market is also encouraged.

Expected Impact

3.4.5.1 Practical and affordable materials/technique solutions in terms of performance, durability, cost and/or complexity of application.

3.4.5.2 Clear prospect for a better understanding among end-users and manufacturers of conservation materials based on wetting phenomena.

3.4.5.3 Effective market uptake of the proposed solution(s) three years after the end of the project.

3.5 Socioeconomic challenges

Cultural heritage is an opportunity for increasing cross-sectorial, cross-disciplinary, cross- border innovation while creating new environments for research data, knowledge and services with engaged stakeholders.

A better preservation and accessibility of artworks generate human interactions, emotions and intercultural dialogue, and stimulate a circular economy loop (enhancement of tourism and local economies) that feeds into the preservation and accessibility of artworks. Social integration is an invaluable benefit that is promoted through human interactions that take place when the actual works of art are physically accessed, enjoyed, and appreciated in the framework of open and dynamic social environments. Better preservation and access to cultural heritage need an intense cooperation between natural sciences and social sciences and humanities. Many different actors of society need to be involved (such as conservators, restaurateurs, artists, heritage scientists, environmental scientists, data analysts, economists, citizens, policy-makers and other actors).

The fundamental action that needs to be taken is to enhance a “virtuous circle” that works as follows:

1) Developing safe and compatible solutions allows longer preservation of the artifacts;

2) More visitors are attracted to the artifacts as it is fully restored and accessible;

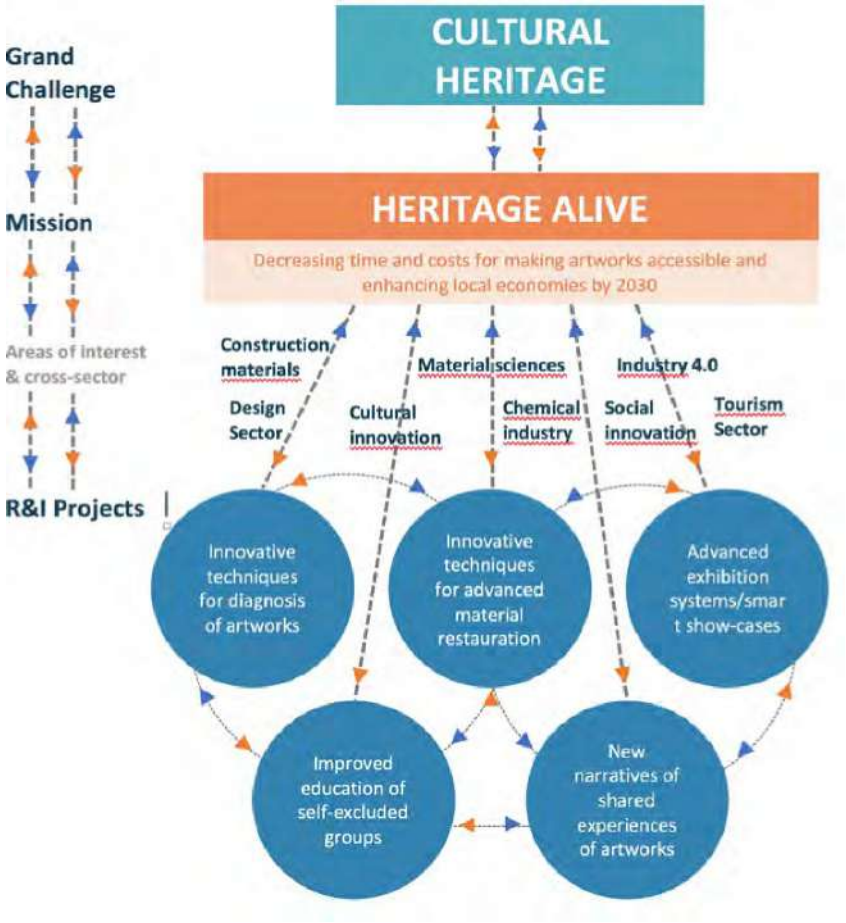
3) More visitors means more income;

4) More income means more resources that can be dedicated to the conservation and valorization of the artifacts, which brings the virtuous loop back at point 1).

Thus, the loop is favored by a system of social cohesion, cultural identity and mutual exchange between different cultures and social sectors.

3.5.1 Integrated management and promotion of natural and cultural assets

To keep cultural heritage alive and create benefits from a better preservation and access to artworks and sites, it is essential that researchers, civil society organizations, private and public sector work together at all levels. The proactive involvement of citizens need a paradigm shift that kick-start from multi-layered stakeholders, from local players, who are the custodians, to the authorities who have the responsibility to ensure that our common heritage can be shared unharmed with future generations, starting with the 'Millennials', who desire authentic cultural experiences and use technology intensively.



Courtesy of Vania Virgili, MIBACT

The promotion of cultural assets will also be facilitated by the fact that the new methodologies specifically developed for Cultural Heritage are derived from advanced frameworks that are common to several research fields, such as nanosciences, soft condensed matter, etc. Because these fields are mutually interconnected, advancements in the Cultural Heritage field can generate innovations in parallel sectors such as medicine (drug delivery, tissue regeneration), robotics (ICT, automatization), food industry (analysis, preservation, packaging), security systems (monitoring, atmosphere control), hygenics (detergency), etc. Viceversa, new achievements in drug delivery and other fields can be adapted for use in the Cultural Heritage field. This is common to the scientific framework that has been developed since the 1990s, where unique and isolated fields no longer exist.

Therefore, the transfer of scientific and technological knowledge developed in the framework of Cultural Heritage preservation to other fundamental fields, can generate increase in living condition, respect for institutions, and decreasing social conflicts and fundamentalisms.