The ARCH Project: Investigating the Impact of Climate Change on Historic Areas

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Abstract. This short contribution introduces the EU Horizon 2020 project ARCH "Advancing resilience of historic areas against climate-related and other hazards" [1]. It summarizes ARCH's objectives, briefly introduces the piloting city cases, describes the work undertaken in the first 18 months of the project, and briefly touches on how these results go beyond the state-of-the-art.

Context and Objectives

Historic towns, old urban quarters, villages, and hamlets, as well as historic landscapes make up a significant part of Europe's identity: Natural heritage sites cover roughly 18% of the European land territory [2], and on average 22% of the European housing stock was constructed before 1946 [3]. These historic areas are deeply embedded in larger urban and rural environments, serving a role in preserving local identity and personality as well as local knowledge. Although climate change has become one of the most significant and fastest growing threats to people and their cultural heritage [4] the impacts of climate-related and other natural hazards on historic areas have not been studied extensively [5], and disaster risk reduction seldom registers as a priority area for management of World Heritage property [6].

Therefore, there is a need for specific methods and tools that provide better information and decision-support for climate change adaptation and disaster risk reduction for heritage managers, urban planners, policymakers, and the general public. These methods and tools need to take into account the unique physical, environmental, economic, social, cultural, and political aspects of historic areas, as well as the enabling conditions these areas provide for taking action.

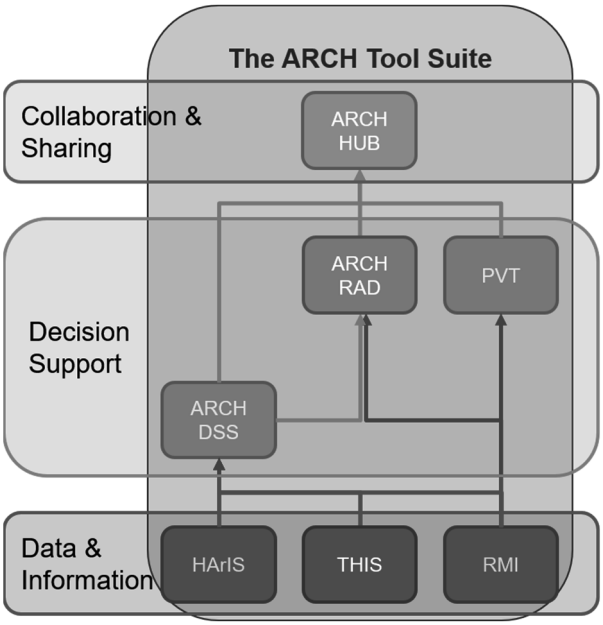

Figure 1: ARCH develops a collaborative, web-based disaster risk management plaform for urban heritage districts.

However, tools and methods alone are not enough. They need to be supported by a stronger promotion of relevant public policies and participatory governance processes that facilitate the active participation of residents from local communities and the general public. The awareness of climate change impacts on historic areas needs to be increased, resilience building strategies need to be included in heritage management policies and practices, while at the same time the role of heritage in climate change adaptation and disaster risk reduction within the wider urban context has to be emphasized.

The EU Horizon 2020 research project ARCH aims to take a step in this direction. ARCH will provide a suite of software tools (see Figure 1) for assessing and improving the resilience of historic areas, conceptualized as part of three layers: The Data and Information Layer includes information on cultural heritage as part of the Historic

Area Information System (HArIS), on specific challenges resulting from climate change as part of the Threats and Hazards Information System (THIS), and of suitable resilience enhancing measures as part of the the Resilience Measures Inventory (RMI).

These information repositories will be made available to practitioners through web tools on the Decision Support Layer. That layer includes the GIS-based ARCH Decision Support System (ARCH DSS) used to monitor natural phenomena and events in real time, to predict damage scenarios and assess the risks of corresponding impacts and consequences, the Resilience Assessment Dashboard (RAD) enabling local stakeholders to perform a structured assessment of their municipality's resilience against the impact of climate change, and the Pathway Visualization Tool (ARCH PVT) allowing the visual design of implementation pathways for resilienc measures. All of these are concentrated and provided by one single collaboration-oriented, user-friendly web site, the ARCH HUB [7].

While providing local practitioners with these tools, at the same time ARCH will advocate new policies as well as necessary changes to existing regulations for heritage management, climate change adaptation, and disaster risk reduction of historic areas.

The ARCH solutions will target heritage managers, urban planners, and other professionals from the fields of climate change adaptation and disaster risk reduction as well as politicians and the general public, in order to improve the cooperation and communication between these stakeholders and to enhance the definition and implementation of sustainable resilience building strategies.

1 City Cases

To assure the best possible understanding of the specific impact of climate change on local communities, and at the same time ensuring maximum applicability of the developed methods and tools, all ARCH research and development is conducted in co-creation with four municipal partners [8], Bratislava (Slovakia), Camerino (Italy), Hamburg (Germany), and Valencia (Spain). These four pilot cities, located all over Europe and facing related, but different specific challenges, work in concert with researchers and SMEs to find solutions focused on the protection of historic areas from the impact of climate change as well as of other natural hazards.

Bratislava. The historical center of Bratislava, the capital city of Slovakia, has become a tourist magnet in recent years. However, with its high housing density, including numerous in-situ preserved Celtic industrial monuments located underground, relatively few urban green areas, and its location along the foothills of the Small Carpathians, pluvial flooding resulting from extreme precipitation events has become a major problem. In addition to examining the extent of and potential solutions to that hazard, the ARCH project also examines the local Devin Castle located on a steep cliff on the Danube river (see Figure 2). Climate change induced changes to freeze and thaw cycles as well as increases in humidity cause erosion effects to the cliff that threaten the rock face to collapse into the river, taking the castle with it.

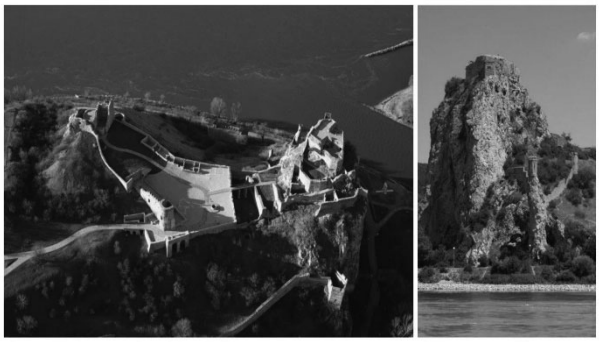

Figure 2: Bratislava's Devin Castle perched on an eroding cliff on the Danube river (Source: [10])

Camerino. Camerino in the Marche region of central Italy is a historic town that was hit badly by a series of major earthquakes in 2016. Its main historic area, located on a hill top and including the cathedral, the Palazzo Ducale and a – up until then – mostly historically intact walled town center are still recovering from that event and are for the most part uninhabitable. With the Camerino city case the ARCH project demonstrates that its methods and tools, mainly designed and developed to mitigate the impact of climate change, can also be applied to help in the aftermath of other natural disasters.

Hamburg. With the interplay of the German Bight's tides and the river Elbe changing slowly as a result of climate change and the increased demands of servicing bigger ships in the harbour, Hamburg and its Speicherstadt World Heritage Site face new challenges: Rows and rows of warehouses were built from 1883 to 1927 on pine pile foundations.

Resulting from prolonged intervals during which the pole heads are outside of the tidal-range, the load bearing properties of these pine poles might slowly but surely decrease, causing the heritage site to subside. As part of the ARCH project risks and vulnerabilities due to these effects are assessed on neighborhood as well as single building level. In addition, the monitoring and management of the historic warehouses is supported via advanced 3D models.

Valencia. Located at the Mediterraean coast, the city of Valencia is surrounded on three sides by the Huerta de Valencia, a peri-urban farmland recognized as Globally Important Agricultural Heritage System by the Food and Agriculture Organization of the United Nations (FAO). L'Horta, as well as Albufera national park, the second examination site for ARCH in Valencia, provides important recreational and economic value to the city in addition to being a huge asset to mitigate the effects of climate change. However, with increases in temperature and drought as well as rising sea levels both cultural landscapes are at serious risk. ARCH provides specialized risk climate services and risk analysis models focusing on agro-climatic changes to L'Horta and waterquality changes to the Albufera Lagoon.

2 Results Achieved so far

ARCH started off with the production of a series of state-of-the-art reports of concepts, approaches, standards, and technologies on topics crucial for the project [9]. These reports dealt with, amongst other things, the current state of conservation practices, the concepts of disaster risk management and building back better, gender mainstreaming, decision-support frameworks, as well as existing standards related to ARCH's topics. Some of the key findings from these reports include:

- Cultural heritage management and disaster risk management remain poorly integrated.
- An indicator-based approach to risk assessments seems most appropriate for historic areas.
- Disaster risk management, for historic areas hinges critically on the inclusion of local communities, local practices, and traditional knowledge.
- Users need to be able to understand the decision process, limitations, and associated uncertainties of a Decision Support System (DSS).

In parallel to the state-of-the-art reports, four City Baseline Reports were compiled that establish the baseline for the municipalities of Bratislava, Camerino, Hamburg, and Valencia, with respect to their selected historic areas [10]. As ARCH has a multi-dimensional thematic focus on heritage management, disaster risk reduction and adaptation to climate change, all three dimensions were addressed in each city's baseline review.

Based on these reports, project partners conducted match-making meetings with each city to match local problems with specific solutions provided by ARCH. These meetings, as well as all co-creation activities of the project, are governed by an ARCH co-creation guideline document that presents a harmonised methodological approach and framework for the cooperation between scientific partners and a city.

In addition to the match-making meetings, each ARCH pilot city identified 'local partnerships' and developed a work plan for local activities, aligned with the research work of the project. [11]

ARCH also looked beyond its pilot cities and compiled a report that maps and characterises European initiatives and case studies on advancing the resilience of cultural heritage to natural and human-induced disasters as well as to the long-term consequences of climate change.

Of the 40 initiatives featured in this report, 32 were described as snapshots and eight as more detailed case studies. [12]

In order to ensure that the solutions developed by ARCH are in line with the needs of local end-users, as expressed in the match-making sessions, and with current practices, a requirements analysis was conducted and system specifications were drawn up. ARCH partners identified 134 requirements across the four pilot cities, each mapped to one or more of the solutions that will be developed by the ARCH project partners. [13]

Based on the exploratory work, ARCH has developed a combined disaster risk management (DRM) and climate change adaptation cycle, the ARCH Disaster Risk Management Framework.

The ARCH DRM Framework is specifically aimed at historic areas and helps actors in the fields of heritage management, disaster risk management, and climate change adaptation to understand which steps are necessary to develop a combined disaster risk management and climate change adaptation plan with specific focus on historic areas. [14]

2.1 Progress beyond the state-of-the-art

Although only halfway through the lifetime of the project, with some work packages still in the early stages of work, there is already significant impact and progress beyond the state of the art:

- The ARCH DRM Framework successfully combines the Disaster Risk Management Cycle with the Climate Change Adaptation planning cycle, also including issues of heritage management and social justice.
- The replicability framework developed for the mapping and characterisation of European initiatives and case studies provides an easily usable blueprint for identification of initiatives that might be suited to be transferred to other contexts.
- The ARCH co-creation guideline provides a practical handbook on how to conduct successful co-creation in many types of applied research projects. [15]
- The establishment of local partnerships in each pilot city and the ongoing co-creation process has already resulted in higher visibility of the issues addressed by ARCH within the city administrations and larger stakeholder networks, e.g. by establishing committed local cross-departmental partnerships that will potentially live beyond the lifetime of the project.
- The involvement of ARCH partners in formal standardisation processes on national and international level brings the project very close to influencing the state-of-the-art in standardisation fields related to the project topics.

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