Cultures and Local Practices of Sustainability

ROUTES Towards Sustainability Network

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Universidad Pontificia Bolivariana
EDICIONES UC

338.9
C968

Cultures and Local Practices of Sustainability. ROUTES Towards Sustainability Network / Ana Elena Builes V., Andrea Casals H. y Gonzalo Valdivieso, Coordinadores editoriales -- 1 edición – Medellín : UPB, 2021.
239 páginas, 14x23 cm. (Serie Iconofacto)
ISBN: 978-958-764-999-4

1. Desarrollo sostenible – 2. Medio ambiente – I. Builes V., Ana Elena, editor – II. Casals H., Andrea, editor – III. Valdivieso, Gonzalo, editor – (Serie)

UPB-CO / spa / RDA
SCDD 21 / Cutter-Sanborn

Cultures and Local Practices of Sustainability. ROUTES Towards Sustainability Network
ISBN: 978-958-764-999-4
DOI: http://doi.org/10.18566/978-958-764-999-4
Primera edición, 2021
Escuela de Arquitectura y diseño
Facultad de Arquitectura
CIDI. Grupo de Investigación en Arquitectura, Urbanismo y Paisaje. Proyecto: Propuesta para una Vivienda de Interés Prioritario con criterios sostenibles para la población del Corregimiento de la Danta en el posconflicto. Moda, ciudad y Economía. Circulación y espacios de circulación de productos vestimentarios y demás procesos comerciales en el sector de la comuna 14 entre el Parque Lleras y el Barrio Provenza. Los distritos de innovación y su impacto en el desarrollo urbano: estudios de caso Bogotá, Medellín y Barranquilla - Fase I. Radicados: 122C-05/18-35, 602B-05/16-69, 606C-08/20-28.

Gran Canciller UPB y Arzobispo de Medellín: Mons. Ricardo Tobón Restrepo
Rector General: Pbro. Julio Jairo Ceballos Sepúlveda
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Imagen portada: Shutterstock ID 1066368659

Dirección Editorial:
Editorial Universidad Pontificia Bolivariana, 2021
Correo electrónico: editorial@upb.edu.co
www.upb.edu.co
Telefax: (57)(4) 354 4565
A.A. 56006 - Medellín - Colombia

Radicado: 2137-19-08-21

Ediciones Universidad Católica de Chile
Vicerrectoría de Comunicaciones y Extensión Cultural
Av. Libertador Bernardo O’Higgins 390, Santiago, Chile

Integrated System for the resilience Enhancement of European Cultural Assets. A multidisciplinary approach to a sustainable model

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Abstract

The advent of globalisation has led men to think of nature as something separate from society, disregarding themselves as an integral part of the environment and perceiving themselves above it. Therefore, a holistic approach is needed, one that places interrelations between environment and human activities in the foreground, without excluding men from the environment, or even the environment from social systems. We need to study and interpret the complex adaptive Socio-Ecological Systems based on the continuous interaction of ecological, economic and social phenomena, which evolve according to resilient cycles.

All this requires a multidisciplinary approach, aiming at conserving biodiversity, managing ecosystems, encouraging interculturality, and promoting advanced sustainable development policies. In this context, a broad and multidisciplinary international partnership, coordinated by the University of Calabria, presents the project *SENECA - Integrated System for the Resilience Enhancement of European Cultural Assets*, which promotes a new multidisciplinary approach for the protection of cultural heritage and European historical areas from the effects of climate change and natural disasters, as well as their sustainable reconstruction.

This approach is based on the development of a smart integrated platform, which will allow the connection between researchers, experts, and decision makers who interact in the different fields of assessment, prevention and risk management, urban planning, and sustainable reconstruction of cultural heritage.

To support the platform, the proposal also foresees the implementation of Heritage Living Labs in pilot sites, which are user-centred and multidisciplinary research tools.

Keywords: cultural heritage, resilience, sustainable reconstruction, decision support system, living lab

1. Introduction

At a European level, the presence of intrinsically vulnerable historical sites has amplified the consequences of the multiple risks associated to climate change and natural disasters. The recent seismic events that hit Italy have been characterised by significant damage to cultural heritage. For example, in the historical centre of Amatrice, the level of damage caused by the earthquake from August 24 in 2016 was remarkably high, with over 60 % of the buildings inspected showing partial or total collapse; the elevated level of destruction was mainly caused by the high vulnerability of the buildings (Fiorentino et al., 2018).

Events of similar magnitude have affected other European countries; the Dodecanese earthquake in 2008 in Greece; the Kraljevo earthquake in 2010 in Serbia; the Lorca earthquake in 2011 in Spain; and the Aegean earthquake in 2017 in Greece. All of which highlight the need for increasing the resilience capacity of the territorial systems and the communities that live in them. In central and northern Europe, the impact of alluvial phenomena is even more significant, considering the frequency and extent of the areas concerned, both due to the long periods of rain and extreme precipitous events. Between 1998 and 2002, the average annual cost of flood damage as a percentage of GDP (gross domestic product) for the most affected European countries (1998-2002) varied from 0.1 % to 0.76 %.[3]

The *Sendai Framework for Disaster Risk Reduction 2015-2030*[4] explicitly mentions, among the expected results, the reduction of damage from natural disasters to cultural heritage along with those pertaining to material goods, the economy, society, and the environment; it also identifies two particular priorities. On the one hand, the need *ex-ante* of assessing vulnerability of cultural heritage in the context of specific exposures to risk, and *ex-post* of surveying and giving information on the damage suffered.

3 APAT-EEA General Training Workshops – Advanced Seminar 2008 Environmental and Soil Management Systems.

4 https://www.wcdrr.org/preparatory/post2015

On the other hand, it describes the need for public and private investments to improve the resilience of cultural assets (Virgili, 2017).

In this context, the *SENECA - Integrated System for the resilience ENhancement of European Cultural Assets* proposal[5], intends to promote a new multidisciplinary approach for the protection of European cultural heritage and historical areas from the effects of climate change and natural disasters, as well as new strategies for their sustainable reconstruction.

The SENECA project is based on a new integrated platform, called *SENECA Smart Integrated Platform*; a toolkit designed to support decision-making processes at all levels of governance at each stage of the event: prevention, protection, and reconstruction. The platform integrates a series of distinct but complementary tools, for example: monitoring and modelling of risk scenarios, acquiring crowd data from citizens and providing support for the recovery process in the post-disaster phase through a new adaptive decision-making system (SENECA-DSS).

The Smart Integrated Platform integrates skills among professionals in the sector, public decision makers, and stakeholders, thus improving the definition of intervention priorities on cultural heritage and post-disaster reconstruction through sustainable solutions.

2. SENECA Smart Integrated Platform

The impacts that the SENECA project produces are expressed on different scales: a micro-scale, which covers damage assessment and mitigation and adaptation strategies, and a macro-scale, which involves methods for assessing hazards and impact on heritage. Consequently, the DSS implemented through the Smart Integrated Platform will be a dynamic

5 The "SENECA - Integrated System for the resilience ENhancement of European Cultural Assets" proposal was presented under the Horizon 2020 program on topic *"LC-CLA-04-2018 - Resilience and sustainable reconstruction of historic areas to cope with climate change and hazard events"*. The proposal coordinated by the University of Calabria has received a final evaluation of 13 out of 15 and is currently on the reserve list. The consortium is made up of 23 partners of 11 nationalities, including ten universities, ten SMEs, 2 public bodies and a large company.

and adaptive system within a cyclical process in real time, based on the information provided at the micro and macro levels.

The central node of the platform is SENECA-HIA, which represents an evolution of the HIA (Heritage Impact Assessment) proposed by ICOMOS (International Council on Monuments and Sites)[6]. In support of the platform, Heritage Living Labs will be implemented, opening innovation ecosystems that are useful for developing shared solutions with communities. To improve resilience towards natural disasters, in fact, the community and cultural aspects must also be considered, as they are connected to the social structure and characteristics of specific social groups (Miller, 2007). The increase in the resilience of heritage is a key factor for European historical areas, which necessarily requires an understanding of both interdependencies and vulnerability factors.

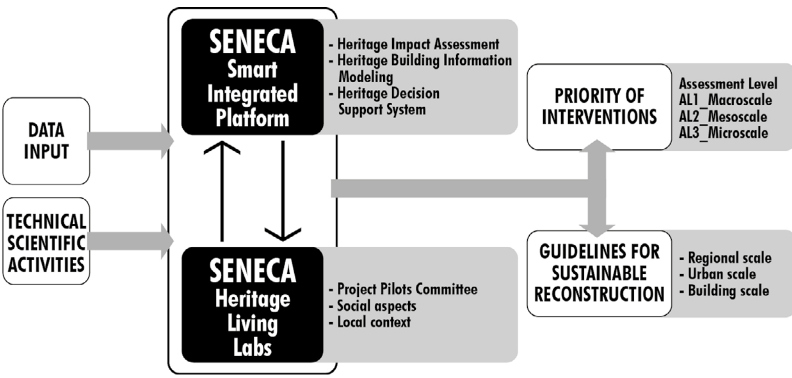
The platform is interactive so that each specific user can access to any information on the exposure, vulnerability, and ability of a specific historical area to face the different natural hazards, together with the relative specific guidelines for its sustainable reconstruction and effective measures to improve resilience. The integrated platform collects information from different domains: risk maps and meteorological data; GIS based information; data deriving from continuous monitoring; data from surveys and remote sensing operations on cultural heritage; destructive and non-destructive diagnostic test results on materials and structures; specific building information models for cultural heritage (BIM); data from public stakeholders; simulation results of new models for the description of damage on multi-scale cultural heritage and other multi-physical interactions with the surrounding environment; information on social media relating to the inhabitants of the sites; results of economic and environmental impact assessments; regulatory and organisational procedures for cultural heritage; new maintenance strategies, etc.

The platform is adaptive, which means that all accessible data is continuously updated and dynamically displayed. In detail, all data deriving from continuous monitoring, remote sensing, and access to open-

[6] www.icomos.org

source resources of existing databases (for seismic, hydrogeological and meteorological events, such as earthquakes, floods, hurricanes, etc.) are automatically synchronised using cloud and data-storage technologies implemented within the platform, to allow decision-makers to increase their ability to anticipate, recognise, adapt, and learn directly from past events. The platform is also a connecting tool for the scientific community working on different aspects of natural risk assessment and prevention.

Figure 1. Concept of SENECA project



The other aspect of the platform, in line with the technological one, concerns the involvement of the community in all phases of the project. This is possible by using an intersectional methodology already successfully tested within the ENTRUST H2020 project[7], which focuses on gender, cultural specificities, socio-economic privilege, and age. This approach is used to develop and provide an inclusive participatory process involving the communities associated with each of the pilot sites. In this logic, living labs are used as containers to organise and coordinate all community-based activities, including deliberative methods (for example, city juries) and co-design methods (for example, community

[7] http://www.entrust-h2020.eu

design charrettes), among others (Schaffers et al., 2011). The integrated platform is, therefore, a unifying tool for the activities of the Heritage Living Labs implemented in each pilot site.

3. The Heritage Living Labs

Public and social involvement in the SENECA project takes place thanks to an inclusive and articulated participatory process made by the Heritage Living Labs. A living lab, generally, is configured as an open and user-driven innovation ecosystem based on the continuous development of partnerships between institutions, companies, and researchers. The key aspects of a living lab are open innovation, the experimental approach in a real-life context, the involvement of end users, and user-driven innovation.

Specifically, the Heritage Living Lab is a place where stakeholders interested in cultural heritage can interact with each other to discuss best practices in the field of protection and prevention strategies. In detail, it allows local communities and other parties involved to transfer knowledge and skills, share experiences and results, have access to shared data, be informed of needs and decisions, and to understand best practices for improving resilience and/or reconstruction sustainability of historic areas (Cossetta & Palumbo, 2014). In addition, these tools can be adopted by institutions and researchers to calibrate, based on the environmental and social characteristics of the historical area, the different models and methodologies to be adopted for risk assessment and for integrated and sustainable reconstruction. It is how the envisaged inclusive participatory processes can be developed and implemented within specific communities.

The Living Lab offers an opportunity to implement cooperation between the different actors involved, who are often ignored by academic research and classic governance structures. In this way, it is possible to collect more accurate data, deeper knowledge, and a better assessment of the local meaning of cultural heritage and an improvement of community resilience.

To identify the societal needs and the elements of the project which require the study of the socio-technical interactions, we have applied a preliminary Theory of change (Rogers, 2014). It is a methodology, commonly used in the non-profit sector, to articulate processes and connections through which the elements of the project (resources and activities) are transformed into outputs that lead to the general objective of the project. Two main groups are involved in the Living Labs; a technical group (architects, engineers, etc.) and the communities of the historical areas, who will be included in the decisions and actions aiming to increase the resilience of the community. The resources will be used in a form of knowledge and process co-production, which progresses through the different work phases up to the project results.

The Heritage Living Lab methodology is applied, together with SENECA-HIA, to the nine pilot cases, to test the validity of the techniques, tools, and information models used. The pilot historical sites, of a heterogeneous nature, have been chosen to cover a wide range of geographical and meteorological areas, landscapes, urban or rural characteristics, specific risks, cultural and historical aspects, and social and economic characteristics.

The nine pilot sites cover the following categories:

- Large historical urban centres (Barcelona, Spain; Naples, Italy).
- Small rural or urban historical centres (Cesky Krumlov, Czech Republic; Nysa, Poland; Camposanto, Italy).
- Self-contained/detached cultural heritage (Hohenzollern, Germany; Cork, Ireland).
- Distributed sites or cultural heritage (Shetland, UK; Cultural Heritage Buildings, Norway).

The project identified six main natural risks: storms, sea level rise, flooding, overheating and extreme heat, seismic and hydrogeological risks; the pilot sites are at risk of at least one of these hazards, with some sites being exposed to multiple risks. Through research on these pilot sites, the related guidelines for sustainable reconstruction and improvement of resilience will be accompanied by specific examples and application cases for natural risk and cultural heritage, grouped into homogeneous categories (by materials, construction technology, structural typology, morphology, age, cultural influences, climatic zone).

Figure 2. Pilot sites of SENECA project

Note: Locations are (1) Historical centre of Naples, Italy; (2) Historical centre of Camposanto, Italy; (3) Jarlshof and Old Scatness, Shetland Islands, UK; (4) Corporation Buildings, Cork, Ireland; (5) Historical centre of Barcelona, Spain; (6) Cultural Heritage Buildings in Halden, Fredrikstad, and Sarpsborg, Norway; (7) Hohenzollern Castle, Germany; Historical centre of Nysa, Poland; Historical centre of Český Krumlov, Czech Republic.

4. The SENECA HIA methodology

As it was mentioned above, one of the main concerns in this project is the need for making methodologies for assessing impacts on cultural heritage more effective. The inspiration for the main idea of the SENECA-

HIA project was the *Guidance on Heritage Impact Assessment for Cultural World Heritage Properties*[8] published by ICOMOS (International Council on Monuments and Sites) in 2011. The HIA Guidelines have been developed to guarantee the protection of the Outstanding Universal Value (OUV) of World Heritage sites[9], especially in the face of the negative impacts of human-planned development, such as large infrastructure projects (ICOMOS, 2011). In fact, the Directive 85/337/EEC[10] would require Environmental Impact Assessments (EIA) to consider the specific impact on cultural heritage. However, the practice shows several shortcomings in the analysis of cultural heritage within the EIA (Patiwael, Groote & Vanclay, 2019). The substantial ineffectiveness of the EIA in correctly determining the impacts on the heritage caused, for example, the delisting of the Dresden Elbe Valley from the World Heritage List, which occurred in 2009 because of the construction of the new Waldschlösschen Bridge (Ringbeck & Rössler, 2011). Precisely, to avoid delisting other sites, ICOMOS has developed a specific evaluation methodology (HIA) focused on the attributes that identify the OVU. Consequently, potential impacts must be assessed, starting from the values certified by UNESCO when the site was included in the World Heritage List (Patiwael et al., 2019). The HIA must therefore ensure the protection and maintenance of these values over time.

The approach proposed by SENECA-HIA differs from the traditional one promoted by ICOMOS in many aspects: it focuses on the potential impacts deriving from natural disasters rather than those from human action; it does not only apply to sites on the World Heritage List, but also to general historical areas; it does not make exclusive reference to the attributes of the OVU, but incorporates the social, legal, political, economic, and organisational aspects, in addition to the physical (environmental, ecological, and technical) aspects, specific to the area examined, so that the risk and resilience levels can be properly estimated.

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8 https://www.icomos.org/world_heritage/HIA_20110201.pdf

9 The World Heritage Convention describes the OUV as "cultural and/or natural significance that is so exceptional that it transcends national boundaries and is of common importance for the present and future generations of all humanity" (UNESCO 2015, 11).

10 https://eur-lex.europa.eu/eli/dir/1985/337/oj

It follows that the assessment of potential damage is not limited to the material heritage only. It also considers the effects of natural events on the intangible cultural heritage, as well as the mutual influence between tangible and intangible cultural heritage in the event of natural disasters.

The application of SENECA-HIA takes place in three distinct but synergistic phases: (a) evaluation and classification of the degree of significance of cultural heritage assets; (b) assessment of the risk level for the different types of cultural heritage located in historical areas (compared to the classic criteria: danger, vulnerability, and exposure); (c) assessment and strengthening of the resilience of local communities in historical areas.

The first phase of SENECA-HIA is based on the concept that cultural heritage belongs to the group of resources whose price, understood as monetary value, is unable to take into consideration the intangible aspects and, therefore, has limited efficacy if used for comparison purposes. For these assets, by applying multi-criteria assessment methods (Nijkamp, Rietveld & Voogd, 1990), it is possible to identify a set of characteristics, attributes, and technical criteria (intangible value of the punctual and widespread cultural heritage, concentration of the population, spatial distribution of cultural heritage, form and contextual value of historical areas, etc.), which determine their overall meaning within a holistic framework (Saaty, 2005). The procedure attributes a certain weight to each identified criterion, specifying its relative importance and, therefore, the order of priority or the measure of the individual contribution to the final estimate judgment. The application of multi-criteria evaluation methods implies the identification of the different characteristics that the resource possesses, of the evaluation criteria and of the weights assigned to these criteria, allowing to estimate the value of a resource not exclusively in a monetary sense. With this methodology, it is also possible to obtain a synthetic estimate of the importance of complex goods (historical centres and sites) different from the single elements. This procedure allows to hierarchically order the cultural heritage, according to their significance, to select the intervention priorities for decision makers.

The second phase defines the correlation between natural risks and specific categories of cultural heritage, whose responses to the same external risk factor are inevitably different due to their intrinsic peculiarities. Different types of analyses (territorial, cultural, morphological, etc.) are needed to identify the factors that exert the greatest influence and to obtain an estimate of the specific risk on the area considered. For example, the environmental context and physical characteristics of a cultural asset, as well as the origin of building materials, are crucial aspects for assessing specific vulnerability and risk levels. By analytically assessing the impacts of any natural risks, specific criteria can be developed for the determination of a multi-factor risk index associated to specific risk maps for cultural heritage. These criteria will consider multi-risk aspects; defined both as different dangerous events that threaten the same elements with or without time coincidence, and as dangerous events that occur at the same time or that follow one another, the so-called cascading effect; multi-vulnerability aspects (referring to the variety of sensitive objectives exposed, such as population, infrastructure, cultural heritage, with possible degrees of vulnerability different to the various risks), and, finally, aspects that consider the possible dangers and vulnerable interactions, involving both a multi-risk and multi-vulnerability perspective.

The third phase of SENECA-HIA concerns the resilience of communities in historical areas, which exerts a direct influence on the ability to manage natural disasters proactively and positively and, therefore, to recover functions related to cultural heritage in the shortest possible time. Community resilience is based on three characteristics: tendency to resistance, which refers to the ability of the community to absorb the impact; recovery tendency, which refers to the speed and ability to recover from stress; and tendency to creativity, which refers to the potential to improve one's functioning because of adversity (Kimhi & Shamai, 2004). The existing Community Resilience Assessment methodologies do not focus on cultural heritage, which instead represents a fundamental resource for historical areas and one of the assets on which to act to improve their resilience. This phase must be carried out through an intense involvement of the community, working specifically on prevention with respect to recovery, through risk reduction and event preparation activities. This methodology will find application within the Heritage Living Labs, through the involvement of local communities and the construction of a series of indicators of resilience capable of considering the physical, social, and economic aspects.

SENECA-HIA allows to emphasize all the aspects that play a role in the protection and management of cultural heritage in historical areas, including those related to their surrounding environmental context. This ensures that any impacts of any natural disaster on a given historical area are correctly assessed to safeguard both heritage and cultural assets by integrating a decision support system that promotes sustainable recovery interventions through correctly applied management and monitoring procedures, involving the contribution of local communities in all phases of the evaluation process.

The SENECA-HIA methodology is intrinsically dynamic and adaptive. It considers the possible variations of risk factors related to climate change and other natural events, and, moreover, it can be used as a verification protocol for retrofit and reconstruction strategies obtaining specific guidelines to support the decision-making processes of the various levels of the local government.

5. SENECA Decision Support System

The outputs of the phases previously described will be implemented and managed automatically through the SENECA Decision Support System (SENECA-DSS). The SENECA-DSS helps to elaborate a complete and detailed reference framework through a holistic approach to characterize a faster and safer decision-making system and to implement effective heritage protection actions in the historical areas under consideration.

Due to the extreme complexity of the analysed elements, the DSS plans to organise the data examined in specific clusters:

- Socio-cultural: factors related to the involvement of local communities and to opportunities of cultural interest.
- Ecological: aspects related to the landscape, natural resources, and the overall environmental system.
- Physical characteristics: physical and territorial ones of the area.
- Organisational: intangible elements of the system, with specific reference to the organisation and management of the network of relationships between stakeholders.

The outcome of this categorisation is expressed by a synthetic numerical index (CHSI - Cultural Heritage Significance Index), defined by metadata implemented within a significance matrix related to the single element being analysed, based on which it is possible to construct maps of significance of cultural heritage.

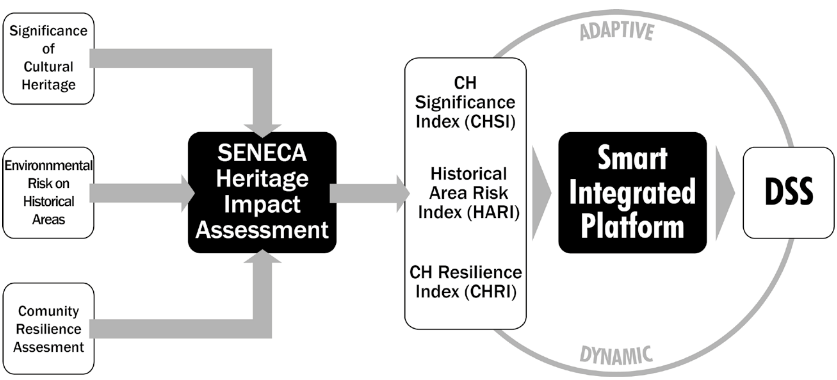
By superimposing the hazard, specific vulnerability, and significance maps, new risk maps can be created, based on the definition of a historic area risk index (HARI - Historic Area Risk Index).

The Cultural Heritage Resilience Index (CHRI) will be defined through the application, within the Heritage Living Labs, of a modified Community Resilience Assessment methodology (according to which local communities will quantitatively evaluate their ability to recover over time based on a series of indicators of resilience). This index is intended as an objective measure of the ability to resist, adapt, and transform against events of climate change and other natural hazards. The conceived indicator will help to identify intervention priorities (by determining weakness factors), innovative actions, and retrofit measures to mitigate the impacts of extreme natural events. The general and adaptive nature of CHRI allows for a broader understanding than that of existing approaches, generally based on national or regional standards and non-unified methodologies.

The task of the DSS, therefore, will be to collect and organise all the interactions, which occur at different spatial scales, between the indexes previously described. To this end, methodologies will be implemented, based on qualitative, semi-quantitative or quantitative approaches for the aggregation of data collected in the intermediate stages (multi-hazard, exposure, and vulnerability).

Multi-hazard and multi-risk methodologies require the aggregation of hazard, exposure and vulnerability information to provide results (maps, key performance indicators, statistics, and indexes, for example) that can be easily consulted and used by different end users; the goal will be to provide useful tools to stakeholders and decision-makers in risk management, focusing the data on the development of a composite view of the various hazards affecting the same area under consideration.

Figure 3. Concept of SENECA Decision Support System



6. Conclusions

The existence of many cultural assets subject to natural risks requires the need to develop simplified tools to quickly determine a priority list of interventions to guide the entire decision-making process, including the choice of strategies and approaches for increasing the resilience of historical areas and the management of available economic resources.

It is essential to proceed with a clear understanding of the potentials and weaknesses of a holistic, non-fragmented approach to disasters. In proposing solutions, it is crucial to proceed both from the engineering and technical areas (like construction), and from the socio-economic ones (like studies on the implications for the population) (Pagliacci, Russo & Sartori, 2017).

The process previously described allows to:

- Obtain complete and detailed data for correct planning and management of Cultural Heritage.
- Determine the critical risk factors for different categories of goods (structures, artifacts, sites).
- Create innovative systems for data management (integrated platform, DSS).
- Develop and consolidate forms of community-based approaches for disaster risk reduction.

The proposed conceptual methodology is flexible and applicable to different case studies and spatial scales (for example, from a single building to large areas) and for different risks.

The ambition of SENECA is to operate at a European level, and this cannot be achieved without addressing cultural diversity and traditions, as well as natural environments and dangers across Europe. Furthermore, an important component for the effectiveness of actions aimed at improving the resilience level of historical areas is the involvement of local communities, which should be encouraged to develop a sense of belonging, since it can provide valuable input on the situation in their life environment. These aspects were addressed by considering a wide selection of pilot sites to be used as a testing laboratory for interventions to improve resilience and creating Heritage Living Labs to increase social awareness in local communities. The application on different pilot sites will prepare the ground for a model that can be exported to other historical areas.

One of the aims of the project is to align the cultural heritage sector with the technological evolution that is gaining ground in other productive sectors; for which the introduction of advanced information technology, including Building Information Model (BIM) and Internet of Things (IoT), will lead to greater transparency and timeliness of processes, while facilitating dialogue and stakeholder participation. The potential for similar gains in the cultural heritage sector is enormous, as better informed and prepared communities, equipped with reliable tools and sustainable approaches, will be able to reduce the impact of natural risks on cultural heritage resources and activate sound recovery plans.

The development of platforms for the knowledge, management, restoration, requalification, safety, and enhancement of cultural heritage and the development of IoT technology for monitoring and controlling resilient interventions proposed in SENECA, will establish the framework for a new and more competitive environment. Companies will have to demonstrate high competence and quality in the supply of traditional processes and, at the same time, new advanced skills to make these processes sustainable and resilient. The principle is that the involvement of the private sector in the methodological development phases of new technologies, for the protection of historical and artistic heritage, should promote a faster transfer of knowledge and tools acquired (and duly validated) in practice, which in turn should contribute significantly to providing the sector with better, sound, and effective capacities to face even more urgent risks (Proença & Revez, 2017).

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