D 1.4

Final report on user needs

Deliverable Report n. 1.4: Final, issue date on 5ᵗʰ December 2023

Grant Agreement number:	**101004468**
Project acronym:	**4CH**
Project title:	**Competence Centre for the Conservation of Cultural Heritage**
Funding Scheme:	**H2020**
Project coordinator:	**Francesco Taccetti, INFN**
Tel:	**+39 3201806514**
E-mail:	**francesco.taccetti@fi.infn.it**
Project website address:	**www.4ch-project.eu**

D 1.4

Final report on user needs

Issue Date:	5th December 2023
Produced by:	TECNALIA
Main author:	Daniele Cortis – *Integration of contents* (INFN)
Co-authors:	Sorin Hermon, Luciarita Nunziata, Valentina Vassallo (CYI)
	Alessandra Gandini, Amaia Sopelana (TECNALIA)
	Federica Maietti, Emanuele Piaia (INCEPTION)
Version:	Final
Reviewed by:	Donato Orlandi - *WP1 Leader* (INFN)
Approved by:	Board of Directors
Dissemination:	Public

Document History

1. 14.12.2021:   Draft version 0.1
2. 22.02.2022:   Draft version 0.2
3. 29.03.2022:   Draft version 0.3
4. 03.05.2022:   Draft version 0.4
5. 03.05.2022:   Draft version 0.5
6. 31.05.2022:   Draft version D1.2
7. 05.12.2023:   Final version D1.4

List of acronyms and abbreviations

CC	*Competence Centre*
CH	*Cultural Heritage*
ICT	*Information Communication Technology*

Definitions

Leave blank intentionally.

List of figures

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

List of tables

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

Table of Contents

Executive summary

This report describes the results of Tasks T1.2 and T1.4 concerning the risk mapping and user needs.

WP1 defines the basis for the achievement of project objective 1, collecting and relating experiences, skills and best practices acquired and implemented so far in the European Countries, with specific reference to EU-funded research. The WP's activities identify innovative approaches in initiatives, policies and strategies for the preservation and conservation of monuments and sites. In this way, it will help define in detail the fields which the Competence Centre will operate.

Reflecting the overall concept, the methodology of WP1 is based on the implementation of 4 requirements and objects, which are explained below.

4CH PHASE 1 | Y1 CONCEPT | REQUIREMENTS AND OBJECTIVES
- Task T1.1 - Analysing the field
- Task T1.2 - Mapping risks
- Task T1.3 - Technological state of the art
- Task T1.4 - User needs

This report focuses on 2 objectives:

Task T1.2 - Mapping risks
Implementation of a map of all kinds of risks, including environmental ones and disasters deriving from the climate change, which can damage Cultural Heritage assets, for prioritizing preservation and conservation activities.

Task T1.4 - User needs
Mapping existing analysis on user needs starting from EU-funded projects and other collective analysis covering different communities and including staff skills and their attitude to digitization, organizational issues and so on.

This report covers the activities carried out from month 33 to month 35 of the project.

1. Background

Holistic documentation of historic buildings, archaeological monuments and sites based on 3D digitization provides a basis for conservation, preservation and valorisation. It is fundamental to effective management and preventive maintenance. Active condition monitoring helps to avoid the effects of environmental decay and catastrophic events, such as earthquakes, floods and fire. High quality digital documentation also helps support reconstruction, rehabilitation and access. The knowledge captured in such documentation contributes to sustainable development, preservation of history and identity (the diversity

of cultures and social bonds that Cultural Heritage embodies), while enabling social and economic development in local areas and regions.

Digital technologies play a key role in allowing innovation in management practices, proving the framework for objective monitoring and scientific evaluation. They facilitate innovative engagement of local citizens in their CH and in co-creation and bottom-up conservation solutions, for example involving local communities in monitoring their local heritage sites. High-quality 3D digitization lies at the heart of some highly innovative solutions.

The 4CH project envisages a holistic approach, which encompasses interdisciplinary contributions, where accurate and precise 3D documentation of the shape and appearance of monuments and sites is linked to relevant information and rich data ranging from the location and history of the CH asset to its structural behaviour, reports into its condition (past and present), state of conservation, and the monitoring of foreseen risks. Holistic documentation aims to create a "Heritage Digital Twin", a digital replica of the asset linked to information and data used to support management, conservation and access. The benefit of creating a digital twin is that various scenarios can be tested on the digital model rather than on the real thing, for example to model the performance of the asset in different conditions, such as changes in tourism flow or to plan for disaster prevention. The 4CH approach will contribute to the design of the Heritage Digital Twin concept, digital twin capable of enriching itself by collecting data from monitoring devices concerning preservation and maintenance, interventions for conservation and restoration, and management. CH institutions will benefit from digitization solutions that are based on standardization, exploit advanced technology and services, while at the same time enabling them to adopt optimal strategies and to improve the skills of their staff, volunteers, and students.

4CH will establish the tools and frameworks needed by the European Competence Centre on Cultural Heritage to make this possible.

1.1. Project objectives

The main aim of the 4CH project is to design and set up a Competence Centre (CC) for the Conservation of Cultural Heritage. The Centre will offer knowledge (advice and support activities) and services to national and regional heritage agencies, cultural heritage institutions, professionals, and citizens. The 4CH project will promote state of the art ICT solutions including 3D digitization, which have great potential for documenting, monitoring, mitigating, and preventing damage caused by natural degradation, human-related developments, and disasters.

To achieve the main goal, as stated above, WP1 pursues a sub-set of objectives:

Project Objective 1 | Establishing the methodological framework for the Competence Centre focusing on advanced digitization for preservation and conservation of Monuments and Sites.

The objective is to design the methodological framework for the Competence Centre. The framework will collect and relate experiences, skills and best practices, innovative approaches, policies, and strategies for preservation and conservation of monuments and sites.

This objective will be pursued by **tasks T1.2 and T1.4 in WP1** concerning identification of all kinds of risks that can cause serious or irreparable damage to heritage assets together with monitoring and diagnostic activities, mitigating measures and repair interventions.
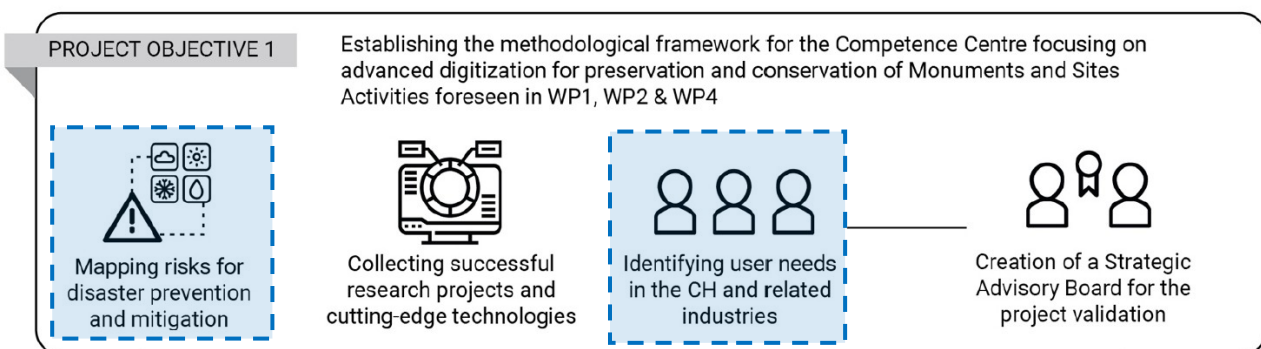
Figure 1. 1 - Project Objective 1 for Task T1.2 and T1.4

1.2. Correlation between Tasks

WP1 defines requirements and the field of activities of the future Competence Centre by four Tasks:

1. **Task T1.1 - Analysis of experiences, skills and best practices acquired and implemented so far in the European Countries, in the field of preservation and conservation of monuments and sites.**
   This task will collect and analyse the current progress of conservation and preservation research and practice in Europe, in order to integrate them in the Centre's recommendations. The results will be mainly achieved with desk work on reports, publications and so on, integrated by surveys and direct contacts where necessary.

2. **Task T1.2 - Implementation of a map of all kinds of risks which can damage Cultural Heritage assets for prioritizing preservation and conservation activities.**
   The task will analyse the current state of research linking causes to adverse effects. It will provide information to organize the knowledge base and the Centre's recommendations.

3. **Task T1.3 - State of the Art, including update via Market Watch, of the technology in the fields in which the Competence Centre will operate: 1) digitization and 3D modelling, 2) conservation and preservation, 3) exploitation of CH assets.**
This task concerns technology, both digital and analogic, as for example techniques and instruments for digitization; diagnostic techniques and their interpretation; materials and nanomaterials; novel methods and devices for visualization; and so on. It will feed information in the knowledge base and generate short reports to be distributed to the community. The information will be regularly updated, especially when new tools or methods appear in the market. Attention will be paid to international reports and to global approaches to the subject, e.g., related EU reports, UNESCO statements, and so on.

4. **Task T1.4 - User needs: mapping existing analysis on user needs and defining their continuous update.**
The task will integrate the user needs reports created with surveys e.g., by EU-funded projects and other collective analyses with targeted surveys covering aspects or communities not yet well analysed, e.g., staff skills and their attitude to digitization, organizational issues and so on.

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

In the following diagram it is possible to see the several inputs and outputs from each task and their indirect correlations.
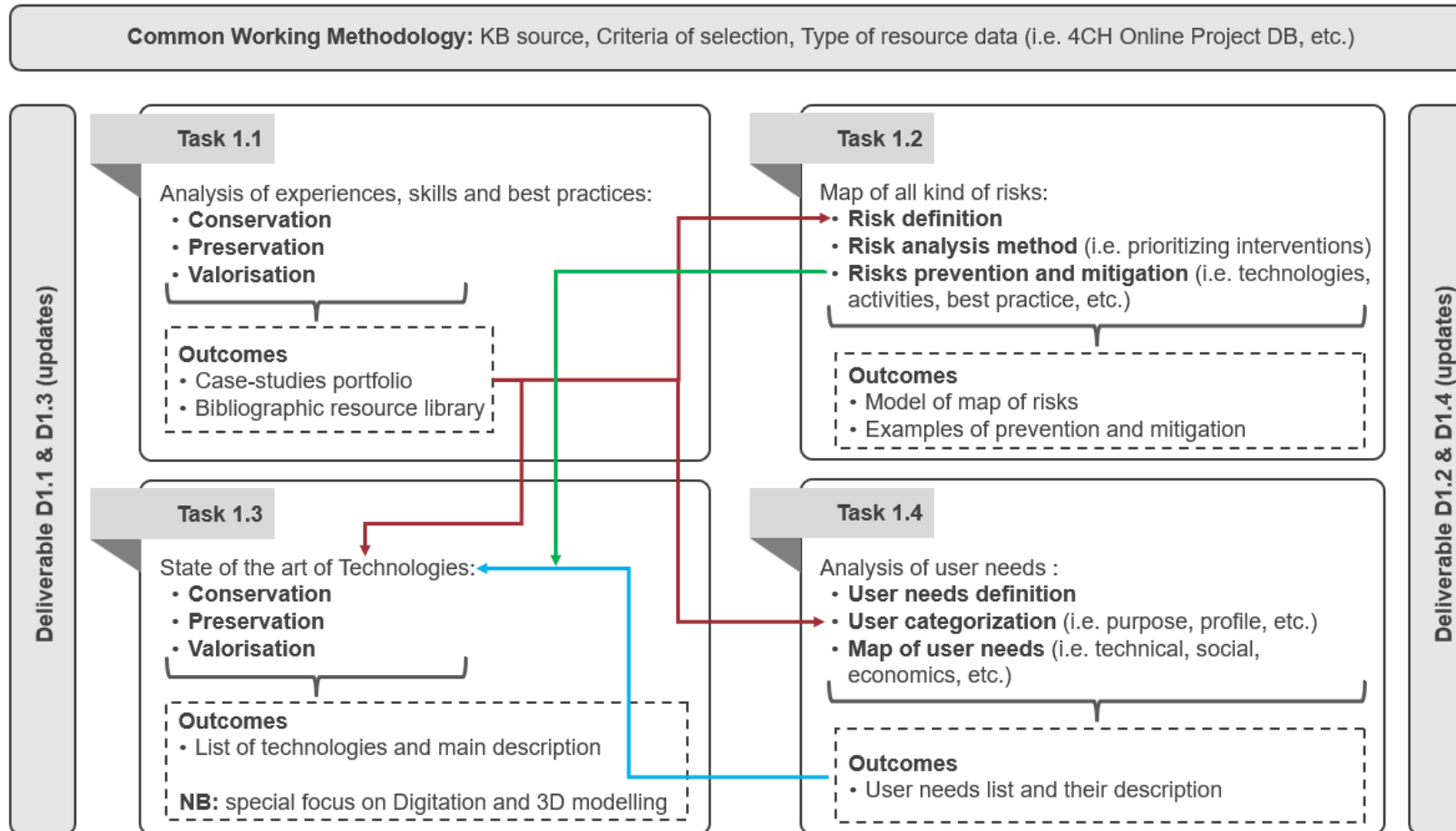
Figure 1. 2 - Correlation between Tasks

1.3.   WP1 working methodology

A shared working methodology has been defined for each task in order to be able to exchange inputs and outputs and have the same analysis strategy.

The working methodology has been used to identify the state of the art, relevant best practices, the main technologies and their possible application in CH, risks related to conservation and preservation and, finally, user needs.

With reference to this, preliminary work was shared between the WP1 tasks, regarding the CH description, the method (matrix) and terminologies. Subsequently, the individual tasks continued the work by detailing and modifying their relative matrices.

For each data source (EU projects, technical reports, interventions on CH assets, bibliographic references, etc.) specific selection criteria were applied to have a common assessment parameter. The aim of this approach is to create a Knowledge Base (KB) identifying the elements of interest: technologies, case studies, possible applications.
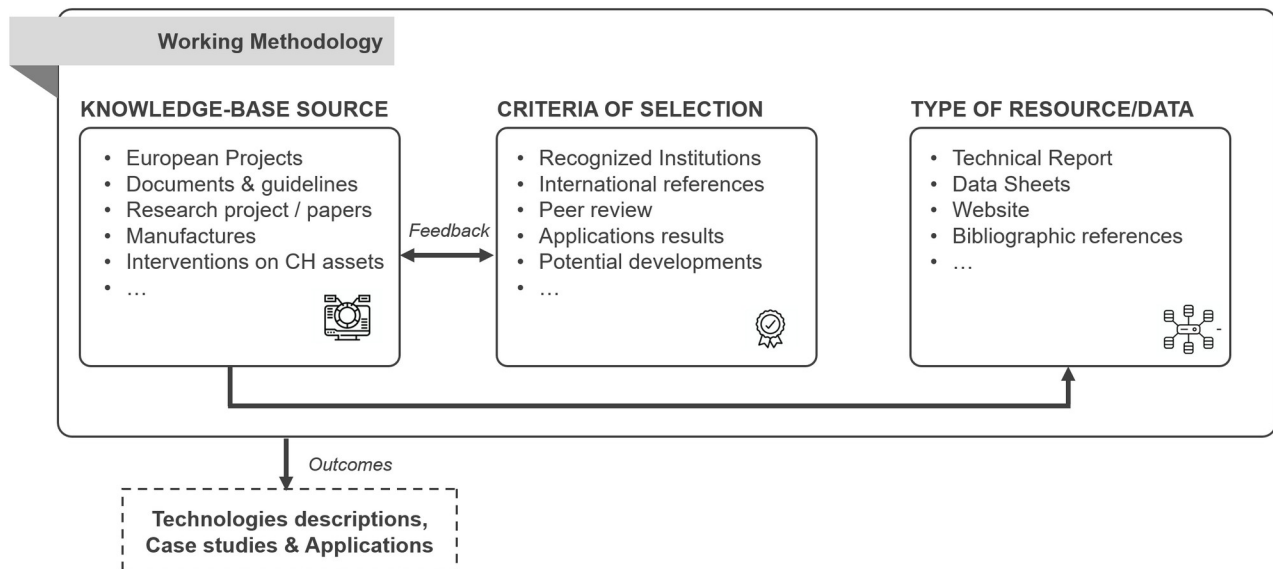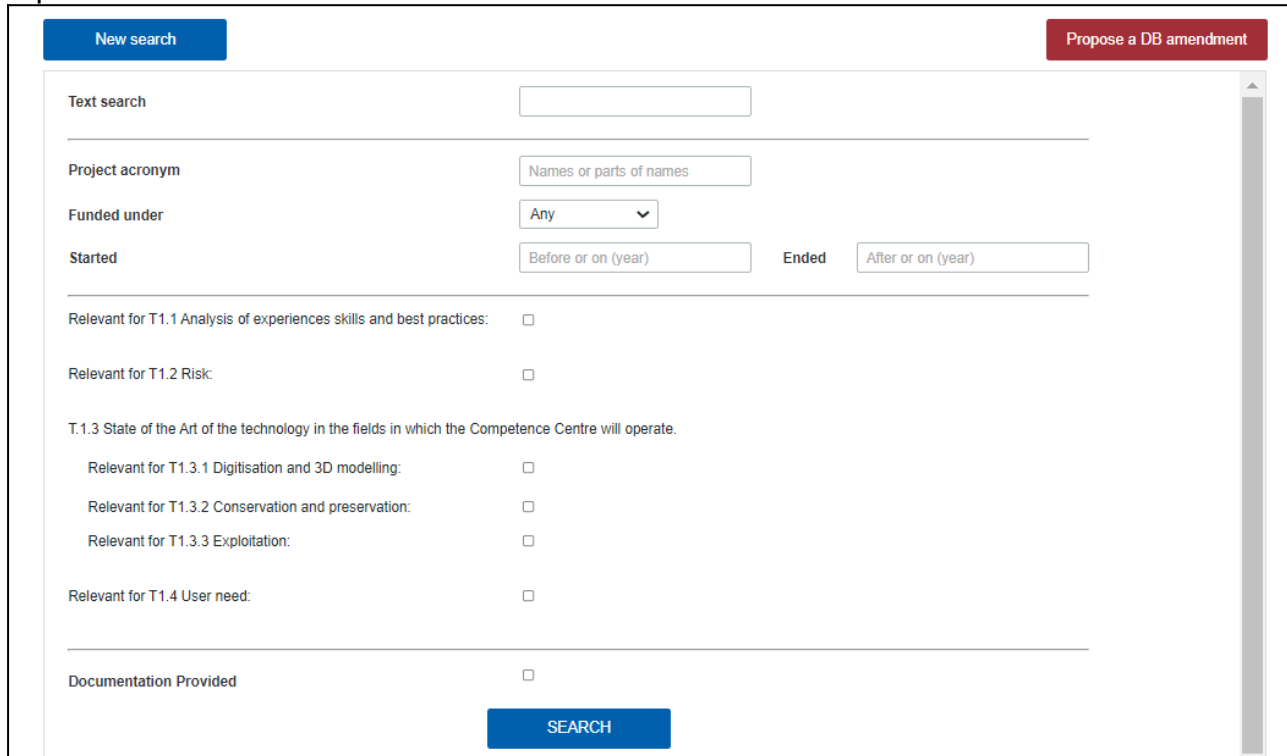
Figure 1. 3 - Common working methodology

A [Database](#) of European projects on topics relevant for the 4CH work programme was created. These include among others 3D modelling for Cultural Heritage, Conservation and Preservation research, Cultural Heritage exploitation and communication with digital technologies, and more. The database contains hundreds of EU projects selected from FP3, FP4, FP5, FP6, FP7, Horizon 2020, CIP, Creative Europe, Interreg and other EU programmes, and is searchable according to different search parameters. The

selection of the pertinent and relevant projects was carried out with the contribution of all the WP1 tasks, each for the topics of its competence. Summary information is presented for each project, with links to the project web site, project outcomes and reports where available.

Figure 1. 4 - Database of European projects on topics relevant for the 4CH work program

2. Implementation of a map of all kinds of risks which can damage Cultural Heritage assets for prioritizing preservation and conservation activities (Task T1.2)

2.1. Introduction

Task 1.2 aims to analyse the current state of research linking causes to adverse effects. It provides information to organise the knowledge base and the Competence Centre's recommendations. The Cyprus Institute (CyI) is the leader of Task 1.2, with the participation of INFN, INCEPTION and UNIBO.

Task 1.2 started on month 1 (January 2021) and ended its first phase on month 17 (May 2022). The first phase of the work focused on the field current situation assessment by

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

analysing various European projects and relevant literature. Then, a map of all kinds of risks (Matrix) affecting Cultural Heritage has been developed. The Matrix aims to evaluate hazards and threats in Cultural Heritage and identify solutions for the preservation, conservation, and valorisation of Cultural Heritage assets. Mainly, the Matrix is based on a division of two types of risks: natural and anthropic. Such division reflects a holistic approach to recognising the risks, their causes, overlapping, and eventually planning actions according to prioritisation. Finally, real case scenarios were opportunely chosen to evaluate the developed methodology and test the Matrix.

Towards the end of the project other working months were foreseen for this Task. An update of the work produced during the previous period has been planned and carried out from month 33 (September 2023) to month 35 (November 2023). In particular, the updated work proposes a standardisation of the Matrix for mapping risks in CH and provides heritage professionals with a system to document endangered Heritage and evaluate hazards through a standardised nomenclature (Risks Matrix vocabulary). That is specifically useful for the selection of appropriate strategies and instruments (e.g., digital tools, analytical instruments) for prioritising Cultural Heritage assets preservation and conservation. Moreover, some of the CH assets previously selected are used to demonstrate the application of the standardised system and methodology in real-case scenarios. The methodology and the system discussed here are preparatory to developing a future digital tool to assist in CH risk analysis for disaster reduction. The current section of Deliverable 1.4 is an update of the work. A related analysis, which focuses on the implementation of workflows and simulation through international pilot cases, will be provided within Task 4.4 (Implementation of workflows and simulation through pilot cases) of Work Package 4.

Finally, based on the whole methodology and its standardisation, Task 1.2 has focused on updating guidelines according to the 4CH project's three main pillars (preservation, conservation, and valorisation of Cultural Heritage) and recommendations for organising the knowledge of the Competence Centre concerning the risks mapping and damages reduction for CH assets.

2.2. State of the art

The conservation and preservation of CH is at the heart of the European cultural discussion. Recently, the debate has largely been focused on CH at Risk. Indeed, over the last decades, natural catastrophes and human activities intensified, causing the severe loss of Cultural Heritage assets worldwide. Consequently, research for scalable solutions to mitigate and prevent them increased. Many local, national and international initiatives have carried out several actions, both on protecting and conserving Cultural Heritage and increasing awareness within a broad range of stakeholders on the value and vulnerability of heritage assets.

To build an overview of the research on risks for the development of Task 1.2, the team collected information about European projects (current and finalised EU projects), selected the most relevant and exhaustive reports about the topic under analysis, and evaluated relevant online platforms. Indeed, some EU-funded research projects have

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

investigated the preservation and sustainable management of Cultural Heritage assets. Innovative solutions and techniques, assessment systems, risk management models, disaster prevention, and ICT tools are some of the major results successfully delivered by projects within the Seventh Framework Programme (FP7) and the Horizon 2020 initiative. Furthermore, the comprehensive state of the art of Risk analysis at the national and European levels, Cultural Heritage hazards and threats, risk management strategies, mapping risks, valorisation of cultural assets and Climate Change issues has been based on a variety of scientific publications.

In conclusion, several initiatives have shown an interest in hazards and threats, focusing on risk management and valorisation of cultural assets. However, the current literature has shown a gap in the documentation, mapping and monitoring of risks that affect Heritage, as well as a lack of comprehensive and holistic tools which identify a cultural heritage asset and its risks with the threefold outcome: conservation, preservation and valorisation. Moreover, the state of the art underlined a gap in developing tools that enable active engagement between local-level and experts' input for Cultural Heritage conservation, preservation and valorisation.

The current section of the Deliverable presents an overview of the state of the art on risks in CH, and the type of material assessed and analysed. For a thorough report on the current state of the art, please refer to Deliverable 1.2.

2.3. Methodology

Cultural heritage includes a wide range of assets, such as historic buildings, buried or underground archaeological sites and artefacts, all of which may be impacted by completely different types of hazards. Indeed, risk exposure is various, and diverse scenarios can be possible. Furthermore, another factor that adds to the vulnerability of CH assets is their location. Because of this, a thorough and standardised system is required to assist various professionals and stakeholders in identifying hazards and taking appropriate actions to reduce risks. As such, it is imperative to address how heritage and its risks are documented, and the tools to be used for that purpose. To ensure the success of the final outcome, a methodology and all necessary work steps had to be defined.

Specifically, the methodology for the implementation of the standardised semantic system aimed at the identification and assessments of risks affecting Cultural Heritage consisted of the following six steps:

- **Definition of the purpose and scope**
  Framing of the research scope and identification of the specific problems to solve.
- **Data collection and identification of key concepts**
  Data collection (e.g., literature review) and its analysis for the identification and

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

excerpt of key concepts (e.g., categories, entities).

- **Design of the Matrix structure**
  Design of the Matrix structure based on the identified key concepts: the fields of the Matrix and how they relate to each other have been determined.
- **Selection and use of case studies for testing the Matrix structure**
  Use of selected Cultural Heritage sites affected by risks or subjected to damages for testing and validating the Matrix structure in the documentation and assessment of the risks and their consequent mitigation.
- **Standardisation of the Matrix structure**
  Standardisation of the Matrix structure and adjustment of relationships between the entities based on the insights obtained from the test cases.
- **Development of a common and standardised nomenclature for risks definition**
  Development of a common and standardised vocabulary for the definition of risks aimed at facilitating their documentation and at managing and preserving CH under threats.

A top-down and a bottom-up approach have been combined to create the proposed standardised system for Cultural Heritage at Risk analysis. In accordance with the conventional top-down methodology, we began by conducting a broad analysis of the risk assessment topic before progressively delving deeper into the lower layers.

The first step was to define the research topic and pinpoint the specific risk reduction issues in CH conservation and preservation that we hoped to resolve. As a first step in addressing risk reduction issues, a standard nomenclature of risks in CH was assessed as a critical gap in this field.

A systematic literature review was conducted. The literature review focused on the threats and hazards of Cultural Heritage sites, vulnerability of Cultural Heritage, climate change, disaster risk management of Cultural Heritage, and Cultural Heritage value chain (creation, production, and transmission).

Successively, after the collection and the analysis of dedicated literature, we were able to obtain a first level of information and extract key concepts for the identification of the hazards affecting CH.

Such a step led to the design of a Matrix structure for the identification, documentation and management of the risks in the CH domain. The Matrix is based on a division of two types of risks, natural and anthropogenic. A dyad like this and its sequential development address a holistic approach for a thorough comprehension of the risks that can damage a cultural asset. However, it is also crucial to examine the interaction among risks and evaluate their impact, rate, and frequency. The Matrix enables heritage

professionals and institutions to map the risks, the actual and possible damages and prioritise the risks according to the specific needs in terms of methods, technologies, financial and human resources at disposal, tools, services, policies, and strategies.

After this first design and construction phase, then, a bottom-up approach was applied using real cases in order to test the accuracy of the Matrix structure. The implementation of the Risk Matrix was fuelled by the direct study of some heritage cases located in Cyprus. The test case phase involved fieldwork activities for the direct analysis of the sites and monuments. Such Heritage cases were used to better understand the hazards that may occur in various CH scenarios, from urban to complex landscape sites, and ultimately to evaluate the approach proposed. These sites are significant examples of multi-layered, past, and contemporary Cypriot heritage that are under threat and need to be preserved for the benefit of the community. Their characteristics helped to fine-tune the Matrix design, and finally, opened new directions for further steps of the Matrix implementation.

Indeed, the sequential step consisted of the structure finishing and its complete standardisation. This process revealed whether the Matrix structure was able to capture the relationships between elements and provide significant insights.

This phase needed the parallel development of a common and standardised nomenclature for risks definition. The methodological pipeline allows always going back to the previous steps in order to update the Risk Matrix and enhance its structure.

2.4. The Risk Matrix: a standardised semantic system for mapping all kinds of risks in Cultural Heritage

The considerations about risks, the evaluation of the gathered sources and the identification of gaps in the field led to the development of a Matrix for the mapping and consequent reduction of risks in Cultural Heritage.

The Matrix is a semantic system for mapping all kinds of risks, giving the possibility to pinpoint the most common risks affecting CH sites, monuments, and landscapes. Since artefacts are frequently a component of these structures, it is important to keep them in mind when addressing risks and dangers. In fact, in addition to their own risks, they might be additionally subject to overlapping threats from the environment they are in or the places where they are conserved.

Standardisation is essential for the successful digitalisation of processes and systems. In this case, the standardisation of the Matrix helps promote interoperability, efficiency,

quality assurance and risk mitigation. Thus, embracing and adhering to standards was a crucial phase in the Matrix's development. This semantic tool attempts to guide professionals and researchers in identifying current damages and tracing hazards that may harm the cultural asset under analysis. It helps define the cultural asset's typology and its current condition, then it guides in mapping the risks and eventually selecting the best conservation, preservation and valorisation strategies.

The initial structure of the Matrix, conceived as a sum of tables, has been then transformed into a standardised and hierarchical structure, updatable and modifiable, giving the possibility to integrate and implement it in case of missing elements.

The standardised Matrix is built on a division of risks into two categories: natural and anthropogenic. We determined the fields of the Matrix and how they relate to each other. We identified the Matrix's fields and their relationships. Moreover, we considered the possibility of the Matrix being symmetric, hierarchical, or exhibiting other particular patterns. A hierarchical structure able to highlight the relationships between the fields has been implemented.

The Matrix is a semantic tool that provides professionals and researchers with a guide to define the cultural asset's type and its actual condition, then map the risks that can damage it and consequently select digital and analytical tools, and strategies to be employed for conservation, preservation and valorisation purposes.

Therefore, the main scopes of the matrix are:

- Identifying and locating the Heritage asset

- Identifying all kinds of risks

Moreover, this semantic system is conceived as a complementary for:

- Assessing damages

- Identifying the best digital strategy for Cultural Heritage asset conservation, preservation and valorisation, and risks reduction.

Following, an updated description of the Matrix, its standardised structure and scope notes of the fields are provided.

Identifying and locating the Heritage

The first level ('*Cultural Heritage*') of the hierarchical structure allows the user to identify and describe the cultural asset through its main characteristics. In order to conduct a preliminary general analysis of the asset, this identification takes into account its

general conditions and features. This upper level is further subdivided into two main macro-groups, broader categories classifications of heritage elements or cultural artefacts, used to categorise the diverse range of Cultural Heritage items and sites. These categories include: '*Monument/Site/Landscape*' and '*Artefact*'. They provide a fundamental structure that enables a cultural asset to be exhaustively and transversally analysed, taking into account not only its features but also their interactions, the relations between those features and hazards, as well as the overlapping of the risks (fig. 2.1).
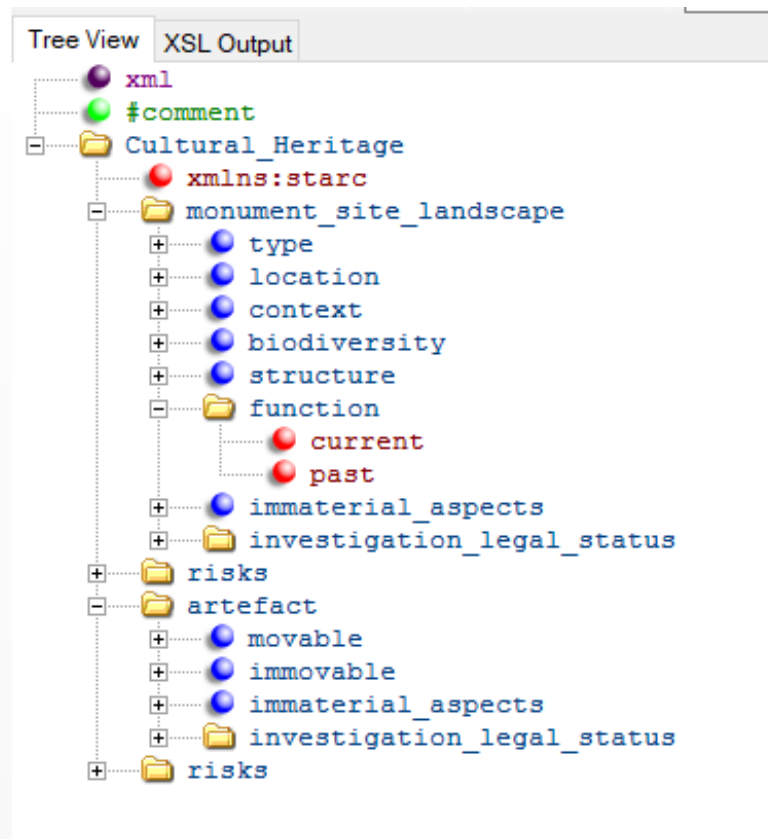
Figure 2. 1 - Identifying and locating the Heritage. In the Matrix, CH is grouped into two categories: i) "monument/site/landscape" and ii) "artefact." Each sub-folder defines and describes the cultural asset's type and its characteristics.

To assist the user in providing a more detailed description of the heritage asset under analysis, each of these levels is divided into sub-levels. Specifically, the '*monument/site/landscape*' presents a series of fields to provide information about: the specific '*type*' of the asset (e.g., built, natural); the type of '*location*' the asset has (e.g., underwater); the '*context*' which is in (e.g., urban context); which kind of '*biodiversity*' is connected to the asset (e.g., flora, geology); the type of '*structure*' the asset is, in terms

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

of relation with other structures (e.g., stand-alone, complex). Among these sub-levels, a highlight is given to the description of the '*function*' of the asset (fig. 2.1). Indeed, the '*function*' is set to provide information on the cultural asset's use through time thanks to the association of attributes: specifically, one attribute is used to describe the asset's current function ('*current*') while another is used to describe the asset's past function ('*past*'), taking into account changes in the asset's intended use over time. In fact, determining the CH functions can help with understanding the asset's current condition, the cause of certain damages, and creating a customised risk assessment for mitigation.

The '*artefact*' section of the schema has been divided into levels that are helpful in identifying the type of item and providing appropriate description. In particular, the fields aid in identifying which category the item falls into and what kind of artefact it represents, such as '*movable*' (e.g., a work of art, a historic replica, written evidence) or '*immovable*' (e.g., frescoes, mosaics).

Lastly, a field called "*immaterial_aspects*" is devoted to the identification and description of elements that are not related to the materiality of the asset but to its immateriality, such as languages, ancient traditions, traditional crafts, artisanship, performing arts, rituals and festivals. Table 2.1 provides the list of the fields for identifying and locating the Cultural Heritage with the related scope note to support the user in filling in the schema with a complete description.

Table 2. 1 - Identifying and locating the Heritage. A scope note is provided for the fields of the sections dedicated to the description of the asset.

MONUMENT/SITE/LANDSCAPE		
type	This field describes the type of asset under analysis, such as if it is a built asset (e.g., a monastery), a carved one (e.g., a church in a cave) or a natural one (e.g., a secular tree).	
location	This field describes the general location in which the asset is included, such as on-ground, underwater, or underground.	
context	This field describes the context of the Cultural Heritage asset under study. For instance, if it is included in an urban or a rural landscape.	
biodiversity	This field describes the variety of all living organisms and their interactions, such as fauna and flora that can affect or alter the ecosystem as well as geological modifications. It can change over time (e.g., extinction or evolution of a species).	
structure	This field describes the type of structure, whether for instance it is a stand-alone one, part of a complex, or if it is considered an ensemble.	
function	**current**	This field describes the current function of the asset if changed with respect to the past (e.g., a museum).

	past	This field describes the function the asset had in the past (e.g., an electricity power plant, church).
immaterial aspect		This field describes the immaterial aspect the asset might be connected to or has (e.g., artisanship, social activity, performing art).
ARTEFACT		
movable		This field describes any movable piece of art such as historic replica, written evidence, architectonic features, ethnographic, eco-facts, and artworks.
immovable		This field describes any immovable element associated with the asset. For instance, the presence of frescoes or graffiti on its walls, or mosaics on the floors.
immaterial aspect		This field describes the immaterial aspect the asset might be connected to or has (e.g., artisanship, social activity, performing art).
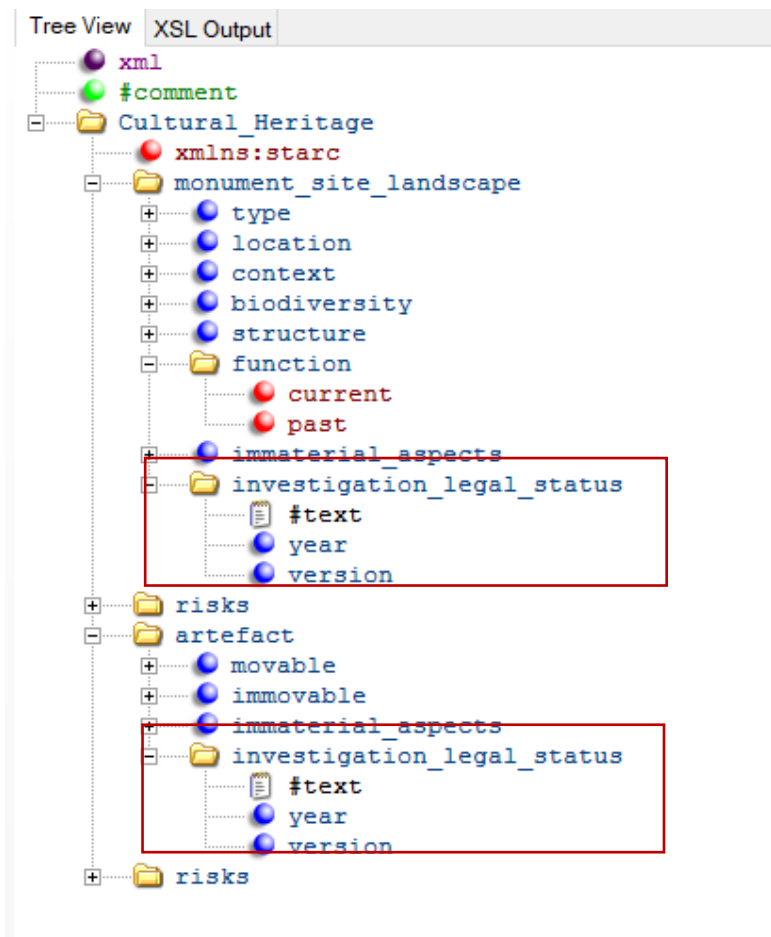
Figure 2. 2 . The schema allows the user to track the history of previous and current documentation.

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

The history of the previous and current documentation is essential and complementary to the risks' mapping. For that reason, the structured schema allows the user to report on the research history and legal condition of the asset ('*research history_legal_status*') by providing information on its status (e.g., studied; un-documented, preserved, recorded, excavated, archived, exhibited, digitally recorded) and on the date and/or version of the documentation (fig. 2.2).

Mapping damages and risks

The first stage in mapping the risks to which a CH asset may be exposed is the identification and framing of the Heritage. Because of this, the schema is designed to include a child section that, under the identified asset (such as a site, building or artefact), provides information and descriptions of all the potential hazards affecting the asset's integrity and well-being ('*risks*'). In the proposed standardised structure, all risks categories are grouped into two macro sections: '*natural_risks*' and '*anthropogenic_risks*'. Additionally, two more subfields have been added to the '*natural_risks*' section: '*cumulative processes*' and '*disasters*'. Their typology is the basis for the differentiation. A process is a series of actions that bring to a particular result. Specifically, cumulative processes are all forms of deterioration that gather gradually over time or any intermittent, fluctuating process and event that occur more than once per year. Based on their nature, the cumulative process can be divided into environmental (e.g., sea level rise, erosion, desertification) and biological processes (e.g., pests, vegetation growth, decay). Because of this, in the Matrix, two sub-fields, '*environmental*' and '*biological*' have been included for the identification and description of these cumulative processes.

Conversely, disasters are catastrophic events that frequently occur outside of human control, and with minimal or no prediction.[1] The insertion of sub-hierarchies under the natural disasters section of the schema allows for the capture of this type of information. For example, the '*invasive species*' field describes unexpected attacks of specific flora or fauna; the '*severe weather*' field gathers disasters that are caused by weather or climate, such as floods, storms and fires; and finally, the '*geological events*' field describes all risks related to geology, such as landslides, volcano activities or earthquakes . Unexpected natural disasters may directly or indirectly endanger Cultural Heritage assets, also posing negative consequences for the economies of the areas

_____

[1] For instance, some natural risks can be partially predictable thanks to the use of scientific and technological means (e.g., weather simulations, climate projections). Several studies focussed on the assessment of the potential impacts of climate extreme events (e.g., heavy rain, flooding, and drought) on Cultural Heritage, producing maps of risks [43] that are coming from the combination of climate variables and indices calculations with historical observations for near and far future climate projections.

affected since they often represent tourist drivers. However, natural processes that arise from the environment in which the heritage asset is placed, like weathering or wearing, may also function as continuous and persistent hazards that lead to its destruction. The Matrix's structure for mapping and characterising natural hazards that affect Cultural Heritage is depicted in Figure 2.3.
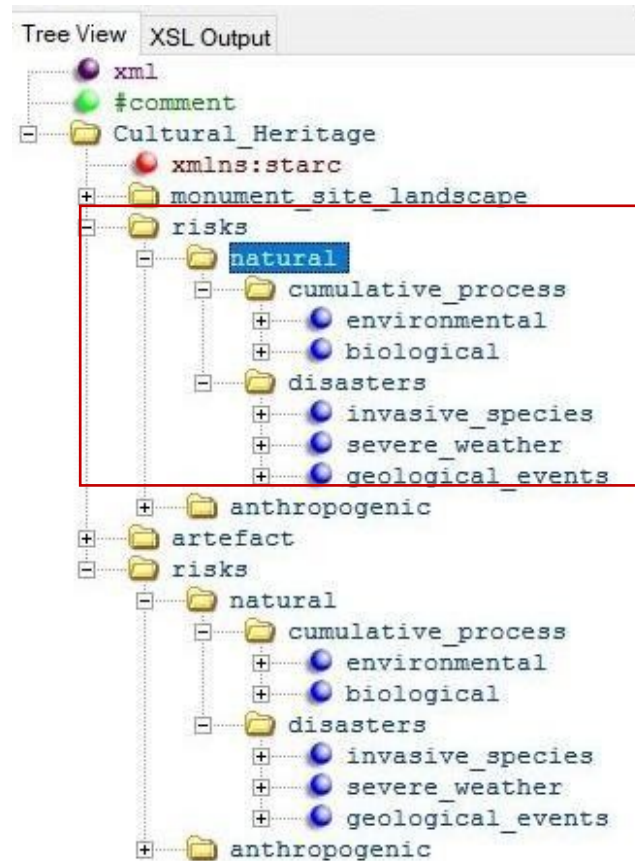
Figure 2. 3 - Mapping the Risks. The structured Matrix section aimed at recording the natural hazards affecting CH.

Cultural Heritage is at risk from a number of human activities, both individual and collective, which can equally alter its functions or result in its complete destruction.[2] The human impact on Cultural Heritage assets mainly depends on three factors: i) the degree of community and institution awareness, ii) legal recognition, and iii) protection.

---

[2] C. A. Sandes. Urban cultural heritage and armed conflict: the case of Beirut Central District. In *Cultural Heritage in the Crosshairs* (pp. 287-313). Brill (2013); A. Almohamad (2021). The destruction and looting of cultural heritage sites by ISIS in Syria: The case of Manbij and its countryside. *International Journal of Cultural Property*, *28*(2), 221-260.

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

The conservation and preservation of CH can occasionally be adversely affected by inadequate laws or lack of rules and conservation frameworks.[3] For instance, a Heritage asset becomes at risk when its significance is lost or diminished. Often, this condition involves physical damage due to consequent neglect, decay or even its use. In turn, heritage degradation negatively impacts local communities, causing a consequent loss of cultural value and identity.[4] Therefore, risk exposure can arise from factors that do not directly cause physical damage to CH but that derive from their loss of significance. For instance, communities may abandon an area for a variety of reasons, such as migration or armed conflicts): in such a case, the local heritage may remain orphaned and lose value due to a lack of care. Indeed, when there is no recognition of an asset as heritage by a community, then there is a separation between those heritage owners who would wish to enact policies and legislation for their curation, and those possessors of the location who are legitimately able to take care of the cultural heritage.[5]

These are complex risks that affect numerous Cultural Heritage assets, which need to be promptly identified and recorded. For that reason, as previously mentioned, the second macro section of the Matrix dedicated to risks describes the '*anthropogenic risks*'. These types of risks have been divided into two subsections, '*intended*' and '*indirect*', in accordance with the previous discussion. Intended risks are associated with intentional human actions that result in inevitable damage to the Cultural Heritage asset. Depending on what caused the damages, this set of risks has been split into two fields in the schema : the field '*management*' describes the risks caused by either good or bad curatorship of a cultural asset, such as its reuse or the lack of interest or care due to corruption; the field '*heritage crimes*' refers to those activities aimed at causing direct damages, such as vandalism or destruction, or resulting from other deliberate criminal activities (e.g., theft, illegal excavation, illicit trafficking). The '*indirect risks*' section deals instead with human actions that do not mean damaging a cultural heritage asset. Nevertheless, in doing so, they must be equally addressed and taken into account in the

---

[3] ICOMOS World Report on Heritage at Risk (2000). Available from:
www.icomos.org/public/risk/world_report/2000/riskindex_eng.ht (Accessed 20 July 2023).

[4] X. Romao, E. Pauperio, E. (2021). An indicator for post-disaster economic loss valuation of impacts on cultural heritage. *International Journal of Architectural Heritage*, *15*(5), 678-697.

[5] An example of this condition is represented by the Margo Jewish Cemetery located in the Turkish military zone of Nicosia (Cyprus) that testifies the Jewish presence after the diaspora of 1885 and World War II. Because of the 1974 Turkish-Cypriot conflict, the cemetery has been attacked, destroyed and neglected. Jewish organisations and other groups have petitioned for free access to the cemetery to conduct religious ceremonies but these requests have been always rejected since 1992 (L. Zaphiriou, C. Nicolaides, M. Miltiadou, M. Mammidou, Van Coufoudakis. *The Loss of a Civilization*. Nicosia (2012). Available from:
http://www.mfa.gov.cy/mfa/Embassies/embassy_thehague.nsf/CF30C1833A24D2FCC22578B00036FA20/$file/Destruction%20of%20cultural%20heritage%20(English%20version).pdf).

mitigation strategy (fig. 2.4). In the schema, each Cultural Heritage asset's section presents a relation with a section for the description of the risks. Table 2.2 provides the list of the fields for mapping the risks, along with scope note, of the two sections dedicated to the natural and anthropogenic risks affecting the CH asset.
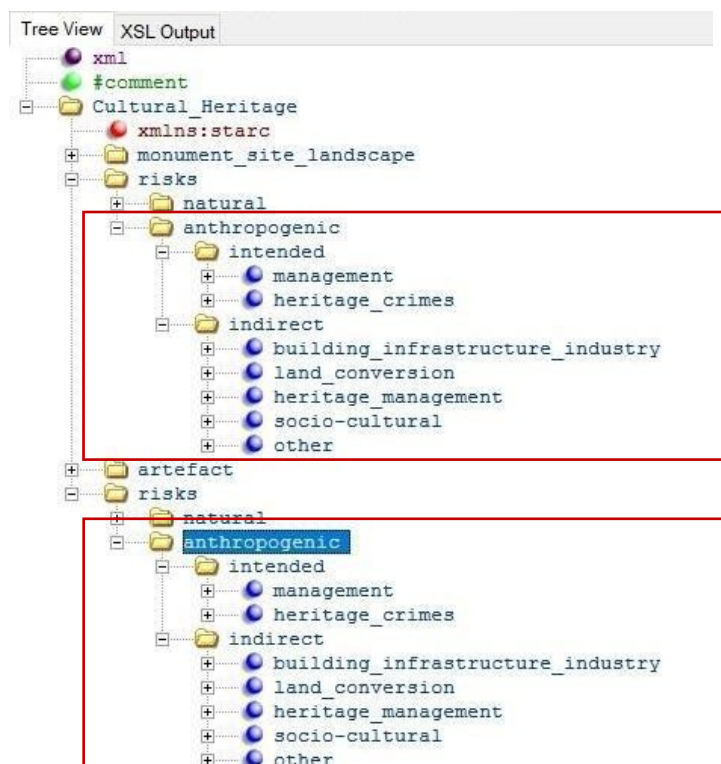
Figure 2. 4 - Mapping the Risks. Anthropogenic risks affecting CH are documented in this section of the structured matrix.

Table 2. 2 - Mapping the Risks. A scope note is provided for the fields of the two sections dedicated to the natural and anthropogenic risks affecting the CH asset.

Natural risks		
Cumulative process	environmental	This field describes the environmental cumulative process the CH asset and its area can be subject to, such as erosion or deposition processes.
	biological	This field describes any biological cumulative process, such as vegetation growth affecting the CH asset.
Disasters	Invasive species	This field describes the presence and type of invasive species (e.g., fauna, flora) causing disasters that can affect the CH asset welfare.

	severe weather	This field describes any occurrence and type of natural disaster due to climate-related causes (e.g., flood) CH asset and its area are subject to.
	geological events	This field describes possible geological events, such as an earthquake.
Anthropogenic risks		
intended	management	Under anthropogenic risks, this field describes those caused by intended management actions affecting the CH welfare, for instance, due to corruption or deliberate decisions.
	Heritage crimes	This field describes all those intended acts of crimes against the CH asset, such as illegal excavations carried out in an archaeological area.
indirect	building_infrastructure_industry	Under the section dedicated to indirect anthropogenic risks, this field describes all those activities connected, for instance, to building or industry activities, such as the construction of a road in the CH vicinity and affecting its well-being.
	land_conversion	This field describes those risks caused by the change of use of the land where the CH asset is located. For instance, the use of land for agricultural purposes can affect the integrity of an archaeological site hidden underneath the agricultural soil.
	Heritage management	This field describes the risks connected with Heritage management and causing indirect damages to a CH asset, such as a bad restoration process or a bad management of the visitors flow.
	socio-cultural	This field describes the indirect risks caused by socio-cultural occurrences, such as a change or loss in value of an asset, or the risks caused by modern performances in an ancient theatre.
	other	This field describes the risks caused by any other possible activities previously not considered, such as the war affecting the safety of a country's Cultural Heritage.

'The final version of the standardised hierarchical Matrix in .xml format is attached in Appendix 1. Risk-Matrix.

Following the identification and assessment of the risks to which the cultural asset is exposed, a sequence of successive assessments must be completed within the framework of cultural asset analysis in order to rank the risks and require additional

documentation. More specifically:
- the impact of the damages
- the severity of the damaging
- the influence of time
- the interaction among risks
- the overlapping of the risks
- the identification of the frequency or/and the rate of the risks

2.5. Application of the standardised Matrix to real case scenarios

As explained in the methodology, examples representing CH assets of different typologies have been used to test the standardised structure developed through a top-down procedure. The bottom-up approach started from the real case scenarios to test the Matrix with the aim of identifying gaps in the risks' description (e.g., lack of fields, relationships between the fields) and, eventually, integrating it. By integrating top-down and bottom-up methodologies, we ensured that the Matrix's structure was rooted in a clear purpose while also being tested and validated using real test cases. Indeed, the real case scenarios helped us to identify issues in the schema, to reason on the hierarchies and relations between the parts, and to fix them thanks to a holistic and, at the same time, schematic standardised vision.

Within the frame of the 4CH project, the selected test cases are relevant for the complex segmentation of their stakeholders and users' needs. Particularly, for the task aims, the following steps guided the analysis of the test cases:

- Identification of the Cultural Heritage assets, their history and relevance

- Evaluation of the diverse layers of interest while mapping the risks

- Assessment of the risks according to the Matrix

Specifically, the Task 1.2 team selected three important case studies located in Cyprus representing different types of cultural assets and differing by type, size, location, regulation, intended use, type of management, and showing diverse research inquiries according to the three main pillars of 4CH: conservation, preservation and valorisation (see D1.2 for a thorough description of the assets). Moreover, the selected assets present several phases of use and reuse, and they are subjected to different kinds of risks. The geographical selection of the cases was due to the necessity to physically survey the places during the matrix development and assessment in order to study and analyse the assets from close.

In the current Deliverable, only two cases are presented to show the application of the standardised Matrix for the risk assessment. In the text, the test cases are described

through the use of the Matrix components while the images show the technical application of the Matrix to describe the heritage assets and the risks affecting them, as well as to validate its effectiveness in documenting the desired information of heritage assets at risk.

The two sites, on which the standardised risk map is applied, are:

- The Paphos gate of the Nicosia city walls

- Ayia Napa Monastery

The further simulation and implementation of workflows through international pilot cases will be carried out within Task 4.4 (Implementation of workflows and simulation through pilot cases) of Work Package 4.

2.5.1 Ayia Napa Monastery (Cyprus) test case

Cyprus's southeast coast is home to the Ayia Napa monastery. Owing to its prominence, this location saw a significant transformation in its urban and sociocultural landscape in less than 50 years. Though the monument has just undergone restoration, its remarkable preservation still makes it a test case for the asset's future role and function in the local and global community. This is why it was selected for the application of the standardised Matrix for the assessment of risks which is subject to.

The current case is an example of a [*monument_site_landscape*] *Cultural Heritage building* located on the southeast coast of Cyprus, in Ayia Napa. It is a [*type*] *Monastery* dedicated to the homonymous Saint who also gives name to the town. The Medieval church is in a [*context*] *urban area* and is built on an [*location*] *underground cave* in the rock characterising the morphology of the area. The monastery consists of [*structure*] a *complex of structures* including the church, the rectangular courtyard and various buildings: a large covered gallery, part of the brethren's building, an old octagonal fountain in the centre of the court, the fortress walls, and the gate tower. The monastery still maintains its [*function_past*] *religious purpose*, adding to that [*function_current*] the function as a *museum* and as a *conference place* for the activity of the religious St. Epiphanius of Salamis Cultural Academy. The church attracted numerous pilgrims' visits for venerating [*artefact_movable*] a *girdle*, a bronze belt that was believed to belong to the Virgin Mary and [*immaterial_aspect*] have the *property to make women fertile*. The cult at the church was also favoured by the presence of [*artefact_immovable*] a *water source* in the cave believed to [*immaterial_aspect*] have a *holy function*.[6]

Due to the popularity of this area for the beaches and nature, in less than 50 years, the site experienced a massive change in its urban and socio-cultural landscape. The entire cultural heritage site, despite the good state of preservation of the monument due to recent restorations, is an example of a historical complex landscape, with multi-layered architectural elements, religious and social activities, subject to anthropogenic risks. While the main [*natural_risks*] dangers are connected to several *cumulative processes*

---

[6] G. der Parthog. Byzantine and Medieval Cyprus: a Guide to the Monuments. Paperback, pp. 322-325. (1995).

(e.g, structural degradation of the building materials, geomorphological degradation of the cave, vegetation growth), the [*anthropogenic_risk*] principal hazard is the *mass tourism activity* and its related damages (e.g., flux of peoples, neighbouring commercial activities, acoustic pollution, dirtiness). During the last years, [*heritage management*] several *valorisation activities are under development*[7] and projects have been proposed[8], aimed at integrating the Monastery into a more sustainable tourism strategy able to highlight the site's cultural and religious identity. Figure 2.5 visually shows the use of the Matrix for the description of the Ayia Napa Monastery and the risks it is subjected to.
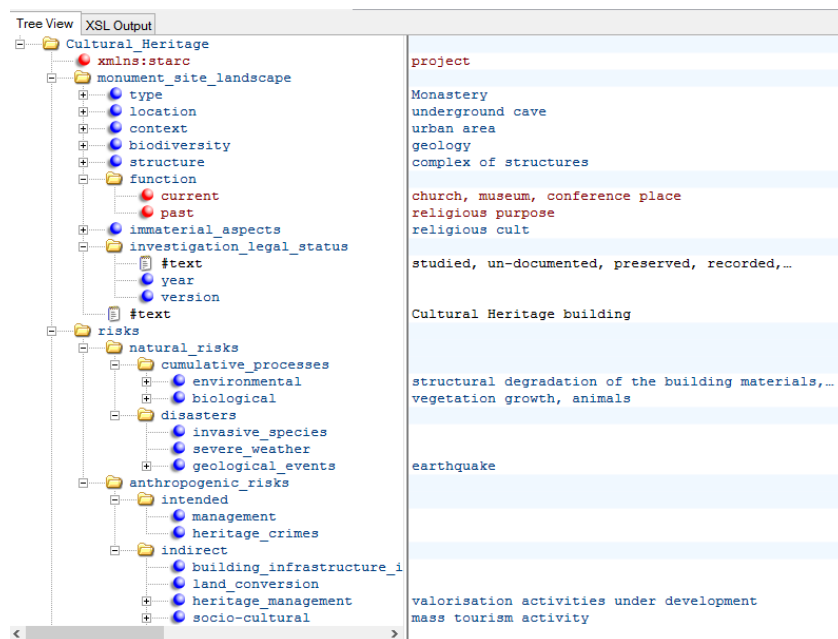
Figure 2. 5 - The use of the Matrix for the description of the Ayia Napa Monastery and the identification of the risks.

2.5.2 The Paphos gate of the Nicosia city walls (Cyprus) test case

Another Cypriot cultural asset was selected to test the Matrix due to the interesting and varied nature of the site. The Paphos gate in Nicosia is a site included in the urban

---

[7] B. Schrade. Sharing the Holiness: Agia Napa and the Byzantine-Latin Transfer of Hagiography and Iconography. In Giangou, T., Kakkoura, C., Karayiannis, V. & Nassis, C. (eds.), ΥΠΡΙΑΚΗΑΓΙΟΛΟΓΙΑ3 und 4. Paralimni 2021-22. Jansen-Verbeke 1997 (2021).

[8] Vassallo et al. (under review) The Valorisation of Religious Underground Built Heritage: Challenges and Potential in the Ayia Napa Area. Pace, G. & Trentin, M. (eds.) *Third Handbook on the Underground4value Training School*. Consiglio Nazionale delle Ricerche; T. Pianese, L. Nunziata, V. Filimonau, B. Hernández Millan. (under review). "B.O.O.S.T.E.R.: Building a mOre respOnsible and Sustainable Tourism in Ayia Napa in a post Covid-19 ERa". Pace, G. & Trentin, M. (eds.) *Third Handbook on the Underground4value Training School*. Consiglio Nazionale delle Ricerche

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs
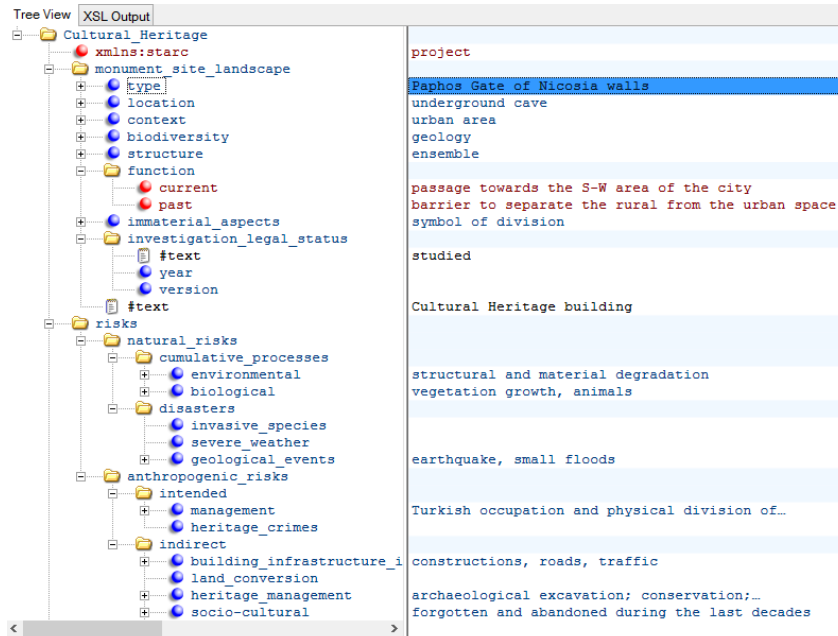
environment. The site presents an on-ground location with complex structures and biodiversity. The entire site holds immaterial aspects of social activity. Indeed, the spatial context of the site offers several points of interest for the conservation, preservation, and valorisation of the heritage asset, taking into consideration the overall spatial and cultural environment of the site.

The so-called [*monument_site_landscape*] *Paphos Gate of Nicosia* is one of the three gates of Nicosia's Venetian walls which are still largely intact and are among the best-preserved Renaissance fortifications in the Eastern Mediterranean area. Until the beginning of the 20th century, the city's gates, the Paphos' one included, functioned [*function_past*] as a *barrier to separate the rural from the urban space* leading to the western part of the island and operated without interruption during the Venetian, the Ottoman periods and under British rule. Today, the gate is integrated into [*context*] the *urban frame,* located [*location*] *on the ground* at the same level as the current pavement and [*function_current*] *serves as a passage* towards the S-W area of the city. The Paphos gate [*structure*] is an *ensemble*, part of the walls which surround and contain the ancient nucleus of the city. Still, [*movable-artefact*] a preserved *ancient wooden door* shows how the area and the passage looked like in the past. Since the 1974 [*anthropogenic risk/indirect/other*] *Turkish occupation* and the physical *division of Nicosia*, the Paphos gate has become [*immaterial aspect*] an iconic *symbol of division* due to its location on the so-called 'Green Line' that divides the city and the island into two parts.[9] Until a few years ago, this site represented an interesting example of Heritage affected by anthropogenic activities. The area was, in fact, [*anthropogenic risk/indirect/socio-cultural*] *forgotten* and *abandoned* during the last decades due to the gradual movement of commercial and cultural activities from the old city centre to other parts of Nicosia. During 2013 and 2014, the outer part of the Paphos gate moat was subject to [*heritage management*] *archaeological excavation, conservation* and *valorisation activities*. An access bridge was constructed over the excavated features and connected the sidewalk with the gate with the aim to preserve, valorise and reactivate the area.[10] Figure 6 shows how the Matrix is used to describe, locate and

---

[9] G. Artopoulos, N. Bakirtzis (2014) Virtual Narratives for Complex Urban Realities: Historic Nicosia as Museum. 10.13140/RG.2.1.4399.3360.

[10] On this occasion, a 3D documentation and a 3D model reconstruction of the gate was created aiming at guaranteeing the continuity of its historical and social value (F. Niccolucci, A. Felicetti, S. Hermon. Populating the Digital Space for Cultural Heritage with Heritage Digital Twins. Data 2022, 7, 105. https://doi.org/10.3390/data7080105). From a valorisation point of view, this study produced a walking experience that aims to integrate the historic site into the pedestrian network of the contemporary city (G. Artopoulos, P. Charalambous. 'Analysis of Spatio-Temporal Data in Virtual Historic Spaces,' in International Conference on Artificial Reality and Telexistence Eurographics Symposium on Virtual Environments, edited by Gerd Bruder, Shunsuke Yoshimoto, and Sue Cobb, Eurographics Proceedings, Eurographics Association: ACM Library, 2018, pp. 9-12. doi:10.2312/egve.20181308).

identify risks affecting the Paphos gate CH asset.

Figure 2. 6 - Paphos gate CH asset and its risks are identified and described through the Matrix.

The test cases selected are built heritage since this type of heritage is the main object of Task 1.2. However, as shown in the Matrix structure, artefacts are often parts of such structures, and, they are subjected not only to their own risks but can suffer from an overlap of threats. Therefore, various risks have to be analysed to guarantee the assets overall preservation. In this context, a specific example of a built heritage asset is represented by museums since they cover two cultural roles: the one as a Cultural Heritage asset itself and the one as a "container" of other Cultural Heritage assets (artefacts). In this regard, Task 1.2 team's actions aimed at developing strategies also for prioritising the preservation and conservation activities of archaeological museums as a Cultural Heritage asset. For that reason, the test and application of the Matrix on an archaeological museum has been carried out. Particularly, the Archaeological Museum of Siteia in Crete, a place conserving unique cultural pieces and subjected to several risks, was used for better implementing the map of risks that took into consideration natural and anthropic factors that can damage the museum and its archaeological finds. The standardised Matrix was also used for the famous Kouros of Palaikastro[11], an important artefact conserved and exhibited at the museum, for the

[11] The artefact is a unique chryselephantine (gold-and-ivory) human statuettes found fragmented in the Minoan settlement of Palaikastro (Crete). Sackett, Hugh, Alexander MacGillivray, Jan Driessen, and Doniert Evely. "The Excavation." *British School at Athens Studies* 6 (2000): 21–34.

identification of the risks affecting archaeological artefacts in museums. The most relevant risks appeared to be: earthquakes, invasive environmental conditions, and museum visitors. The 3D documentation of the artefact and consequent analysis contributed to the set of requirements and protocols for a science and technology-based conservation and preservation of the whole Cultural Heritage asset.

2.6.   A standardised vocabulary for Risks

Controlled vocabularies, such as gazetteers and thesauri, are crucial resources for reference in many fields of scholarly work and guarantee interoperability across multiple platforms and their diverse data types. In this vein, in accordance with the goals of semantic interoperability and the Task 1.2 methodology, the team implemented a controlled vocabulary for the Matrix. Based on their current use in the CH field for the description of risk-related topics, a number of glossaries and/or thesauri have been identified and evaluated for that scope (table 2.3). The assessment's conclusion is that most of the vocabularies that are currently in use are primarily used for conservation and preservation efforts, but they partially cover the heritage at risk topic.

Table 2. 3 - List of the selected vocabularies (with weblink) and their assessment for the implementation of the Matrix thesaurus.

Vocabulary	Creator	Assessment
Getty Thesaurus: AAT	The Getty Research Institute	The Art and Architecture Thesaurus is a hierarchical vocabulary. The full published data set contains around 57,390 records for generic concepts. The thesaurus includes terms, scope notes, bibliographic citations, and other information relating to fine art, architecture, decorative arts, archival materials, archaeology, conservation, and other material culture. This thesaurus is not comprehensive. It grows through contributions aiming to gather terminology necessary for cataloguing, linking, and discovering information concerning visual arts.
Illustrated Glossary Technician Training for the Maintenance of In Situ Mosaics	The Getty Conservation Institute; Institut National du Patrimoine	This glossary aims to establish a common vocabulary for documenting construction techniques, mosaic conditions, and previous and current interventions carried out on mosaics. It aims to achieve consistent and objective recording. The text descriptions refer only to the visual evidence observed on site and not to the causes of deterioration. It is accompanied by photographs and drawings. Moreover, a reference stratigraphy is provided to identify mosaic construction techniques, and the most common types of mosaic floors are presented. Terms are divided into four main categories:

---

http://www.jstor.org/stable/40916612

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

		structural deterioration, surface deterioration, presence of bio-deterioration agents and deterioration of interventions.
EwaGlos – European Illustrated Glossary of Conservation Terms for Wall Paintings and Architectural Surfaces	THE HoRnEmann InSTITuTE	The main focus of EwaGlos is to clarify the current use of a term within different cultures and languages. For that reason, it offers English definitions with translations into ten other languages. This vocabulary intends to foster transnational cooperation between state offices, conservation institutions, universities, as well as building trades, tradesmen and the construction industry. However, it has neither hierarchical structures, nor a thesaurus which would combine terms according to their relationships. This glossary is beneficial for conservator-restorers and other professionals involved in the preservation of wall paintings and architectural surfaces. The glossary is divided into three chapters and a materials appendix distinguished by different colours for user-friendliness: a) art and Craft Techniques: Construction, Surface Design, Construction aids B) Condition: Deterioration Sources, Deterioration Phenomena C) Interventions: Documentation and Investigation, Preventive Conservation, Conservation, Restoration D) materials appendix.
Preservation Glossary	Conservation Center for Arts and Artefacts	This glossary was created as part of the Community Stewardship Program and can assist specific services in the CH sector (e.g., conservation treatment, surveys and consultation, digitization, preservation planning, project management).
Visual glossary	Australian Institute for the Conservation of Cultural Material	This glossary proposes a selection of terms useful for identifying damage and deterioration by comparison with the glossary image and description. The images can be used to identify deterioration in the collection and are helpful visual support in describing an object's condition. This resource has been compiled by conservators all over Australia. The definitions used in this glossary are informed by those used in reCollections.
Illustrated glossary on stone deterioration patterns	ICOMOS	The ISCS glossary constitutes an important tool for scientific discussions on decay phenomena and processes. Specifically, it is helpful for studies on stone deterioration. The glossary is arranged into six families: General terms, Crack and deformation, Detachment, Features induced by material loss, Discoloration and deposit, and Biological colonisation.
ARCH Glossary	European project ARCH	This glossary has been prepared in the framework of the European project HORIZON 2020 ARCH -Advancing Resilience of historic areas against Climate-related and other Hazards. The glossary is based on and extends the H2020 RESIN Glossary and the CIPedia.
First Aid to Cultural Heritage In Times of Crisis	ICCROM	It is a tool for working towards an agreed definition of some complex terms developed within the First Aid to Cultural Heritage in Times of Crisis course, organised in August 2018 in the Netherlands. It is drawn from diverse vocabularies, dictionaries, encyclopaedias, charters, conventions and bibliographic resources (e.g., the United Nations Office for

		Disaster Risk Reduction (UNISDR) terminology and an Internationally agreed glossary of basic terms related to Disaster Management).
Heritage Definitions: Definitions of terms used within heritage protection legislation and documents	Heritage England	It is a list of definitions of selected terms used within heritage protection legislation and documents published on historicengland.org.uk.

For example, the AAT thesaurus, which was mainly created for the description of Cultural Heritage at large, just includes few terms related to the risks description. Moreover, the examined thesauri and glossaries offer a variety of perspectives based on the particular field of CH they cover. In some cases, the selected glossaries are fairly accurate, but they only address specific topics: stones, for example, are covered by *the ISCS glossary*; wall painting and architectural surfaces are treated by the *EwaGlos*). Some of them have accompanying visual documentation. Nevertheless, they refer to possible cases of damages (e.g., Visual glossary) but they do not describe the causes of those damages. Furthermore, despite attempting a more formal and organised approach, most of them do not present a formal and standardised nomenclature. Thus, the assessment of the available vocabularies highlighted a need for a specific terminology dedicated to the CH at-risk field and alignment between the various available resources. Subsequently, the analysis highlighted the importance of having precise descriptions of terms and a shared vocabulary or thesaurus, eventually aimed at the development of a domain ontology on risks.[12]

After the glossaries and vocabularies were examined, their terms were assessed, compared, and aligned for the implementation of the Risk Matrix thesaurus (fig. 2.7). It has been demonstrated, in fact, that using terms from established vocabularies can ensure standardisation and interoperability.

---

[12] V. Vassallo, E. Christophorou, S. Hermon, F. Niccolucci, Revealing cross-disciplinary information through formal knowledge representation – a proposed Metadata for ancient Cypriot inscriptions. Digital Heritage International Congress (DigitalHeritage), 28 October – 1 November 2013 Marseille, France (Eds. A. C. Addison, L. De Luca, G. Guidi, S. Pescarin), IEEE.

Figure 2. 7 - Assessment and comparison of terms included in existing vocabularies devoted to risk-related topics in CH.

Our controlled vocabulary was developed using a terms mapping tool[13] set on the AAT thesaurus as a reference of terms. This thesaurus is, in fact, the only one among those identified that presents a standardised structure.
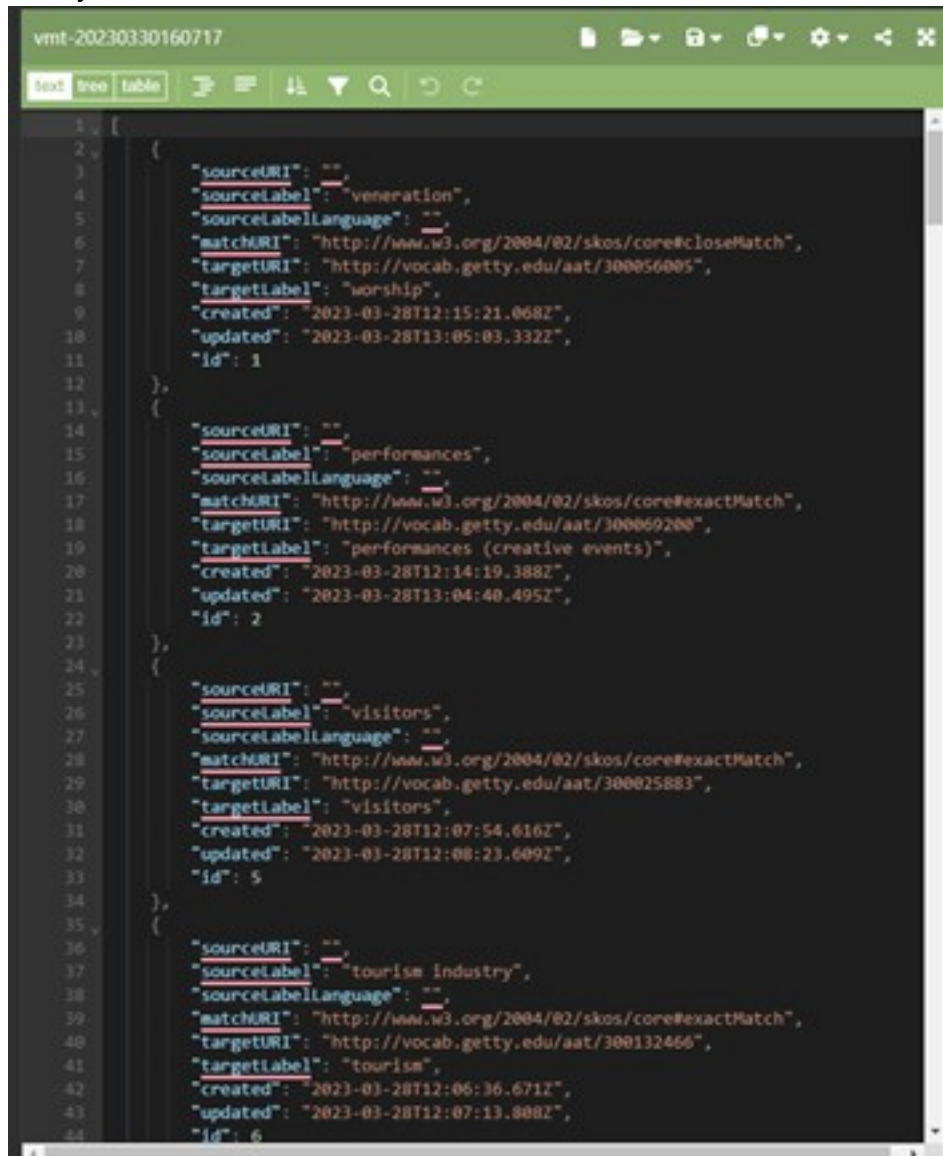
The vocabulary on risks was developed and exported in .JSON format so that SKOS mapping relationships could be used to express the data hierarchy (fig. 2.8). Additionally, since the reference thesaurus (the AAT) partially includes terms dedicated to the risks domain, the exported file has been further expanded by adding additional concepts required to describe the studied domain.

The implemented vocabulary is thought to be a dynamic and updatable one according to the need to incorporate new terms or concepts as well as to the occurrence of new developments in the risks domain. Indeed, updatability is crucial in the perspective of reviewing the vocabulary, to reflect changes in content, users, and context as well as

---

[13] The Vocabulary Matching Tool is a tool provided by the ARIADNE Research Infrastructure [58] and allows users to align vocabulary concepts with Getty AAT concepts. The tool is a browser-based application that presents concepts from chosen sources and targets vocabularies side by side, exposing additional contextual evidence to allow the user to make an informed choice when deciding on potential mappings.

following the identification of gaps, errors, or inconsistencies. Such updatability is correlated with the resource's discoverability and accessibility of, guaranteed by its standardisation, and the possibility to share it with the community to contribute to the domain knowledge and foster the contribution of the community itself in its development. The standardised vocabulary is actually intended for future integration in digital platforms and repositories aimed at CH risks analysis and management.

The final version of the risks vocabulary in .JSON format is attached in Appendix 2. Risk-Vocabulary.

Figure 2. 8 - The vocabulary in .JSON format for integration in digital platforms and repositories aimed at CH risks analysis and management.

2.7. Guidelines and recommendations

Beyond the aim of analysing the current state of research linking causes to adverse effects, Task 1.2 aims to provide information to organise the knowledge base and the Competence Centre's recommendations. Therefore, once the semantic standardised system is developed, the last step of the Task consists of preparing guidelines useful to the successive activities and strategies' planning aimed at the conservation, preservation and valorisation of the asset within the future Competence Centre.

The work carried out by Task 1.2 aims to provide a reference framework related to mapping the risks affecting Cultural Heritage assets for their Conservation, Preservation and Valorisation. Thanks to the application and use of the semantic standardised system –the Risk Matrix, Cultural Heritage monuments and sites (and their artefacts) can be examined as the sum of their tangible characteristics (e.g., geometry, shape, material properties) and intangible ones (e.g., traditions, rituals) within their natural and anthropic environment.

The selected case studies, beyond serving as tests for the implementation and fine-tuning of the semantic system, provide a simulation of the application on real case scenarios and show how the activities of the Competence Centre will work in the Cultural Heritage risks analysis.

The results of the work carried out by Task 1.2 allowed to draft some guidelines and give some recommendations for the Competence Centre concerning the risk analysis.

Particularly, the pipeline of the Cultural Heritage asset's risk analysis within the Competence Centre would follow these steps:

1. *Locating the Heritage*: through the use of the Matrix, it defines and describes the cultural asset's type and its characteristics, physical and immaterial, within its natural and anthropogenic context; it also provides the user with a path for tracing the CH asset's previous conservation activities and damages.

2. *Mapping damages and risks*: through the use of the Matrix, the user can assess the conditions of the CH asset and identify all the possible risks and threats due to anthropic and natural factors affecting its welfare. It helps to map existing hazards and understand their nature, amplitude and behaviour over time under various predictive scenarios.

3. *Investigation of tools and methods*: once the risks and threats of the asset are recognised, the user is guided towards the appropriate tools and methods (e.g., chemical-physical analysis, 3D documentation, X-ray investigation) needed for solving the issues or reducing the damages identified.

4. *Heritage Knowledge Base*: it allows framing the aim of the intervention on the

Cultural Heritage asset giving the possibility to gather, integrate and access all the relevant sources and information produced, providing solutions aimed at conservation, preservation and valorisation of CH.

Identifying all the hazards that may affect and damage CH assets and examining their causality remains as crucial as evaluating their impact, rate, and frequency. The Matrix for CH risk analysis and damages reduction covers two main aspects of the guidelines/recommendations proposed for the Competence Centre: 1) locating the heritage and 2) mapping damages and risks. Consequently, such steps pave the path for the last two: 3) investigating tools and methods for solving or reducing the issues, and 4) provide access to a Heritage Knowledge Base that aggregates and integrates all the resources and information related to the asset with the aim to plan activities for solving the issues affecting the asset wellbeing.

The update of the pipeline previously proposed in D1.2 can be visually summarised as follows (fig. 2.9):
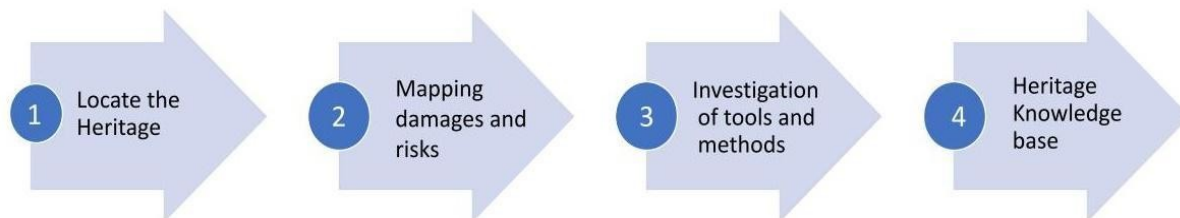
Figure 2. 9 - Risk analysis and damage reduction in Cultural Heritage: the pipeline shows the steps in the use of the Matrix for Cultural Heritage risk analysis and the proposal of solutions for damage reduction.

The future direction of this work and the application within the Competence Centre would be the full integration and operation of the standardised Matrix in the 4CH Knowledge Base to assist the users in the mapping process of risks and damages, and eventually helping in the mitigation strategy. Indeed, future developments of the semantic system will further enrich the risk analysis activities within the services that will be provided by the CC. For instance, the implementation of the semantic system as a plug-in or application for systems like Building Information Model (BIM), further integrated with a list of digital tools and methods for the documentation and the best preservation solutions, may be useful for an automatic analysis of risks and vulnerability assessment. That would facilitate and speed up the selection of proper technologies and of consequent mitigation actions to be carried out for the conservation, preservation and valorisation of Cultural Heritage assets. In this context, Cultural Heritage assets will be represented by their Digital Twins, digital counterparts that, incorporating all their

dynamic and real-time information, will allow the users to access, retrieve and manage complex data and their inter-relationships, as well as optimise solutions for their conservation, preservation and valorisation.

2.8.   Appendix 1. Risk-Matrix

<?xml version="1.0" encoding="utf-8"?>

<Cultural_Heritage xmlns:starc="project">

  <monument_site_landscape>

    <type>This field describes the type of asset under analysis, such as if it is a built asset (e.g., a monastery), a carved one (e.g., a church in a cave) or a natural one (e.g., a secular tree).</type>

    <location>This field describes the general location in which the asset is included, such as on-ground, underwater, or underground.</location>

    <context>This field describes the context of the Cultural Heritage asset under study. For instance, if it is included in an urban or a rural landscape.</context>

    <biodiversity>This field describes the variety of all living organisms and their interactions, such as fauna and flora that can affect or alter the ecosystem as well as geological modifications. It can change over time (e.g., extinction or evolution of a species).</biodiversity>

    <structure>This field describes the type of structure, whether for instance it is a stand-alone one, part of a complex, or if it is considered an ensemble.</structure>

    <function current="This field describes the current function of the asset if changed with respect to the past (e.g., a museum)." past="This field describes the function the asset had in the past (e.g., an electricity power plant, church)." />

    <immaterial_aspects>This field describes the immaterial aspect the asset might be connected to or has (e.g., artisanship, social activity, performing art).</immaterial_aspects>

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

<investigation_legal_status>This field describes the research history and legal condition of the asset by providing information on its status (e.g., studied; un-documented, preserved, recorded, excavated, archived, exhibited, digitally recorded).<year>This field describes the research history and legal condition of the asset by providing information on its the date.</year><version>This field describes the research history and legal condition of the asset by providing information on the version of the documentation.</version></investigation_legal_status>

</monument_site_landscape>

<risks>

<natural_risks>

<cumulative_processes>

<environmental>This field describes the environmental cumulative process the CH asset and its area can be subject to, such as erosion or deposition processes.</environmental>

<biological>This field describes any biological cumulative process, such as vegetation growth affecting the CH asset.</biological>

</cumulative_processes>

<disasters>

<invasive_species>This field describes the presence and type of invasive species (e.g., fauna, flora) causing disasters that can affect the CH asset welfare.</invasive_species>

<severe_weather>This field describes any occurrence and type of natural disaster due to climate-related causes (e.g., flood) CH asset and its area are subject to.</severe_weather>

<geological_events>This field describes possible geological events, such as an earthquake.</geological_events>

```
        </disasters>

    </natural_risks>

    <anthropogenic_risks>

      <intended>

        <management>This field describes those caused by intended management
actions affecting the CH welfare, for instance, due to corruption or deliberate
decisions.</management>

        <heritage_crimes>This field describes all those intended acts of crimes against the
CH asset, such as illegal excavations carried out in an archaeological
area.</heritage_crimes>

      </intended>

      <indirect>

        <building_infrastructure_industry>Under the section dedicated to indirect
anthropogenic risks, this field describes all those activities connected, for instance, to
building or industry activities, such as the construction of a road in the CH vicinity and
affecting its well-being.</building_infrastructure_industry>

        <land_conversion>This field describes those risks caused by the change of use of
the land where the CH asset is located. For instance, the use of land for agricultural
purposes can affect the integrity of an archaeological site hidden underneath the
agricultural soil.</land_conversion>

        <heritage_management>This field describes the risks connected with Heritage
management and causing indirect damages to a CH asset, such as a bad restoration
process or a bad management of the visitors flow.</heritage_management>

        <socio-cultural>This field describes the indirect risks caused by socio-cultural
occurrences, such as a change or loss in value of an asset, or the risks caused by
modern performances in an ancient theatre.</socio-cultural>
```

<other>This field describes the risks caused by any other possible activities previously not considered, such as the war affecting the safety of a country's Cultural Heritage.</other>

</indirect>

</anthropogenic_risks>

</risks>

<artefact>

<movable>This field describes any movable piece of art such as historic replica, written evidence, architectonic features, ethnographic, eco-facts, and artworks.</movable>

<immovable>This field describes any immovable element associated with the asset. For instance, the presence of frescoes or graffiti on its walls, or mosaics on the floors.</immovable>

<immaterial_aspects>This field describes the immaterial aspect the asset might be connected to or has (e.g., artisanship, social activity, performing art).</immaterial_aspects>

<investigation_legal_status>This field describes the research history and legal condition of the asset by providing information on its status (e.g., studied; un-documented, preserved, recorded, excavated, archived, exhibited, digitally recorded).<year>This field describes the research history and legal condition of the asset by providing information on its the date.</year><version>This field describes the research history and legal condition of the asset by providing information on the version of the documentation.</version></investigation_legal_status>

</artefact>

<risks>

<natural_risks>

```
<cumulative_processes>

    <environmental>This field describes the environmental cumulative process the CH
asset and its area can be subject to, such as erosion or deposition
processes.</environmental>

    <biological>This field describes any biological cumulative process, such as
vegetation growth affecting the CH asset.</biological>

  </cumulative_processes>

  <disasters>

    <invasive_species>This field describes the presence and type of invasive species
(e.g., fauna, flora) causing disasters that can affect the CH asset
welfare.</invasive_species>

    <severe_weather>This field describes any occurrence and type of natural disaster
due to climate-related causes (e.g., flood) CH asset and its area are subject
to.</severe_weather>

    <geological_events>This field describes possible geological events, such as an
earthquake.</geological_events>

   </disasters>

  </natural_risks>

  <anthropogenic_risks>

   <intended>

    <management>Under anthropogenic risks, this field describes those caused by
intended management actions affecting the CH welfare, for instance, due to corruption
or deliberate decisions.</management>

    <heritage_crimes>This field describes all those intended acts of crimes against the
CH asset, such as illegal excavations carried out in an archaeological
area.</heritage_crimes>
```

```
</intended>

<indirect>

<building_infrastructure_industry>This field describes all those activities
connected, for instance, to building or industry activities, such as the construction of a
road in the CH vicinity and affecting its well-being.</building_infrastructure_industry>

<land_conversion>This field describes those risks caused by the change of use of
the land where the CH asset is located. For instance, the use of land for agricultural
purposes can affect the integrity of an archaeological site hidden underneath the
agricultural soil.</land_conversion>

<heritage_management>This field describes the risks connected with Heritage
management and causing indirect damages to a CH asset, such as a bad restoration
process or a bad management of the visitors flow.</heritage_management>

<socio-cultural>This field describes the indirect risks caused by socio-cultural
occurrences, such as a change or loss in value of an asset, or the risks caused by
modern performances in an ancient theatre.</socio-cultural>

<other>This field describes the risks caused by any other possible activities
previously not considered, such as the war affecting the safety of a country's Cultural
Heritage.</other>

</indirect>

</anthropogenic_risks>

</risks>

</Cultural_Heritage>
```

2.9. Appendix 2. Risk Vocabulary

[
    {
        "sourceURI": "",
        "sourceLabel": "veneration",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#closeMatch",
        "targetURI": "http://vocab.getty.edu/aat/300056005",
        "targetLabel": "worship",
        "created": "2023-03-28T12:15:21.068Z",
        "updated": "2023-03-28T13:05:03.332Z",
        "id": 1
    },
    {
        "sourceURI": "",
        "sourceLabel": "performances",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300069200",
        "targetLabel": "performances (creative events)",
        "created": "2023-03-28T12:14:19.388Z",
        "updated": "2023-03-28T13:04:40.495Z",
        "id": 2
    },
    {
        "sourceURI": "",
        "sourceLabel": "visitors",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300025883",
        "targetLabel": "visitors",
        "created": "2023-03-28T12:07:54.616Z",
        "updated": "2023-03-28T12:08:23.609Z",
        "id": 5
    },

```
{
        "sourceURI": "",
        "sourceLabel": "tourism industry",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300132466",
        "targetLabel": "tourism",
        "created": "2023-03-28T12:06:36.671Z",
        "updated": "2023-03-28T12:07:13.808Z",
        "id": 6
},
{

        "sourceURI": "",
        "sourceLabel": "handling",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#relatedMatch",
        "targetURI": "http://vocab.getty.edu/aat/300379507",
        "targetLabel": "handling (art handling)",
        "created": "2023-03-28T12:03:12.467Z",
        "updated": "2023-03-28T12:05:52.127Z",
        "id": 7
},
{

        "sourceURI": "",
        "sourceLabel": "restoration",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300053742",
        "targetLabel": "restoration (process)",
        "created": "2023-03-28T11:59:29.992Z",
        "updated": "2023-03-28T12:00:17.434Z",
        "id": 8
},
{

        "sourceURI": "",
        "sourceLabel": "neglect",
        "sourceLabelLanguage": "",
```

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

"matchURI": "http://www.w3.org/2004/02/skos/core#relatedMatch",
            "targetURI": "http://vocab.getty.edu/aat/300404508",
            "targetLabel": "abandonment (process)",
            "created": "2023-03-28T11:56:04.498Z",
            "updated": "2023-03-28T11:58:34.496Z",
            "id": 9
    },
    {

            "sourceURI": "",
            "sourceLabel": "negligence ",
            "sourceLabelLanguage": "en",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300055583",
            "targetLabel": "negligence",
            "created": "2023-03-28T11:54:55.139Z",
            "updated": "2023-03-28T11:55:23.163Z",
            "id": 10
    },
    {

            "sourceURI": "",
            "sourceLabel": "forestation",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#closeMatch",
            "targetURI": "http://vocab.getty.edu/aat/300054511",
            "targetLabel": "forestry",
            "created": "2023-03-28T11:42:23.477Z",
            "updated": "2023-03-28T11:51:22.651Z",
            "id": 11
    },
    {
            "sourceURI": "",
            "sourceLabel": "agriculture ",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300054463",
            "targetLabel": "agriculture (discipline)",
            "created": "2023-03-28T10:29:20.851Z",

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

            "updated": "2023-03-28T11:42:17.852Z",
            "id": 12
    },
    {

            "sourceURI": "",
            "sourceLabel": "war",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300055314",
            "targetLabel": "wars",
            "created": "2023-03-28T10:27:39.900Z",
            "updated": "2023-03-28T10:28:19.469Z",
            "id": 13
    },
    {

            "sourceURI": "",
            "sourceLabel": "mining",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300054710",
            "targetLabel": "mining",
            "created": "2023-03-28T10:26:21.596Z",
            "updated": "2023-03-28T10:26:46.388Z",
            "id": 14
    },
    {

            "sourceURI": "",
            "sourceLabel": "pollution",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300055344",
            "targetLabel": "pollution",
            "created": "2023-03-28T09:49:25.561Z",
            "updated": "2023-03-28T09:50:00.082Z",
            "id": 15
    },
    {

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

```
        "sourceURI": "",
        "sourceLabel": "transportation",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300055244",
        "targetLabel": "transportation",
        "created": "2023-03-28T09:48:00.206Z",
        "updated": "2023-03-28T09:48:39.897Z",
        "id": 16
    },
    {

        "sourceURI": "",
        "sourceLabel": "industrial activity",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#closeMatch",
        "targetURI": "http://vocab.getty.edu/aat/300055459",
        "targetLabel": "industrialization",
        "created": "2023-03-28T09:40:23.762Z",
        "updated": "2023-03-28T13:03:14.178Z",
        "id": 17
    },
    {

        "sourceURI": "",
        "sourceLabel": "constructions",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#closeMatch",
        "targetURI": "http://vocab.getty.edu/aat/300004794",
        "targetLabel": "structures (single built works)",
        "created": "2023-03-28T09:18:33.916Z",
        "updated": "2023-03-28T09:38:42.519Z",
        "id": 18
    },
    {

        "sourceURI": "",
        "sourceLabel": "collectors",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
```

                "targetURI": "http://vocab.getty.edu/aat/300025234",
                "targetLabel": "collectors",
                "created": "2023-03-28T09:15:46.560Z",
                "updated": "2023-03-28T09:18:04.405Z",
                "id": 19
        },
        {

                "sourceURI": "",
                "sourceLabel": "illicit trafficking ",
                "sourceLabelLanguage": "en",
                "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
                "targetURI": "http://vocab.getty.edu/aat/300249982",
                "targetLabel": "trafficking (illicit)",
                "created": "2023-03-28T09:14:29.870Z",
                "updated": "2023-03-28T09:18:11.061Z",
                "id": 20
        },
        {

                "sourceURI": "",
                "sourceLabel": "illegal excavations",
                "sourceLabelLanguage": "en",
                "matchURI": "http://www.w3.org/2004/02/skos/core#broadMatch",
                "targetURI": "http://vocab.getty.edu/aat/300266151",
                "targetLabel": "excavations (sites)",
                "created": "2023-03-28T09:11:30.573Z",
                "updated": "2023-03-28T09:18:16.685Z",
                "id": 21
        },
        {

                "sourceURI": "",
                "sourceLabel": "theft",
                "sourceLabelLanguage": "",
                "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
                "targetURI": "http://vocab.getty.edu/aat/300055292",
                "targetLabel": "theft (social issue)",
                "created": "2023-03-28T09:09:40.440Z",
                "updated": "2023-03-28T09:10:18.419Z",

            "id": 22
        },
        {

                "sourceURI": "",
                "sourceLabel": "arson",
                "sourceLabelLanguage": "",
                "matchURI": "http://www.w3.org/2004/02/skos/core#relatedMatch",
                "targetURI": "http://vocab.getty.edu/aat/300236886",
                "targetLabel": "arsonists",
                "created": "2023-03-28T09:06:17.695Z",
                "updated": "2023-03-28T09:08:14.144Z",
                "id": 23
        },
        {

                "sourceURI": "",
                "sourceLabel": "vandalism",
                "sourceLabelLanguage": "",
                "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
                "targetURI": "http://vocab.getty.edu/aat/300055299",
                "targetLabel": "vandalism",
                "created": "2023-03-28T09:05:12.310Z",
                "updated": "2023-03-28T13:02:42.946Z",
                "id": 24
        },
        {

                "sourceURI": "",
                "sourceLabel": "quarrying",
                "sourceLabelLanguage": "",
                "matchURI": "http://www.w3.org/2004/02/skos/core#closeMatch",
                "targetURI": "http://vocab.getty.edu/aat/300054712",
                "targetLabel": "quarrying",
                "created": "2023-03-28T08:57:09.486Z",
                "updated": "2023-03-28T08:57:58.214Z",
                "id": 25
        },
        {

                "sourceURI": "",

"sourceLabel": "political",
"sourceLabelLanguage": "",
"matchURI": "http://www.w3.org/2004/02/skos/core#broadMatch",
"targetURI": "http://vocab.getty.edu/aat/300187571",
"targetLabel": "political events",
"created": "2023-03-28T08:41:29.950Z",
"updated": "2023-03-28T08:52:28.240Z",
"id": 26
},
{

        "sourceURI": "",
        "sourceLabel": "modern re-use",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#broadMatch",
        "targetURI": "http://vocab.getty.edu/aat/300056392",
        "targetLabel": "adaptive reuse",
        "created": "2023-03-28T08:39:11.265Z",
        "updated": "2023-03-28T08:40:40.639Z",
        "id": 27
},
{

        "sourceURI": "",
        "sourceLabel": "volcano",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300132325",
        "targetLabel": "volcanoes",
        "created": "2023-03-28T08:37:42.102Z",
        "updated": "2023-03-28T13:02:31.283Z",
        "id": 28
},
{

        "sourceURI": "",
        "sourceLabel": "landslide",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300054732",

"targetLabel": "landslides",
"created": "2023-03-28T08:36:08.081Z",
"updated": "2023-03-28T13:02:26.427Z",
"id": 29
    },
    {

        "sourceURI": "",
        "sourceLabel": "erosion",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300054116",
        "targetLabel": "erosion",
        "created": "2023-03-13T16:35:17.595Z",
        "updated": "2023-03-28T13:04:31.855Z",
        "id": 31
    },
    {

        "sourceURI": "",
        "sourceLabel": "decay",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#closeMatch",
        "targetURI": "http://vocab.getty.edu/aat/300438573",
        "targetLabel": "natural decay",
        "created": "2023-03-13T16:27:23.023Z",
        "updated": "2023-03-28T13:04:33.910Z",
        "id": 32
    },
    {

        "sourceURI": "",
        "sourceLabel": "ground-water",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300250545",
        "targetLabel": "groundwater",
        "created": "2023-03-13T16:53:34.338Z",
        "updated": "2023-03-28T13:02:16.347Z",
        "id": 33

        },
        {
                "sourceURI": "",
                "sourceLabel": "vibration",
                "sourceLabelLanguage": "en",
                "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
                "targetURI": "http://vocab.getty.edu/aat/300073789",
                "targetLabel": "vibration (physical)",
                "created": "2023-03-13T16:59:21.241Z",
                "updated": "2023-03-28T08:35:00.855Z",
                "id": 34
        },
        {

                "sourceURI": "",
                "sourceLabel": "animal migration",
                "sourceLabelLanguage": "",
                "matchURI": "http://www.w3.org/2004/02/skos/core#broadMatch",
                "targetURI": "http://vocab.getty.edu/aat/300055405",
                "targetLabel": "migration (function)",
                "created": "2023-03-13T17:03:55.383Z",
                "updated": "2023-03-13T17:05:09.066Z",
                "id": 35
        },
        {

                "sourceURI": "",
                "sourceLabel": "pest",
                "sourceLabelLanguage": "",
                "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
                "targetURI": "http://vocab.getty.edu/aat/300253640",
                "targetLabel": "pests (organisms)",
                "created": "2023-03-13T17:06:12.410Z",
                "updated": "2023-03-28T13:02:07.595Z",
                "id": 36
        },
        {

                "sourceURI": "",
                "sourceLabel": "vegetation",

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

```
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300266061",
        "targetLabel": "vegetation",
        "created": "2023-03-13T17:08:43.918Z",
        "updated": "2023-03-13T17:23:40.222Z",
        "id": 37
    },
    {

        "sourceURI": "",
        "sourceLabel": "degradation",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300228676",
        "targetLabel": "degradation",
        "created": "2023-03-13T17:23:15.324Z",
        "updated": "2023-03-13T17:23:36.629Z",
        "id": 38
    },
    {

        "sourceURI": "",
        "sourceLabel": "fauna",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300310150",
        "targetLabel": "fauna",
        "created": "2023-03-13T17:24:49.526Z",
        "updated": "2023-03-13T17:25:05.807Z",
        "id": 39
    },
    {

        "sourceURI": "",
        "sourceLabel": "flora",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300310152",
        "targetLabel": "flora (plants)",
```

```
            "created": "2023-03-13T17:32:57.588Z",
            "updated": "2023-03-28T08:34:35.247Z",
            "id": 40
    },
    {

            "sourceURI": "",
            "sourceLabel": "fire",
            "sourceLabelLanguage": "en",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300417275",
            "targetLabel": "fire (physical concept)",
            "created": "2023-03-13T17:46:36.500Z",
            "updated": "2023-03-28T08:34:43.079Z",
            "id": 41
    },
    {

            "sourceURI": "",
            "sourceLabel": "earthquake ",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300054728",
            "targetLabel": "earthquakes",
            "created": "2023-03-13T17:51:02.353Z",
            "updated": "2023-03-28T13:01:57.426Z",
            "id": 42
    },
    {

            "sourceURI": "",
            "sourceLabel": "flood",
            "sourceLabelLanguage": "",
            "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
            "targetURI": "http://vocab.getty.edu/aat/300054731",
            "targetLabel": "floods (natural events)",
            "created": "2023-03-13T17:47:53.935Z",
            "updated": "2023-03-28T13:01:54.218Z",
            "id": 43
    },
```

```
{
        "sourceURI": "",
        "sourceLabel": "hail",
        "sourceLabelLanguage": "",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300055376",
        "targetLabel": "hail",
        "created": "2023-03-13T17:47:59.863Z",
        "updated": "2023-03-13T17:50:35.208Z",
        "id": 44
    },
    {
        "sourceURI": "",
        "sourceLabel": "sea level raise",
        "sourceLabelLanguage": "en",
        "matchURI": "http://www.w3.org/2004/02/skos/core#exactMatch",
        "targetURI": "http://vocab.getty.edu/aat/300266795",
        "targetLabel": "sea-level rise",
        "created": "2023-03-13T16:30:00.903Z",
        "updated": "2023-03-28T13:04:22.462Z",
        "id": 45
    }
]
```

3. User needs: mapping existing analysis on user needs and defining their continuous update (Task T1.4)

3.1. Aims and objectives

The aim of **Task 1.4** was to map existing user needs identified in previous EU funded projects and scientific literature as well as their skills and attitudes towards digitization, together with targeted surveys to cover aspects not yet analysed or partially addressed. The research strategy has been designed to cover both top-down as well as bottom-up users' needs to capture the overall needs and expectations of different profiles.

To this end, the following objectives guided the development of the Task:
- Identification of main users of digital cultural heritage, together with their associated expertise and motivation;
- Identification of Users Profiles and their role in the preservation, conservation and valorisation of monuments and sites, according to the value proposition canvas;
- Evaluate the potential of Digital technologies in mitigating risks and challenges that cultural heritage is facing, identifying opportunities, barriers and possible limitations to the identified users;
- Define top-down users' needs through an exhaustive literature review and bottom-up users' needs of practitioners, site managers, and curators through specific surveys;
- Identification of possible services and products aiming at filling in the gaps detected in the users' needs analysis, according to their profiles, roles, and purposes for heritage digitization.

3.2. Methodology

3.2.1. Identification of key projects and relevant literature

In order to identify the main users' needs and requirements associated with the digitization of cultural heritage, a desk-based and bibliographic research of scientific resources has been taken as a basis for deploying an explorative analysis to this end. The comprehensive state of the art of existing users' needs analysis at the national and European level has been based on current and finalised EU projects and scientific publications.

3.2.2. Definition of a template for the analysis

A data gathering template has been developed to collect relevant information from the analysed documents, which identifies general information on the document, users' characteristics and needs addressed. The template has been designed to gather information in a systemized way and to ensure comparability, by including, where possible, a drop-down list of predefined options. These are mainly related to the type of users' categories, the purpose of digitisation and the scale addressed. Furthermore, in order to ensure fluent communication and comparative analysis among WP1 Tasks results, a common vocabulary has been established which resulted in macro categories grouping the different options. These are especially related to the type of cultural heritage considered and the scale.

3.2.3. Purpose of digitisation, type of users' categories and training profiles

Purpose of digitization and definition of users' categories

Walsh et al.[14] conducted a literature review to compare how users have been categorised in the field of digital cultural heritage. Despite the variety of labels used in previous studies, it was possible to identify similarities and group them according to their domain of expertise, technical skills and motivation for engagement. The study strongly focuses on access and discovery of cultural heritage material, especially collections and digital libraries. **Valorisation** of cultural heritage is one of the most recognised benefits associated with the digitalisation of cultural heritage as it becomes more accessible to people notwithstanding their location or their financial means[15] and increases visibility, an aspect which gained even more relevance with the spread of the COVID-19 pandemic. The valorisation of cultural resources through digital content contributes to knowledge building and sharing and fosters accessibility to all. It is mainly associated with the general public, visitors and tourists, companies from the creative industries, education and associations and NGOs, as well as museum curators which aim at delivering improved visitors' experiences and decision-makers aiming at promoting cultural heritage. The value of cultural heritage digitization is also valuable for **conservation** purposes, enabling research, documentation, diagnosis, intervention and planning, to safeguard its values for future generations, as well as contributing to restoration and reconstruction in sites affected by conflicts and natural disasters. Furthermore, 3D digitisation can contribute to better protect cultural heritage sites and objects by enabling research or discovery using 3D models instead of direct handling[16]. The type of digitalization, in terms of technology to be used, format and quality, related to conservation may vary considerably considering the size of the asset and the final aim for which the digital representation has been generated. Users associated with this category also vary and may include decision-makers, institutions responsible for a cultural heritage site or museum curators, restores or companies offering conservation services and professional researchers. Digitisation in cultural heritage has also demonstrated its potential in **preservation**, contributing to the prevention, reduction and anticipation of damages in relation to natural degradation, climate change, human development and natural disasters, which can also include scenario simulations. As for conservation activities, preservation has a large variety of use cases, which require different technical equipment, strategies and quality levels. Users will vary accordingly, together with the content of the digital resource, considering the role they have in the overall workflow and the skills required. These include institutions responsible for the management of buildings and sites, professionals and SMEs working in preservation,

---

[14] Walsh, D., Clough, P., Foster, J. (2016). User categories for digital cultural heritage, CEUR Workshop Proceedings, 1611

[15] Interreg Europe (2018). A Policy Brief from the Policy Learning Platform on Environment and resource efficiency

[16] European Commission. Directorate-general for communications networks, content and technology. Data Interactive Technologies, Digital for Culture and Education Expert Group on Digital Cultural Heritage and Europeana (2020). Basic principles and tips for 3D digitisation of tangible cultural heritage for cultural heritage professionals and institutions and other custodians of cultural heritage

<u>decision-makers</u> and <u>professional researchers</u>, as well as <u>associations and communities</u> aiming at preserving their heritage.

According to the European Commission progress report on the implementation of cultural material digitisation[17] , more than half of Member States prioritise the digitisation of library and archival cultural resources and more than one-third of Member States reported funding programmes for digitisation of immovable cultural heritage such as monuments, historical buildings and archaeological sites, with increased development on 3D digitisation. Furthermore, the document states that the digitisation strategy is centralised at the Ministry level in more than two-thirds of Member States however, the role of national institutions is considered as key in the process.

Users' categories and training profiles

4CH project, in Deliverable 4.2 "Report in service deployment and training", has defined three main training profiles, providing the following definitions:

Practitioner. This profile includes professionals working hands-on with data capture, data analysis, etc., and includes, for example, researchers, curators, documentation specialists, collection specialists, digital specialists, and research supporters.
Manager. This profile includes people responsible for managing teams, such as repository managers, data managers, and section leaders.
Policy-maker. This profile includes executives and decision-makers of public bodies and private organisations.

These broad training profiles reflect the different stages of a professional career with different training needs and levels of learning and are not always directly related to job titles.

As the aim of the work described in this document is to define users' needs, the understanding of the job of potential users accessing the services offered by the Competence Centre is essential. The user categories, previously identified in D1.2 "Initial report on user needs", have therefore been maintained throughout this second analysis. These categories have been associated with the proposed training profiles. Even though some of them can be directly associated with a specific training profile, some categories resulted in overlapping two profiles, as the user job may go beyond a specific function. This is the case for example of the category "Professionals and SMEs providing services for preservation, conservation and restoration" which indeed need technical skills to perform the work but also require managerial skills and overall vision of the sector for business planning.

---

[17] European Commission. Directorate-General For Communications Networks, Content and Technology (2019). Implementation of Commission Recommendation on the digitisation and online accessibility of cultural material and digital preservation (2011/711/eu). Consolidated Progress Report 2015-2017

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs
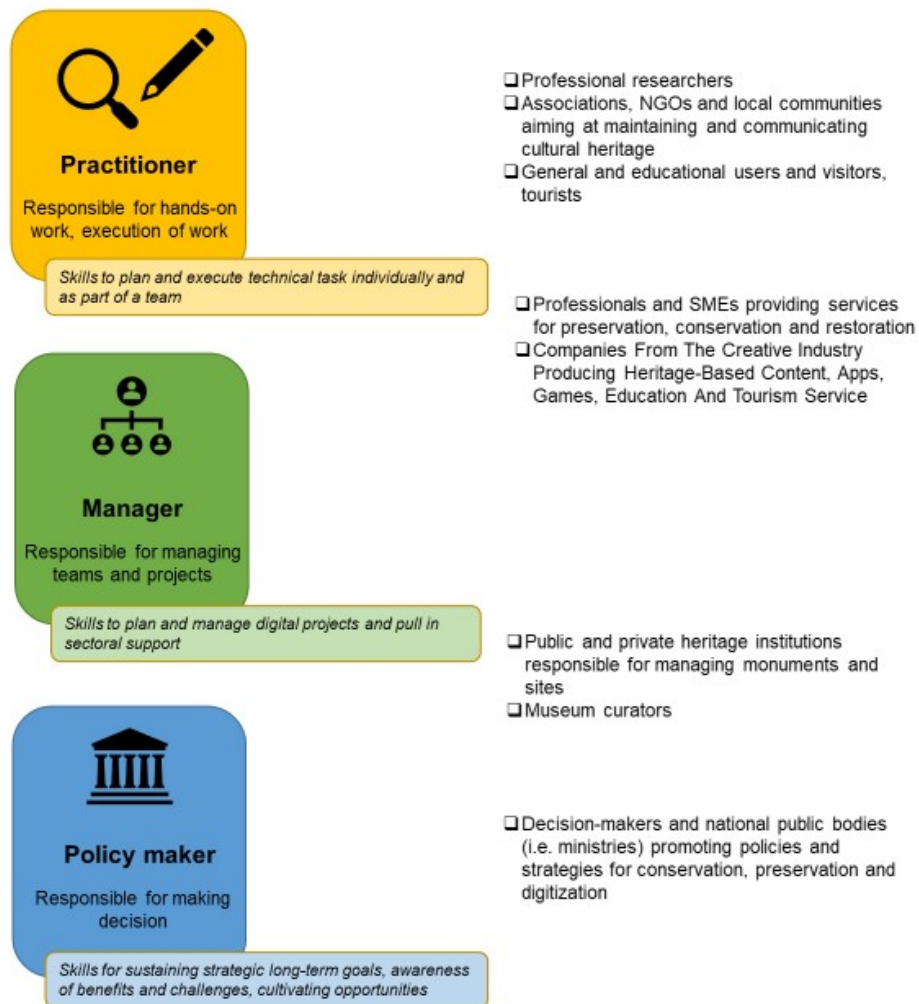
Figure 3. 1 - Relation between training profiles and users' categories

3.2.4. Value proposition canvas

The process to identify and gather users' needs was built upon the methodology Value Proposition Canvas. Introduced by Osterwalder et al.[18], this method is a plug-of the Business Model Canvas. While the Business Model Canvas helps to create value for the business, the Value Proposition Canvas is intended to create value for the customer. More concretely, it assists companies to deepen the features of their Value

---

[18] Osterwalder, A. et al. (2014). Value Proposition Design: How to Create Products and Services Customers Want. Hoboken: John Wiley & Sons

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

Propositions appropriate to potential target Customer Segments, enabling the company to evaluate the "fit" between the value created and the customers' expectations.

Being similar to customers' needs, when the users' needs are discovered, the new product, services or product-service systems can be more accurately developed. In this sense, to achieve the task's objectives, those needs usually have a bearing on the added value intended to be offered.

Figure 3. 2 shows the graphical representation of the Value Proposition Canvas with two sides: the Customer Profile (right side of the picture), where it is possible to clarify the customer understanding, and the Value Map (left side), where it is possible to describe how the company intend to create value for the identified customer.
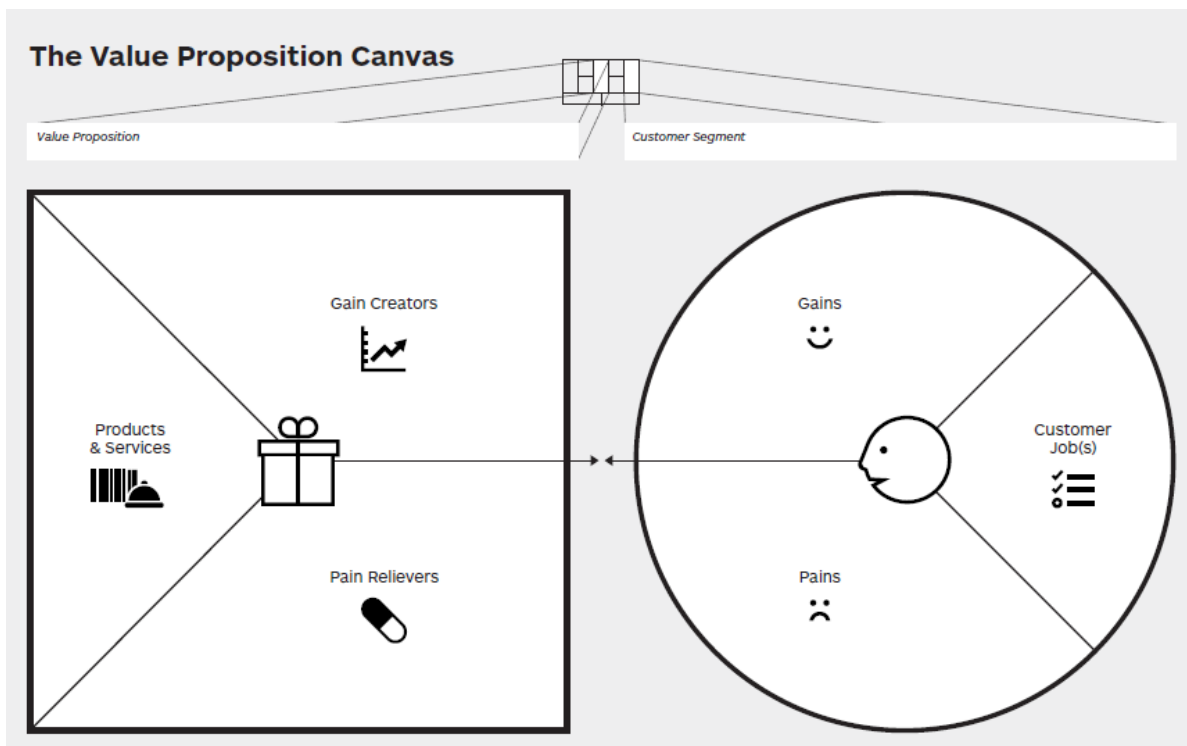
Figure 3. 2 - Value Proposition Canvas

Within Deliverable 1.2 "Initial report on user needs" the Customer Profile was addressed, that is the right side of the VP CANVAS. Built on the detailed description of the different user categories related to digitisation of Cultural Heritage, their jobs, gains and pains were explored. The left side of the VP CANVAS, the Value Proposition, was addressed in Task 1.4 specifically focusing on the pain relievers associated with the previously identified user needs. Hence, the results from this analysis will serve to define the value proposition of the Competence Centre.

When Pain Relievers are explored, the main reflection is oriented towards exploring how proposed services could minimize the users' pains. In this sense, the objective is to explore if the services would alleviate eventual users' pains (obstacles, risks, bad outcomes) resulting from their jobs. Some questions for reflection are for example:

1. Could your service produce savings in terms of time, money or effort for the users?
2. Could your service put an end to the difficulties and challenges the users encounter while performing their job?
3. Could your service eliminate risks (financial, technical, social) in your users' jobs?

3.2.5. Surveys

The first set of users' needs, derived from the top-down approach, was validated through the 4CH community. In 2022, a survey was launched among stakeholders to determine how important, according to their experience, the needs identified are, concerning conservation, preservation and valorisation of artifacts, collections, and archives, as well as monuments, sites and landscapes. The results of the top-down analysis and the validation process were detailed in Deliverable 1.2 "Initial report on user need".

As a second step of Task 1.4, the experiences and practices collected were further analysed and, for each user need, several pain relievers, intended as products or services helping to solve problems or minimize risks were identified. A second validation process, in form of a questionnaire, involving stakeholders from different domains and representing different user categories was launched, with the aim of contributing to the services set-up of the Competence Centre. The identified pain relievers and the results of the validation process, together with the overall conclusions, are presented in the following sections.

3.3.   Design of the literature review

A literature review addressing past and ongoing EU-funded projects as well as scientific papers was designed and carried out. Cordis and Scopus databases were searched to find projects with the following queries:

- CORDIS: "DIGITAL AND HERITAGE"
- SCOPUS: (TITLE-ABS-KEY (digital AND heritage AND users AND requirements) OR (TITLE-ABS-KEY (digital AND heritage AND users AND needs))

Cordis results were restricted to projects, belonging to the H2020 and FP7 Programmes, while Scopus results were restricted to English language, relevant fields,

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

conferences or papers and with a defined author. The following table summarises the number of projects and papers identified:

Table 3. 1 - Number of projects and papers analysed

Access date	Database	Query	Number of entries	Number of restricted entries
12.04.2021	Cordis	Digital heritage	2699	154
	Scopus	Digital heritage users' requirements OR digital heritage users needs	393	268

A first screen was done to identify relevant projects that were classified as follows:
1. 0 The project does not seem to be relevant to 4CH project
2. 1 The project seems interesting and may include information on users' needs

Papers abstracts were classified as follows:
3. 0 The paper does not seem to be relevant to 4CH project
4. 1 The paper could be interesting, but it is necessary to read more
5. 2 The paper refers to general needs (not specific to users categories) or a specific technology
6. 3 The paper is focused on digitalisation of monuments and sites and clearly addresses users' needs

In order to systematise the information, a second screening of the projects with relevancy 1 and papers with relevancy 2 or 3 was performed and considered the following aspects:

- Identification of the user category:
  - Public and/or private heritage institutions responsible for managing monuments and sites
  - Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization
  - Professionals and SMEs providing services or products for preservation, conservation and restoration
  - Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage
  - Companies from the creative industry producing heritage-based content, apps, games, education and tourism services
  - General and educational users and visitors, tourists
  - Museums curators
  - Professional researchers
  - Others

- Identification of the main purpose of digitalisation and associated macrocategory (conservation, preservation and valorisation):
  - Historic and bibliographic research
  - Studies on CH
  - Documentation of CH
  - Communication of CH
  - Preventive conservation
  - Diagnostic activities
  - Identification of the risks and deterioration patterns
  - Materials conservation tests
  - Pre-consolidation, cleaning, consolidation and protection of CH materials
  - Reinforcement of CH buildings
  - Monitoring
  - Maintenance practices
  - Management and administration practices
  - Promotion and support of interventions for conservation
  - Project of restoration
  - Reconstruction
  - Adaptive re-use of CH
  - Accessibility
  - Dissemination through publications
  - Organisation of events and festivals
  - Encounters with communities
  - Creation of partnership and networking
  - Advertisements with CH
  - Gamings with CH
1. Cultural Heritage scale considered:
   - Artifact
     - Collection
     - Archive/ library
     - Open air/ landscape
     - Intangible
   - Monuments / groups of buildings / sites (and landscape)
     - Stand-alone / individual
     - Group
     - Complex
     - Settlement
     - Landscape
     - Route
     - Intangible

2. Identification of users' jobs (Main problems users are trying to solve; Task users are trying to perform; Objectives they try to achieve)

3. Identification of users' pains (obstacles that could affect users while they are performing the actions listed in the "users jobs")

4. Identification of users' gains (benefits users expect/desire/would be surprised to obtain while performing the activities listed in the "users jobs")

5. Description of the user need(s)

6. Description of the user pain reliever(s)

Figure 3.4 - Data collection template

As previously described, building upon the methodology Value Proposition Canvas, the Customer Profile and the Value Map were evaluated through the literature review and results were reported in D1.2 and D1.4 respectively, as shown in Table 3.2:

Table 3. 2 - Details of categorisation step

DeL No.	Categorisation	
D1.2	User Category	*Please, select the main user category. If it is a multiple choice, please include a new row per category*
D1.2	Purpose of digitalisation	*Please, select the main purpose of digitalisation among the proposed categories*
D1.2	Scale	*Please, select the CH scale it addresses*

D1.2	Users jobs	*Based on the USER CATEGORY, please list the main problems users are trying to solve; or tasks that users are trying to perform in their work; the objectives they try to achieve.*
D1.2	Users pains	*Please describe the obstacles that could affect users while they are performing the actions listed in the "users jobs" (main difficulties and challenges; negative social consequences; risks)*
D1.2	Users gains	*Describe benefits users expect/desire/would be surprised to obtain while performing the activities listed in the "users jobs" (savings, quality, easiness of procedure, what are they looking for?)*
D1.4	Pain relievers	*Describe how proposed services could minimize the users' pains: to explore if the services would alleviate eventual users' pains (obstacles, risks, bad outcomes) resulting from their jobs.*

3.4. Reports' analysis and conclusions

3.4.1. Projects and papers analysis

In the first scanning, 154 projects and 268 scientific papers were analysed, of these, 36 projects and 99 papers were considered as interesting for the 4CH project and finally 22 projects and 95 papers have been deeply analysed as they provided available information specifically addressing users' needs.
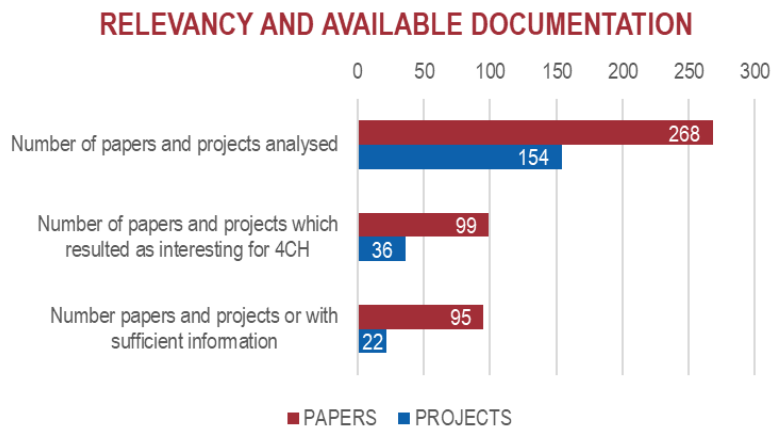
Figure 3.5 – Projects and papers relevancy and available documentation

The following graphs show the statistical distribution of the analysed documentation about the Cultural Heritage type, the digitization purpose and the user category:

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs
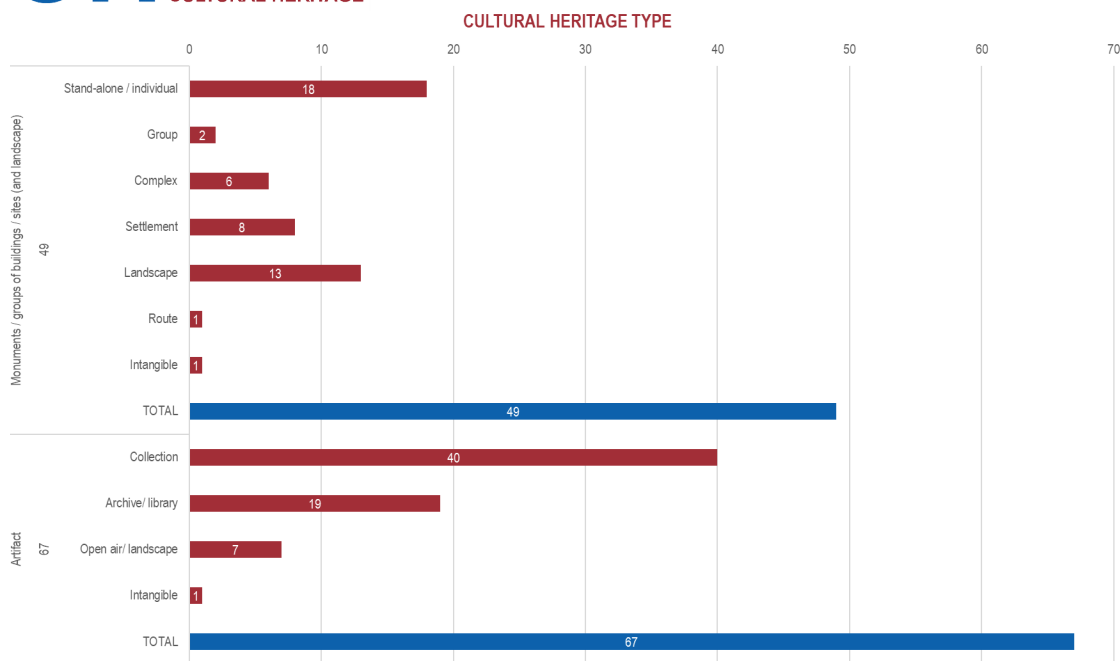
Figure 3.6 - Relationship between analysed projects and papers and cultural heritage type

PURPOSE OF DIGITIZATION
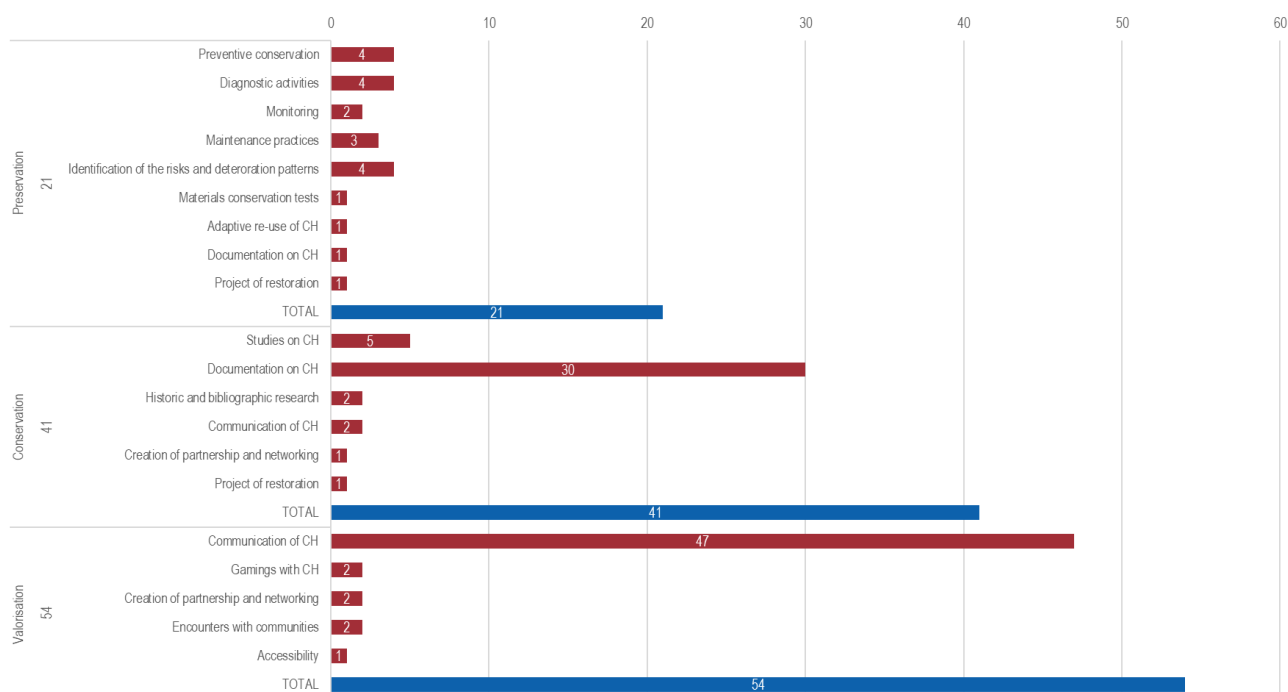
Figure 3.7 - Relationship between analysed projects and papers and purpose of digitization

USER CATEGORY

- Public and/ or private heritage institutions responsible for managing monuments and sites
- Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization
- Professionals and SMEs providing services or products for preservation, conservation and restoration
- Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage
- General and educational users and visitors, tourists
- Museum curators
- Professional researchers

Figure 3.8 - Relationship between analysed projects and papers and type of user categories

The information has been systematized and classified, according to the user needs analysis, leading to the definition of **25 users needs**, namely:

UN01 - Optimized and time-saving procedures for data capturing and processing

UN02 - Solutions for adapting content aiming to an inclusive, accessible and barrier-free museum

UN03 - Creating interactive museum experiences to better connect visitors

UN04 - The need for society to be actively involved in cultural heritage activities, not only as an observer but also as a creator

UN05 - Enhancing and making accessible underwater or inaccessible heritage

UN06 - The need for comprehensive risk assessment methods for cultural heritage affected by climate change and natural hazards

UN07 - Spreading knowledge on remote sensing applications for cultural heritage sites

UN08 - Common protocols, implementation guidelines and sharing of lessons learned for regeneration and adaptive reuse of historic city centres

UN09 - Creating immersive, populated, interactive reconstructions of archaeological sites to enhance users experiences

UN10 - The need for high-resolution interactive 3D visualization tools

UN11 - Smart monitoring systems with minimally invasive installation and analysis systems to identify deterioration processes

UN12 - Facilitate digital models sharing and information exchange

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

UN13 - Highly accurate digital surrogates for conservation method selection and simulation of ageing effects

UN14 - Reduced specialised equipment knowledge for diagnosis studies

UN15 - The need to have a digital replica for studies and conservation purposes

UN16 - Time upgradable 3D modelling

UN17 - Visually organize 3D digital archives by the display of different levels of information

UN18 - Provision of infrastructure and services for data sharing, access and re-use

UN19 - Availability of tools to gather and integrate diverse digital materials, archive them appropriately and make the information accessible

UN20 - Generating and customizing visualization that allows users to dynamically and creatively experience digital contents

UN21 - Long-term preservation framework for large volumes of digital data

UN22 - Availability of digital archiving standards

UN23 - Reuse and recontextualization assessment standards

UN24 - Facilitate networking and share resources in the touristic sector through a common communication system based on digital information
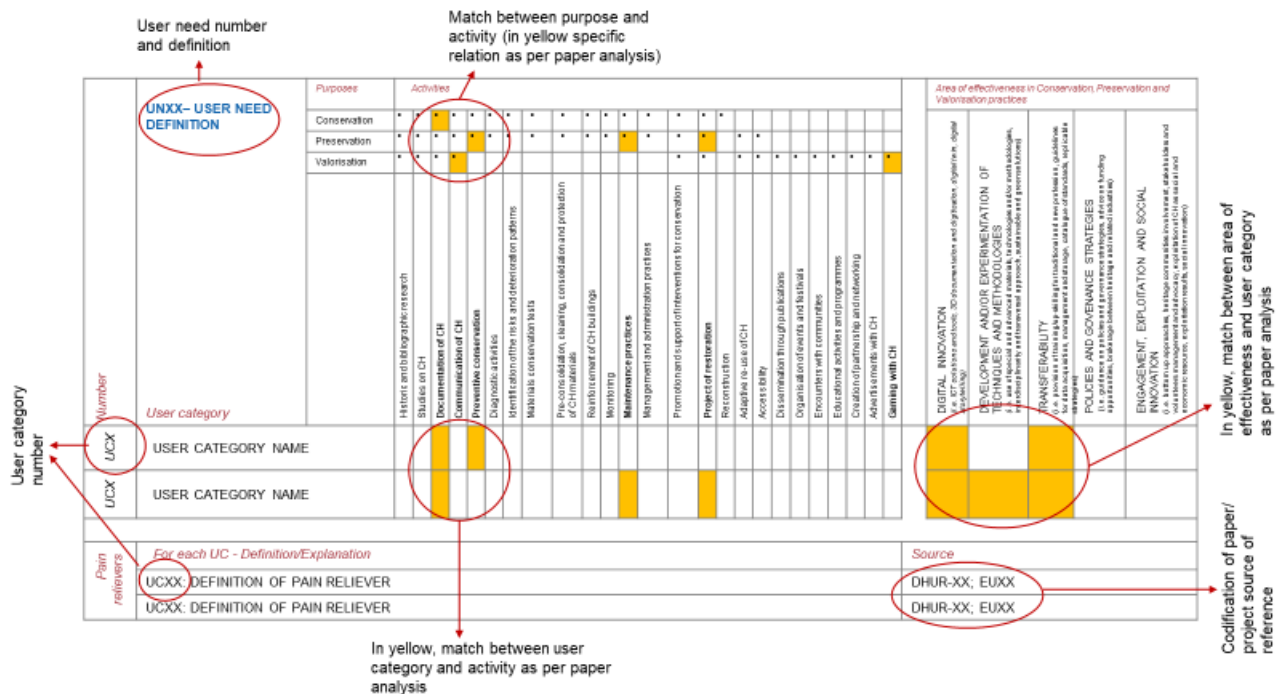
UN25 - Benefits and provides opportunities for scientific research but also enables the "public to explore collections for inspiration, learning and 'enjoyment' and 'to research, share and interpret"

The complete description of **users' needs**, including the **associated user category**, **type of cultural heritage**, the **purpose of digitization** and field, as well as the **users' jobs**, **pain** and **gain** were fully documented in D1.2, Section 3.5 "Summary of main recommendations".

Further investigating user needs and with the objective of better addressing the requirements and activities of the future Competence Centre, Task 1.4, in this second period of activity, has addressed how these needs can be possibly related to potential **"pain relievers"** within the context of the future Value Proposition of the Competence Centre. The analysis in this period was focused on evaluating the literature previously reviewed and, by deeply scrutinising users' pains and gains, the pain relievers as solutions that alleviate users' pains, underpinning the creation of value were discovered.

From the very beginning of the project, WP1 shared a common methodology to ensure alignment within tasks, transversal and cross-thematic analysis have been carried out, especially in the development of Task 1.1 and 1.4. User's categories were therefore classified considering the purpose and activities established by a common terminology. Following the same theoretical framework, in this second analysis, literature has also been examined about the areas of effectiveness in Conservation, Preservation and Valorisation practices established in D1.1, allowing for a direct association with the proposed skills. The results of the analysis are presented in the form of summary tables, which are organised by User Need (UN). For each user need, the associated users'

categories (UC) are listed and following the breakdown structure of the literature review, the activities and the area of effectiveness of the specific user category are highlighted in yellow, together with the related purpose (conservation, preservation, valorisation of cultural heritage). The dot between the purpose and the activity establishes the possible relation between the two, while the yellow cell highlights the specific relation encountered in the papers and projects analysed. At the bottom of the table, for each user category, the proposed pain relievers are listed, together with the codification reference of the paper or project analysed. The following figure schematises the information contained in each table:

Figure 3.8 – Information available in the pain relievers tables

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

UN01 - OPTIMIZED, COST-EFFICIENT AND TIME-SAVING PROCEDURES FOR DATA CAPTURING AND PROCESSING

Purposes / Activities

The activities columns are:
Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Purposes rows:
- Conservation (highlighted: Documentation of CH)
- Preservation (highlighted: Preventive conservation; Maintenance practices; Project of restoration)
- Valorisation (highlighted: Communication of CH; Gaming with CH)

Area of effectiveness in Conservation, Preservation and Valorisation practices
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinary and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVERNANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category	Activities (highlighted)	Area of effectiveness (highlighted)
UC01	Public and/ or private heritage institutions responsible for managing monuments and sites	Documentation of CH; Preventive conservation	DIGITAL INNOVATION; TRANSFERABILITY
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration	Maintenance practices; Project of restoration	DIGITAL INNOVATION; DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES; TRANSFERABILITY
UC04	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	Communication of CH	DIGITAL INNOVATION; DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES
UC05	Companies from the Creative Industry producing heritage-based content, Apps, games, education and tourism service	Gaming with CH	DIGITAL INNOVATION; DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES
UC07	Museum curators	Communication of CH	DIGITAL INNOVATION; TRANSFERABILITY

Pain relievers / Remarks / User Jobs

For each UC - Definition/Explanation	Source
UC01: Updatable digital platform for data archiving and storage to support documentation, management and conservation	DHUR-22; DHUR-84; DHUR-234; DHUR-256
UC01: Increase knowledge on digital technologies and standards	DHUR-84; DHUR-234
UC03: Optimization and integration of technologies to create digital models with different levels of accuracy for surveying and monitoring projects	DHUR-20; DHUR-51; EU-61
UC03: Single and friendly interface to access data and information provided by different digital imaging techniques	DHUR-108
UC04: Fast digitization technologies aimed at the production of multimedia content for knowledge sharing	DHUR-116
UC05: Semi-automatic or automatic 3D models generation through content reuse for video game designers	EU-17
UC07: Standardized workflows and optimal reproduction processes for artworks, reducing manual post-processing	DHUR-64; EU-05

UN02 - SOLUTIONS FOR ADAPTING CONTENT AIMING TO AN INCLUSIVE, ACCESSIBLE AND BARRIER-FREE MUSEUM

Purposes / Activities

Purpose	Activities (icons present)
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Adaptive re-use of CH; **Accessibility**
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; **Communication of CH**; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; **Accessibility**; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION (*i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling*)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (*i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions*)
- TRANSFERABILITY (*i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies*)
- POLICIES AND GOVENANCE STRATEGIES (*i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries*)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (*i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation*)

Number: UC06

User category: General and educational users and visitors, tourists

Highlighted (orange) activities: Communication of CH; Accessibility
Highlighted (orange) areas of effectiveness: Development and/or experimentation of techniques and methodologies; Engagement, exploitation and social innovation

Pain relievers

Definition/Explanation	Source
UC06: New technologies to enhance inclusive tourism and full accessibility to cultural heritage	DHUR-131; EU-04

UN03 - CREATING INTERACTIVE MUSEUM EXPERIENCES TO BETTER CONNECT VISITORS

Purposes / Activities

Purposes	Activities
Conservation	icons across: Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation
Preservation	icons across: Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Reconstruction; Adaptive re-use of CH
Valorisation	icons across: Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH (highlighted); Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Project of restoration; Reconstruction; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Activities columns: Historic and bibliographic research · Studies on CH · Documentation of CH · **Communication of CH** · Preventive conservation · Diagnostic activities · Identification of the risks and deterioration patterns · Materials conservation tests · Pre-consolidation, cleaning, consolidation and protection of CH materials · Reinforcement of CH buildings · Monitoring · Maintenance practices · Management and administration practices · Promotion and support of interventions for conservation · Project of restoration · Reconstruction · Adaptive re-use of CH · Accessibility · Dissemination through publications · Organisation of events and festivals · Encounters with communities · Educational activities and programmes · Creation of partnership and networking · Advertisements with CH · Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices:
- **DIGITAL INNOVATION** (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- **DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES** (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- **TRANSFERABILITY** (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- **POLICIES AND GOVENANCE STRATEGIES** (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- **ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION** (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category	Communication of CH	Digital Innovation	Development and/or experimentation	Transferability	Policies and governance	Engagement, exploitation and social innovation
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration	�as highlighted		■			■
UC06	General and educational users and visitors, tourists	■	■				■
UC07	Museum curators	■	■		■		■

Pain relievers

Definition/Explanation	Source
UC03: Methodologies aimed at bringing users into the design process for the creation of new cultural heritage products or services	DHUR-110
UC06: Digital technologies and online applications to promote, interact and interpret cultural heritage	DHUR-03; DHUR-25; DHUR-39; DHUR-48; DHUR-49; DHUR-60; DHUR-78; DHUR-107; DHUR-197; EU-08
UC07: Improved skills in communication criteria for virtual reconstruction and digital experiences	DHUR-157; EU-05; EU-12; EU-19; EU-24; EU-81

UN04 - THE NEED FOR SOCIETY TO BE ACTIVELY INVOLVED IN CULTURAL HERITAGE ACTIVITIES, NOT ONLY AS AN OBSERVER BUT ALSO AS A CREATOR

Purposes / Activities

Purposes	Activities (columns)
Conservation	Historic and bibliographic research; Studies on CH; **Documentation of CH**; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Adaptive re-use of CH; Accessibility
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION *(i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)*
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES *(i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)*
- TRANSFERABILITY *(i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)*
- POLICIES AND GOVENANCE STRATEGIES *(i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)*
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION *(i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)*

Number	User category	Highlighted Activity	Highlighted Area of effectiveness
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration	Communication of CH; Creation of partnership and networking	Transferability; Engagement, exploitation and social innovation
UC04	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	Encounters with communities	Digital innovation; Transferability; Engagement, exploitation and social innovation
UC06	General and educational users and visitors, tourists	Communication of CH	Engagement, exploitation and social innovation
UC07	Museum curators	Documentation of CH	Transferability; Engagement, exploitation and social innovation

Pain relievers

Definition/Explanation	Source
UC03: Recommendations and methods for communication and crowdsourcing platforms and tools	DHUR-95; DHUR-126
UC04: Tools and methods to facilitate contact with cultural institutions and improve communication activities to include local knowledge in heritage transmission	DHUR-70; EU-09
UC06: To undergo immersive, personalized and active experiences through high-quality views and 3D reconstructions combining educational aspects	DHUR-160; DHUR-172; DHUR-180; DHUR-181; DHUR-192; DHUR-203; DHUR-205; DHUR-255
UC07: Inclusion of collaborative and participatory approaches to enrich metadata	DHUR-05

UN05 - ENHANCING AND MAKING ACCESSIBLE UNDERWATER OR INACCESSIBLE HERITAGE

Purposes / Activities

Purpose	Activities (marked)
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; **Documentation of CH**; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Reinforcement of CH buildings; **Monitoring**; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility
Valorisation	Historic and bibliographic research; Studies on CH; **Documentation of CH**; **Communication of CH**; Project of restoration; Reconstruction; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; **Gaming with CH**

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION *(i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)*
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES *(i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)*
- TRANSFERABILITY *(i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)*
- POLICIES AND GOVENANCE STRATEGIES *(i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)*
- ENGAGEMENT. EXPLOITATION AND SOCIAL INNOVATION *(i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)*

Number	User category	Highlighted Activity	Highlighted Area of effectiveness
UC01	Public and/ or private heritage institutions responsible for managing monuments and sites	Monitoring	DIGITAL INNOVATION; TRANSFERABILITY
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration	Documentation of CH	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES
UC06	General and educational users and visitors, tourists	Communication of CH	DIGITAL INNOVATION; ENGAGEMENT. EXPLOITATION AND SOCIAL INNOVATION
UC07	Museum curators	Gaming with CH	ENGAGEMENT. EXPLOITATION AND SOCIAL INNOVATION

Pain relievers

Definition/Explanation	Source
UC01: Computational platform to perform complex analysis and monitoring based on time-series data	DHUR-161
UC03: Technologies for digital models acquisition in hard to access environment	EU-54
UC06: Virtual and augmented reality tools to explore underwater heritage	EU-14
UC07: Digital technologies for showcasing objects not visible to the general public	DHUR-38, DHUR-122

	UN06 - THE NEED FOR COMPREHENSIVE RISK ASSESSMENT METHODS FOR CULTURAL HERITAGE AFFECTED BY CLIMATE CHANGE AND NATURAL HAZARDS	Purposes	Activities																										Area of effectiveness in Conservation, Preservation and Valorisation practices				
		Conservation	▣	▣	▣	▣	▣	▣	▣	▣	▣		▣	▣	▣	▣	▣	▣	▣														
		Preservation	▣	▣	▣	▣	▣		▣	▣			▣	▣	▣	▣	▣	▣		▣	▣												
		Valorisation	▣	▣	▣	▣							▣		▣	▣		▣	▣	▣	▣	▣	▣	▣	▣								
Number	*User category*		Historic and bibliographic research	Studies on CH	Documentation of CH	Communication of CH	Preventive conservation	Diagnostic activities	**Identification of the risks and deterioration patterns**	Materials conservation tests	Pre-consolidation, cleaning, consolidation and protection of CH materials	Reinforcement of CH buildings	**Monitoring**	Maintenance practices	Management and administration practices	Promotion and support of interventions for conservation	Project of restoration	Reconstruction	Adaptive re-use of CH	Accessibility	Dissemination through publications	Organisation of events and festivals	Encounters with communities	Educational activities and programmes	Creation of partnership and networking	Advertisements with CH	Gaming with CH		DIGITAL INNOVATION *(i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)*	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES *(i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)*	TRANSFERABILITY *(i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)*	POLICIES AND GOVENANCE STRATEGIES *(i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)*	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION *(i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)*
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization								▮				▮																			▮	

Pain relievers	Definition/Explanation	Source
	UC02: Predictive modelling tools based on low-cost fine scale data models	DHUR-59
	UC02: Dedicated operational services and applications for heritage and landscapes monitoring	DHUR-44
	UC02: Informed decision support systems based on data driven approaches	EU-28; EU-37

UN07 - SPREADING KNOWLEDGE ON REMOTE SENSING APPLICATIONS FOR CULTURAL HERITAGE SITES

Purposes / Activities

Purpose	Activities (with markers)
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Activity column headers

- Historic and bibliographic research
- Studies on CH
- **Documentation of CH**
- Communication of CH
- **Preventive conservation**
- Diagnostic activities
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- **Monitoring**
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- Adaptive re-use of CH
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number / User category

Number	User category	Highlighted activity	Highlighted area of effectiveness
UC01	Public and/ or private heritage institutions responsible for managing monuments and sites	Preventive conservation	Digital Innovation; Transferability
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	Monitoring	Transferability
UC08	Professional researchers	Studies on CH	Development and/or experimentation of techniques and methodologies; Transferability

Pain relievers

Definition/Explanation	Source
UC01: Increase knowledge on different technologies for heritage conservation, including sensors, gateways and storage for continuous monitoring and control of environmental parameters	DHUR-257
UC02: Training and skills acquisition on remote sensing imagery for heritage monitoring	DHUR-44
UC08: Increase knowledge of emerging technologies supporting documentation and conservation of cultural heritage	DHUR-86; EU-42

UN08 - COMMON PROTOCOLS, IMPLEMENTATION GUIDELINES AND SHARING OF LESSONS LEARNED FOR REGENERATION AND ADAPTIVE REUSE OF HISTORIC CITY CENTRES

Area of effectiveness in Conservation, Preservation and Valorisation practices

Purposes / Activities

Purposes	Activities (marked)
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; **Adaptive re-use of CH**; Accessibility
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Activity column headers:
- Historic and bibliographic research
- Studies on CH
- Documentation of CH
- Communication of CH
- Preventive conservation
- Diagnostic activities
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- Monitoring
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- **Adaptive re-use of CH**
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness column headers:
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category	...	DEVELOPMENT AND/OR EXPERIMENTATION	...	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION
UC04	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage		▓ (highlighted)		▓ (highlighted)

Pain relievers

Definition/Explanation	Source
UC04: Increase knowledge of good practices and examples of regeneration initiatives	EU-44

UN09 - CREATING IMMERSIVE, POPULATED, INTERACTIVE RECONSTRUCTIONS OF ARCHAEOLOGICAL SITES TO ENHANCE USERS EXPERIENCES

Purposes / Activities

Purposes	Historic and bibliographic research	Studies on CH	Documentation of CH	Communication of CH	Preventive conservation	Diagnostic activities	Identification of the risks and deterioration patterns	Materials conservation tests	Pre-consolidation, cleaning, consolidation and protection of CH materials	Reinforcement of CH buildings	Monitoring	Maintenance practices	Management and administration practices	Promotion and support of interventions for conservation	Project of restoration	Reconstruction	Adaptive re-use of CH	Accessibility	Dissemination through publications	Organisation of events and festivals	Encounters with communities	Educational activities and programmes	Creation of partnership and networking	Advertisements with CH	Gaming with CH
Conservation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Preservation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■							
Valorisation	■	■	■	■										■	■		■	■	■	■	■	■	■	■	■

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category	Studies on CH (highlight)	Communication of CH (highlight)	DIGITAL INNOVATION	TRANSFERABILITY	ENGAGEMENT
UC01	Public and private heritage institutions responsible for managing monuments and sites	■		■	■	
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration		■	■		■

Pain relievers

Definition/Explanation	Source
UC01: Improve knowledge of the selection of options available to ensure optimal choice of methods	DHUR-28
UC03: Increase knowledge on the use and potential of virtual reality and gaming to disseminate and investigate archaeological sites	EU-62

UN10 - THE NEED FOR HIGH-RESOLUTION INTERACTIVE 3D VISUALIZATION TOOLS

Purposes | **Activities**

Purposes	
Conservation	
Preservation	
Valorisation	

Activities (column headers):
- Historic and bibliographic research
- Studies on CH
- Documentation of CH
- Communication of CH
- Preventive conservation
- Diagnostic activities
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- Monitoring
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- Adaptive re-use of CH
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices:
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT. EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category
UC06	General and educational users and visitors, tourists
UC07	Museum curators
UC08	Professional researchers

Pain relievers

Definition/Explanation	Source
UC06: 3D viewer to promote and allow non-expert users to engage with cultural heritage datasets	DHUR-77
UC06: Realistic spatial database system that considers the user's line-of-sight in information retrieval	DHUR-73
UC07: Visualization infrastructure for the collaborative exploration and analysis of large and complex 3D scanning data	EU-80
UC08: Alternative 4D modelling solutions for professionals not familiar to BIM platform	DHUR-32

UN11 - SMART MONITORING SYSTEMS WITH MINIMALLY INVASIVE INSTALLATION AND ANALYSIS SYSTEMS TO IDENTIFY DETERIORATION PROCESSES

Purposes / *Activities* / *Area of effectiveness in Conservation, Preservation and Valorisation practices*

Purposes	Activities (marks indicated with X)
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; **Identification of the risks and deterioration patterns** (highlighted); Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Activity column headers (left to right):
Historic and bibliographic research · Studies on CH · Documentation of CH · Communication of CH · Preventive conservation · Diagnostic activities · **Identification of the risks and deterioration patterns** · Materials conservation tests · Pre-consolidation, cleaning, consolidation and protection of CH materials · Reinforcement of CH buildings · Monitoring · Maintenance practices · Management and administration practices · Promotion and support of interventions for conservation · Project of restoration · Reconstruction · Adaptive re-use of CH · Accessibility · Dissemination through publications · Organisation of events and festivals · Encounters with communities · Educational activities and programmes · Creation of partnership and networking · Advertisements with CH · Gaming with CH

Area of effectiveness column headers:
- DIGITAL INNOVATION (*i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling*)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (*i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions*)
- TRANSFERABILITY (*i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies*)
- POLICIES AND GOVERNANCE STRATEGIES (*i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries*)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (*i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation*)

Number	User category	...	Area of effectiveness
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration	Identification of the risks and deterioration patterns (highlighted)	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (highlighted)

Pain relievers

Definition/Explanation	Source
UC03: Affordable, customizable, user-friendly solutions based on non-invasive and non-destructive technology	EU-99; EU-61

UN12 - FACILITATE DIGITAL MODELS SHARING AND INFORMATION EXCHANGE

		Purposes	Activities																								Area of effectiveness in Conservation, Preservation and Valorisation practices				
		Conservation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■														
		Preservation	■	■	■	■	■	■	■	■	■	■	■	■				■	■												
		Valorisation	■	■	■	■									■	■		■	■	■	■	■	■	■	■						

Number	User category		Historic and bibliographic research	Studies on CH	Documentation of CH	Communication of CH	Preventive conservation	Diagnostic activities	Identification of the risks and deterioration patterns	Materials conservation tests	Pre-consolidation, cleaning, consolidation and protection of CH materials	Reinforcement of CH buildings	Monitoring	Maintenance practices	Management and administration practices	Promotion and support of interventions for conservation	Project of restoration	Reconstruction	Adaptive re-use of CH	Accessibility	Dissemination through publications	Organisation of events and festivals	Encounters with communities	Educational activities and programmes	Creation of partnership and networking	Advertisements with CH	Gaming with CH	DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)	TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)	POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)
UC01	Public and/ or private heritage institutions responsible for managing monuments and sites				■																							■	■			
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization				■																							■		■		
UC06	General and educational users and visitors, tourists		■	■	■																											■
UC08	Professional researchers			■		■																								■		

	Definition/Explanation	Source
Pain relievers	UC01: Common framework for cultural heritage 3D documentation and models that supports interdisciplinarity	EU-01
	UC02: Improve metadata quality of digital cultural content	DHUR-102
	UC02: Common framework for cultural heritage 3D documentation and models that supports interdisciplinarity	DHUR-129; DHUR-130
	UC06: Tools and platforms facilitating heritage resources sharing and reuse for educational purposes	DHUR-54; DHUR-65; DHUR-66; DHUR-152
	UC06: Facilitate navigation through large and complex collection to enhance users experience of using digital libraries	DHUR-85; DHUR-174; DHUR-238
	UC08: Semi-automatic description and matching of existing catalogues for architects and archaeologists	DHUR-82
	UC08: Optimized workflow process through combination of multiple capture techniques	DHUR-101

UN13 - HIGHLY ACCURATE DIGITAL SURROGATES FOR CONSERVATION METHOD SELECTION AND SIMULATION OF AGEING EFFECTS

Number	User category	Purposes / Activities	Area of effectiveness in Conservation, Preservation and Valorisation practices

Purposes (rows): Conservation, Preservation, Valorisation

Activities (columns):
- Historic and bibliographic research
- Studies on CH
- Documentation of CH
- Communication of CH
- Preventive conservation
- **Diagnostic activities**
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- Monitoring
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- Adaptive re-use of CH
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness:
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration

Pain relievers

Definition/Explanation	Source
UC03: Optimal conservation methodologies according to different criteria through automatic digitization and documentation	DHUR-237; EU-06

Number	UN14 - REDUCED SPECIALISED EQUIPMENT KNOWLEDGE FOR DIAGNOSIS STUDIES / User category	Purposes	Activities

Purposes: Conservation, Preservation, Valorisation

Activities: Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices:
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration

Pain relievers / relieversRemarks / User Jobs	Definition/Explanation	Source
	UC03: Automatic data pre-processing, warning systems and tools for action recommendations	EU-99

UN15 - THE NEED TO HAVE A DIGITAL REPLICA FOR STUDIES AND CONSERVATION PURPOSES

	Purposes	Activities	Area of effectiveness in Conservation, Preservation and Valorisation practices
	Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; **Communication of CH**; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction	
	Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; **Communication of CH**; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Adaptive re-use of CH; Accessibility	
	Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; **Communication of CH**; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH	

Activities (column headers): Historic and bibliographic research | Studies on CH | Documentation of CH | **Communication of CH** | Preventive conservation | Diagnostic activities | Identification of the risks and deterioration patterns | Materials conservation tests | Pre-consolidation, cleaning, consolidation and protection of CH materials | Reinforcement of CH buildings | Monitoring | Maintenance practices | Management and administration practices | Promotion and support of interventions for conservation | Project of restoration | Reconstruction | Adaptive re-use of CH | Accessibility | Dissemination through publications | Organisation of events and festivals | Encounters with communities | Educational activities and programmes | Creation of partnership and networking | Advertisements with CH | Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices (column headers):
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category		Area of effectiveness
UC08	Professional researchers		DIGITAL INNOVATION (highlighted)

Pain relievers

Definition/Explanation	Source
UC08: 3D models allowing interaction with objects	EU-26

	UN16 - TIME UPGRADABLE 3D MODELLING	Purposes	Activities																											Area of effectiveness in Conservation, Preservation and Valorisation practices				

Conservation row (activities marked): Historic and bibliographic research, Studies on CH, Documentation of CH, Communication of CH, Preventive conservation, Diagnostic activities, Identification of the risks and deterioration patterns, Materials conservation tests, Pre-consolidation cleaning consolidation and protection of CH materials, Reinforcement of CH buildings, Monitoring, Maintenance practices, Management and administration practices, Promotion and support of interventions for conservation, Project of restoration, Reconstruction

Preservation row (activities marked): Historic and bibliographic research, Studies on CH, Documentation of CH, Communication of CH, Preventive conservation, Diagnostic activities, Identification of the risks and deterioration patterns, Materials conservation tests, Pre-consolidation cleaning consolidation and protection of CH materials, Reinforcement of CH buildings, Monitoring, Maintenance practices, Management and administration practices, Promotion and support of interventions for conservation, Project of restoration, Adaptive re-use of CH, Accessibility

Valorisation row (activities marked): Historic and bibliographic research, Studies on CH, Documentation of CH, Communication of CH, Promotion and support of interventions for conservation, Project of restoration, Adaptive re-use of CH, Accessibility, Dissemination through publications, Organisation of events and festivals, Encounters with communities, Educational activities and programmes, Creation of partnership and networking, Advertisements with CH, Gaming with CH

Activity column headers:
- Historic and bibliographic research
- Studies on CH
- **Documentation of CH**
- Communication of CH
- Preventive conservation
- Diagnostic activities
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- Monitoring
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- Adaptive re-use of CH
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness column headers:
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category																																	
UC08	Professional researchers	(Documentation of CH highlighted)																													(DIGITAL INNOVATION highlighted)				

Pain relievers

Definition/Explanation	Source
UC08: Incremental method for information upgrading	DHUR-24

UN17 - VISUALLY ORGANIZE 3D DIGITAL ARCHIVES BY THE DISPLAY OF DIFFERENT LEVELS OF INFORMATION

Purposes / Activities

Activity	Conservation	Preservation	Valorisation
Historic and bibliographic research	✓	✓	✓
Studies on CH	✓	✓	✓
Documentation of CH	✓	✓	✓
Communication of CH	✓	✓	✓
Preventive conservation	✓	✓	
Diagnostic activities	✓	✓	
Identification of the risks and deterioration patterns	✓	✓	
Materials conservation tests	✓	✓	
Pre-consolidation, cleaning, consolidation and protection of CH materials	✓	✓	
Reinforcement of CH buildings	✓	✓	
Monitoring	✓	✓	
Maintenance practices	✓	✓	
Management and administration practices	✓	✓	
Promotion and support of interventions for conservation	✓	✓	✓
Project of restoration	✓		✓
Reconstruction	✓		
Adaptive re-use of CH		✓	✓
Accessibility		✓	✓
Dissemination through publications			✓
Organisation of events and festivals			✓
Encounters with communities			✓
Educational activities and programmes			✓
Creation of partnership and networking			✓
Advertisements with CH			✓
Gaming with CH			✓

Area of effectiveness in Conservation, Preservation and Valorisation practices:
- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

User category

Number	User category	Activities highlighted	Area of effectiveness highlighted
UC01	Public and/ or private heritage institutions responsible for managing monuments and sites	Documentation of CH	DIGITAL INNOVATION
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization		DIGITAL INNOVATION; DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES
UC08	Professional researchers	Studies on CH; Documentation of CH	

Pain relievers

Definition/Explanation	Source
UC01: Enriched 3D models for different experts, users profiles and disciplines	DHUR-129; EU-01
UC02 Web system to manage different scales of detail and information sharing among actors through portable devices	DHUR-21
UC08: Structured digital archive of 3D models that can reduce or increase the weight of information displayed according to the purpose	DHUR-24
UC08: Easy and fast methods and tools for the production and interpretation of combined cultural heritage and 3D data	DHUR-57; DHUR-71; DHUR-119; DHUR-196

UN18 - PROVISION OF INFRASTRUCTURE AND SERVICES FOR DATA SHARING, ACCESS AND RE-USE

Purposes / Activities

Purposes	Activities
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Adaptive re-use of CH; Accessibility
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

User category / Activities matrix (yellow = highlighted)

Number	User category	Historic and bibliographic research	Documentation of CH	Communication of CH	Diagnostic activities	Creation of partnership and networking	DIGITAL INNOVATION	TRANSFERABILITY	POLICIES AND GOVENANCE STRATEGIES	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization					■			■	
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration				■		■	■	■	
UC04	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage			■			■			
UC06	General and educational users and visitors, tourists		■	■			■			■
UC08	Professional researchers	■	■	■					■	

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Pain relievers

Definition/Explanation	Source
UC02: Cross domain portal to standardize searching options	DHUR-42
UC03: New systems of representation and data management for different type of materials collected and processed	DHUR-19
UC04: Inclusion of open data and crowdsourcing methods in digital resources	DHUR-62
UC06: Ubiquitous access to digital cultural heritage content	DHUR-171; DHUR-54; DHUR-152; DHUR-199
UC08: Ubiquitous access to digital cultural heritage content	DHUR-53; DHUR-240
UC06: Open access data modality, tools for sharing museum resource and to make multimedia lessons	DHUR-65; DHUR-66
UC08: Digital libraries enhanced by annotation collaboratory facilities for cooperative and collaborative knowledge working	DHUR-61
UC08: Data portal that enables professionals to provide access to their resources (datasets, collections)	DHUR-226; DHUR-251

UN19 - AVAILABILITY OF TOOLS TO GATHER AND INTEGRATE DIVERSE DIGITAL MATERIALS, ARCHIVE THEM APPROPRIATELY AND MAKE THE INFORMATION ACCESSIBLE

Purposes / Activities

Purpose	Activities (marked)
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Accessibility; Dissemination through publications
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category	Highlighted Activities	Highlighted Areas of effectiveness
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	Documentation of CH; Maintenance practices	Digital Innovation; Transferability
UC06	General and educational users and visitors, tourists	Communication of CH	Digital Innovation
UC08	Professional researchers	Documentation of CH; Project of restoration	Digital Innovation; Transferability

Pain relievers / Remarks / User Jobs

Definition/Explanation	Source
UC02: Digital archiving platform to facilitate the interaction between users from different specialties	DHUR-63
UC02: Platform for data integration facilitating information accessibility to the public	DHUR-92
UC06: Tools to guide users in finding appropriate information	DHUR-85; DHUR-238
UC08: Improve metadata integration and retrieval effectiveness	DHUR-07; DHUR-50; DHUR-68; DHUR-240
UC08: Platforms enabling data integration of different disciplines supporting all the phases of restoration	DHUR-06

UN20 - GENERATING AND CUSTOMIZING VISUALIZATION THAT ALLOWS USERS TO DYNAMICALLY AND CREATIVELY EXPERIENCE DIGITAL CONTENTS

Purposes / Activities

Purposes	Activity columns (icons)
Conservation	marked across Studies on CH, Documentation of CH, Communication of CH, Preventive conservation, Diagnostic activities, Identification of risks, Materials conservation tests, Pre-consolidation…, Reinforcement of CH buildings, Monitoring, Maintenance practices, Management and administration practices, Promotion and support of interventions, Project of restoration, Reconstruction
Preservation	marked across Historic and bibliographic research, Studies on CH, Documentation of CH, Communication of CH, Diagnostic activities, Identification of risks, Materials conservation tests, Pre-consolidation…, Monitoring, Maintenance practices, Management and administration practices, Adaptive re-use of CH, Accessibility
Valorisation	marked across Historic and bibliographic research, Studies on CH, Documentation of CH, Communication of CH, Adaptive re-use of CH, Accessibility, Encounters with communities, Educational activities and programmes, Creation of partnership and networking, Advertisements with CH, Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices

Activities columns:
- Historic and bibliographic research
- Studies on CH
- Documentation of CH
- Communication of CH
- Preventive conservation
- Diagnostic activities
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- Monitoring
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- Adaptive re-use of CH
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness columns:
- **DIGITAL INNOVATION** (*i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling*)
- **DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES** (*i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions*)
- **TRANSFERABILITY** (*i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies*)
- **POLICIES AND GOVERNANCE STRATEGIES** (*i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries*)
- **ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION** (*i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation*)

User category (highlighted cells)

Number	User category	Highlighted Activities	Highlighted Areas of effectiveness
UC03	Professionals and SMEs providing services or products for preservation, conservation and restoration	Communication of CH; Diagnostic activities	DIGITAL INNOVATION; DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES
UC06	General and educational users and visitors, tourists	—	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION
UC07	Museum curators	Documentation of CH; Communication of CH; Advertisements with CH	DIGITAL INNOVATION; ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION
UC08	Professional researchers	Studies on CH; Documentation of CH; Communication of CH; Materials conservation tests	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES; TRANSFERABILITY

Pain relievers

Definition/Explanation	Source
UC03: Intuitive and friendly tools allowing interactive inspections and dissemination based on mixed reality	DHUR-23
UC03: Personalization technologies which provide users with guides that enhance their cultural experience	DHUR-110
UC06: Virtual tour of the geological heritage through mobile to enhance tourism quality	DHUR-132
UC07: Interoperable digital workflows to enhance the vision of the real object enriched by digital content and make information more accessible	DHUR-38; DHUR-122
UC07: Architecture for managing digital collections related to the creation, management, preservation, and visualization of digital collections	DHUR-56
UC08: Availability of interfaces allowing different users to explore and interpret collections	DHUR-02; DHUR-225
UC08: Low-cost method based on AR technologies for digital heritage representation	DHUR-83
UC08: New techniques supporting visual inspections and raw data intuitive access	DHUR-99

UN21 - LONG-TERM PRESERVATION FRAMEWORK FOR LARGE VOLUMES OF DIGITAL DATA

Purposes / Activities

Purposes	Activities
Conservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Pre-consolidation, cleaning, consolidation and protection of CH materials; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Reconstruction
Preservation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Identification of the risks and deterioration patterns; Materials conservation tests; Reinforcement of CH buildings; Monitoring; Maintenance practices; Management and administration practices; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility
Valorisation	Historic and bibliographic research; Studies on CH; Documentation of CH; Communication of CH; Preventive conservation; Diagnostic activities; Promotion and support of interventions for conservation; Project of restoration; Adaptive re-use of CH; Accessibility; Dissemination through publications; Organisation of events and festivals; Encounters with communities; Educational activities and programmes; Creation of partnership and networking; Advertisements with CH; Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices

- DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)
- TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)
- POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)

Number	User category	Highlighted Activities	Highlighted Area of effectiveness
UC08	Professional researchers	Documentation of CH; Preventive conservation	TRANSFERABILITY

Pain relievers / relievers / Remarks / User Jobs	Definition/Explanation	Source
	UC08 Preservation framework that is verifiable, open and extensible to ensure longevity, integrity and quality of primary materials	DHUR-04; DHUR-53
	UC08: Service-oriented research infrastructure for repositories, tools and services integration	DHUR-260

UN22 - AVAILABILITY OF DIGITAL ARCHIVING STANDARDS

Purposes	Activities
Conservation	(marked)
Preservation	(marked)
Valorisation	(marked)

Activities columns:
- Historic and bibliographic research
- Studies on CH
- **Documentation of CH**
- **Communication of CH**
- Preventive conservation
- Diagnostic activities
- Identification of the risks and deterioration patterns
- Materials conservation tests
- Pre-consolidation, cleaning, consolidation and protection of CH materials
- Reinforcement of CH buildings
- Monitoring
- Maintenance practices
- Management and administration practices
- Promotion and support of interventions for conservation
- Project of restoration
- Reconstruction
- Adaptive re-use of CH
- Accessibility
- Dissemination through publications
- Organisation of events and festivals
- Encounters with communities
- Educational activities and programmes
- Creation of partnership and networking
- Advertisements with CH
- Gaming with CH

Area of effectiveness in Conservation, Preservation and Valorisation practices:
- DIGITAL INNOVATION *(i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)*
- DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES *(i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)*
- TRANSFERABILITY *(i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)*
- POLICIES AND GOVENANCE STRATEGIES *(i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)*
- ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION *(i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)*

Number	User category	(Communication of CH)	(Documentation of CH)	...	TRANSFERABILITY
UC02	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	■ (highlighted)			■ (highlighted)
UC08	Professional researchers		■ (highlighted)		■ (highlighted)

Pain relievers / relievers Remarks / User Jobs

Definition/Explanation	Source
UC02: Methods for making digital archive platforms accessible and useful to public	DHUR-58
UC08: Framework for enhancing access to metadata contents	DHUR-07

UN23 - REUSE AND RECONTEXTUALIZATION ASSESSMENT STANDARDS

Purposes / *Activities*

Area of effectiveness in Conservation, Preservation and Valorisation practices

Purposes	Historic and bibliographic research	Studies on CH	**Documentation of CH**	Communication of CH	Preventive conservation	Diagnostic activities	Identification of the risks and deterioration patterns	Materials conservation tests	Pre-consolidation, cleaning, consolidation and protection of CH materials	Reinforcement of CH buildings	Monitoring	Maintenance practices	Management and administration practices	Promotion and support of interventions for conservation	Project of restoration	Reconstruction	Adaptive re-use of CH	Accessibility	Dissemination through publications	Organisation of events and festivals	Encounters with communities	Educational activities and programmes	Creation of partnership and networking	Advertisements with CH	Gaming with CH
Conservation	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣									
Preservation	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣		▣	▣							
Valorisation	▣	▣	▣		▣									▣	▣		▣	▣	▣	▣	▣	▣	▣	▣	▣

Area of effectiveness in Conservation, Preservation and Valorisation practices:

- **DIGITAL INNOVATION** *(i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)*
- **DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES** *(i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)*
- **TRANSFERABILITY** *(i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)*
- **POLICIES AND GOVENANCE STRATEGIES** *(i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)*
- **ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION** *(i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)*

Number	*User category*					*Transferability*
UC07	Museum curators		(Documentation of CH highlighted)			(Transferability highlighted)

Pain relievers

Definition/Explanation	*Source*
UC07: Methods for reuse assessment of the digital library community	DHUR-139; DHUR-147

	UN24 - FACILITATE NETWORKING AND SHARE RESOURCES IN THE TOURISTIC SECTOR THROUGH A COMMON COMMUNICATION SYSTEM BASED ON DIGITAL INFORMATION	Purposes	Activities

Purposes / Activities matrix

Purpose	Historic and bibliographic research	Studies on CH	Documentation of CH	**Communication of CH**	Preventive conservation	Diagnostic activities	Identification of the risks and deterioration patterns	Materials conservation tests	Pre-consolidation, cleaning, consolidation and protection of CH materials	Reinforcement of CH buildings	Monitoring	Maintenance practices	Management and administration practices	Promotion and support of interventions for conservation	Project of restoration	Reconstruction	Adaptive re-use of CH	Accessibility	Dissemination through publications	Organisation of events and festivals	Encounters with communities	Educational activities and programmes	Creation of partnership and networking	Advertisements with CH	Gaming with CH
Conservation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
Preservation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓									
Valorisation	✓	✓	✓	✓ (highlighted)										✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

Area of effectiveness in Conservation, Preservation and Valorisation practices

Number	User category	...	DIGITAL INNOVATION (i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES (i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)	TRANSFERABILITY (i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)	POLICIES AND GOVENANCE STRATEGIES (i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION (i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)
UC04	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	(Communication of CH highlighted)	(highlighted)				

Pain relievers

Definition/Explanation	Source
UC04: Communication system that facilitates tourist routes and thematic routes across the territory	DHUR-156

UN25 - BENEFITS AND PROVIDES OPPORTUNITIES FOR SCIENTIFIC RESEARCH BUT ALSO ENABLES THE 'PUBLIC TO EXPLORE COLLECTIONS FOR INSPIRATION, LEARNING AND ENJOYMENT' AND 'TO RESEARCH, SHARE AND INTERPRET"

Purposes	Activities
Conservation	▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣
Preservation	▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣
Valorisation	▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣ ▣

Area of effectiveness in Conservation, Preservation and Valorisation practices

Number	User category	Historic and bibliographic research	Studies on CH	**Documentation of CH**	**Communication of CH**	Preventive conservation	Diagnostic activities	Identification of the risks and deterioration patterns	Materials conservation tests	Pre-consolidation, cleaning, consolidation and protection of CH materials	Reinforcement of CH buildings	Monitoring	Maintenance practices	Management and administration practices	Promotion and support of interventions for conservation	Project of restoration	Reconstruction	Adaptive re-use of CH	Accessibility	Dissemination through publications	Organisation of events and festivals	Encounters with communities	Educational activities and programmes	Creation of partnership and networking	Advertisements with CH	Gaming with CH	DIGITAL INNOVATION *(i.e. ICT solutions and tools, 3D documentation and digitisation, digital twin, digital storytelling)*	DEVELOPMENT AND/OR EXPERIMENTATION OF TECHNIQUES AND METHODOLOGIES *(i.e. use of special and advanced materials, technologies and/or methodologies, interdisciplinarity and transversal approach, sustainable and green solutions)*	TRANSFERABILITY *(i.e. provision of training/up-skilling for traditional and new profession, guidelines for data acquisition, management and storage, catalogue of standards, replicable strategies)*	POLICIES AND GOVENANCE STRATEGIES *(i.e. guidance on policies and governance strategies, advice on funding opportunities, brokerage between heritage and related industries)*	ENGAGEMENT, EXPLOITATION AND SOCIAL INNOVATION *(i.e. bottom up approaches, heritage communities involvement, stakeholders and volunteers management and advocacy, exploitation of CH as social and economic resource, exploitation results, social innovation)*
UC08	Professional researchers			▮	▮																						▮				▮

	Definition/Explanation	Source
Pain relievers	UC08 Technologies to help engage the general public in restoration processes	DHUR-241
	UC08: Increase acceptance and adoption of 3D imaging to develop mass digitisation	DHUR-246

3.4.2. Surveys

Users needs validation survey (2022)

The users' needs survey was launched and kept active during April 2022. A total of 48 responders were accounted, being 22 professional researchers, followed by 7 "others", 6 decision-makers and national public bodies, 4 associations, NGOs, local communities and citizens, 3 professionals and SMEs, 3 public and/ or private heritage institutions, 2 companies from the creative industries and 1 museum curator.

Stakeholders were asked to vote on the importance of each identified need with a scale from 1 (not at all important) to 5 (very important).

The following users' needs were indicated by at least 75% of the respondents as fairly important to very important (4-5 on a scale of 5):

- UN01- Optimized, cost-efficient and time-saving procedures for data capturing and processing
- UN06 - The need for comprehensive risk assessment methods for cultural heritage affected by climate change and natural hazards
- UN08 - Common protocols, implementation guidelines and sharing of lessons learned for regeneration and adaptive reuse of historic city centers
- UN12 - Facilitate digital model sharing and information exchange
- UN17 - Visually organize 3D digital archives by the display of different levels of information.
- UN18 - Provision of infrastructure and services for data sharing, access and re-use.
- UN19 - Availability of tools to gather and integrate diverse digital materials, archive them appropriately and make the information accessible.
- UN20 - Generating and customising visualisation that allows users to dynamically and creatively experience digital contents
- UN21 - Long-term preservation framework for large volumes of digital data
- UN22 - Availability of digital archiving standards
- UN23 - Reuse and recontextualization assessment standards.
- UN25 - Benefits and provides opportunities for scientific research but also enables the 'public to explore collections for inspiration, learning and enjoyment' and 'to research, share and interpret.

The following users' needs were indicated by between 65% and 74% of the respondents as fairly important to very important (4-5 on a scale of 5)

- UN02 - Solutions for adapting content aiming to an inclusive, accessible and barrier-free museum
- UN03 - Creating interactive museum experiences to better connect visitors
- UN05 - Enhancing and making accessible underwater or inaccessible heritage
- UN07 - Spreading knowledge on remote sensing applications for cultural heritage sites
- UN09 - Creating immersive, populated, interactive reconstructions of archaeological sites to enhance users experiences

- UN10 - The need for high-resolution interactive 3D visualization tools
- UN11 - Smart monitoring systems with minimally invasive installation and analysis systems to identify deterioration processes
- UN15 - The need to have a digital replica for studies and conservation purposes
- UN16 - Time upgradable 3D modelling

The following users' needs were indicated by between 59% and 64% of the respondents as fairly important to very important (4-5 on a scale of 5):

- UN04 - The need for society to be actively involved in cultural heritage activities, not only as an observer but also as a creator
- UN13 - Highly accurate digital surrogates for conservation method selection and simulation of ageing effects
- UN14 - Reduced specialized equipment knowledge for diagnosis studies
- UN24 - Facilitate networking and share resources in the touristic sector through a common communication system based on digital information

The results of the survey launched in 2022 for each user need are reported in D1.2, Section 3.4.2 "Surveys".

Pain relievers survey (2023)

The second survey was launched at the beginning of October 2023 and kept active till the 3rd of November. 49 respondents were accounted, belonging to the following categories: 32 professional researchers, 5 decision-makers and national public bodies, 5 public and/ or private heritage institutions responsible for managing monuments and sites, 4 professionals and SMEs providing services or products for preservation, conservation and restoration, 2 companies from the creative industry producing heritage-based content, apps, games, education and tourism services and 1 Association, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage.

The objective of the survey was to validate the identified and proposed pain relievers to better address the interests of users in defining and developing the services offered by the Competence Centre.

The following Figure shows the percentage of representativeness of the respondents' professional categories:

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

USERS CATEGORIES

Public and/ or private heritage institutions responsible for managing monuments and sites	10%
Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for…	10%
Professionals and SMEs providing services or products for preservation, conservation and restoration	8%
Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural…	2%
Companies from the creative industry producing heritage-based content, apps, games, education and…	4%
General and educational users and visitors, tourists	0%
Museum curators	0%
Professional researchers	65%

Figure 3.1 – Survey respondents for each user category

Despite being launched through several communication channels of 4CH partners, the survey was not representative for some of the users' categories: no responses were received by the categories "general and educational users and visitors, tourists" and "museum curators" and the few responses were received form the categories "Associations, NGOs, local communities and citizens" and "companies from the creative industry". This may be also related to the network established and consolidated through the project, which mainly addresses professionals and institutions in charge of the conservation and preservation of cultural heritage and not the general public as such.

Nevertheless, all the proposed pain relievers were well received by the community of stakeholders, all of them evaluated with a high-ranking rate, showing the importance of considering those in the development of the activities and services offered by the Competence Centre. Reviewing the results achieved with this validation, even if not exhaustive, all the pain relievers are considered to be a solid basis for the future actions of the Centre. The summary of the responses received and rankings are reported in <mark>Appendix 1.</mark>

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

Research results

As reported in D4.1 "Report on service deployment and training" 4CH proposes three types of services, namely consultancy and orientation, training and capacity building and support in innovation and projects, defining different subcategories through which the Competence Centre will advise, support and serve the Cultural Heritage Community.

As the main objective of Task 1,4 is to identify users' needs to align them with the activities offered by the Competence Centre, the identified pain relievers are associated with the initially proposed services. The analysis presented in this section has been performed by type of user category, as this allows for better focus on the services or solutions tailored to the type of users that will access or contact the Competence Centre and more importantly, considering recent and common barriers they usually face.

The analysis made to align the solutions with the pain relievers has been summarised in form of Tables, which are included as Appendix 3 of this document. Overall, the main conclusions derived from such analysis are summarised below through highlighting the most valuable insights for the competence centre in terms of services

UC01: PUBLIC AND/ OR PRIVATE HERITAGE INSTITUTIONS RESPONSIBLE FOR MANAGING MONUMENTS AND SITES

In this group of Users, **training services** appear as the most valuable solutions to address the vast majority of pain relievers this type of User would demand. In particular, those problems they face are related to increasing knowledge about technologies for heritage conservation, knowing available options to ensure the optimal choice of methods and demanding a common framework for cultural heritage 3D documentation and models that support interdisciplinarity.

Orientation, guidance and consultancy services are valuable when this type of user has to deal with the implementation of new technologies or digital solutions to facilitate their daily routines, such as standardisation or developing complex analysis and monitoring based on time-series data and, providing enriched 3D models for different experts, users profiles and disciplines.

As far as **enabling technologies** are concerned, this type of user would value most a computational platform to perform complex analysis and monitoring based on time-series data as well as an updatable digital platform for data archiving and storage to support documentation, management and conservation.

UC02: DECISION-MAKERS AND NATIONAL PUBLIC BODIES (I.E. MINISTRIES) PROMOTING POLICIES AND STRATEGIES FOR CONSERVATION, PRESERVATION AND DIGITIZATION

Taking into consideration the main responsibilities of this type of user, it is worth mentioning that **enabling technologies, datasets, and physical equipment** have been

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

found as the most valuable solutions to those pain relievers related to predictive modelling based on low-cost fine-scale data models, web systems to manage different scales of detail, a cross-domain portal to standardize searching options, digital archiving platform to facilitate the interaction between users from different specialities and, platform for data integration facilitating information accessibility to the public.

It also should be highlighted that **collaborative research and networking** can help to envision novel and practical solutions for improving metadata quality of digital cultural content, for cultural heritage 3D documentation supporting interdisciplinarity and, data integration facilitating information accessibility to the public.

UC03: PROFESSIONALS AND SMES PROVIDING SERVICES OR PRODUCTS FOR PRESERVATION, CONSERVATION AND RESTORATION

Similar to the previous type of user, there appears a huge demand for **enabling technologies, datasets, and physical equipment** to alleviate the vast majority of the type of solutions that would alleviate the problems they are dealing with. Those technologies should be focused on:

- digital models with different levels of accuracy for surveying and monitoring projects,
- friendly interfaces to access data and information with digital imaging techniques,
- developing automatic data pre-processing, warning systems and tools for action recommendations,
- new systems of representation and data management for different types of materials collected and processed,
- intuitive and friendly tools allowing interactive inspections and dissemination based on mixed reality and,
- personalization tools which provide users with guides that enhance their cultural experience.

Training has appeared relevant to the requirement of digital model acquisition in hard to access environments for which enabling technology would be also a valuable solution as well as to understanding optimal conservation methodologies according to different criteria through automatic digitization and documentation.

Some solutions coming from **dissemination and knowledge sharing** are valuable to alleviate problems this type of user copes with such as requiring methodologies aimed at bringing users into the design process for the creation of new cultural heritage products or services, methods for communication and crowdsourcing platforms and tools, and, promoting the use and potential of virtual reality and gaming to disseminate and investigate archaeological sites.

UC04: ASSOCIATIONS, NGOS, LOCAL COMMUNITIES AND CITIZENS AIMING AT MAINTAINING AND COMMUNICATING CULTURAL HERITAGE

This group of users would value solutions concerning **dissemination and knowledge sharing** to the production of multimedia content for knowledge sharing and increase knowledge of good practices and examples of regeneration initiatives.

Worthy mentioning is the fact that solutions such as **contacts and communication** are valuable to the inclusion of open data and crowdsourcing methods in digital resources as well as to facilitate contact with cultural institutions and improve communication activities to include local knowledge in heritage transmission.

UC05: COMPANIES FROM THE CREATIVE INDUSTRY PRODUCING HERITAGE-BASED CONTENT, APPS, GAMES, EDUCATION AND TOURISM SERVICE

Since this group is demanding solutions such as semi-automatic or automatic 3D model generation through content reuse for video game designers, **training and enabling technologies** are those solutions equally valuable for them.

UC06: GENERAL AND EDUCATIONAL USERS AND VISITORS, TOURISTS

In this case, the **enabling technologies, datasets, and physical equipment** group of solutions are relevant for most of the pain relievers they would demand:

- New technologies to enhance inclusive tourism and full accessibility to cultural heritage
- Digital technologies and online applications to promote, interact and interpret cultural heritage
- To undergo immersive, personalized and active experiences through high-quality views and 3D reconstructions combining educational aspects
- Virtual and augmented reality tools to explore underwater heritage
- 3D viewer to promote and allow non-expert users to engage with cultural heritage datasets
- Realistic spatial database system that considers the user's line-of-sight in information retrieval
- Tools and platforms facilitating heritage resources sharing and reuse for educational purposes
- Facilitate navigation through large and complex collections to enhance users experience of using digital libraries

Solutions related to **contacts/help and communication** are relevant for aspects related to global access to cultural heritage resources, these are digital cultural heritage content, data modality, tools for sharing museum resources and multimedia lessons or guiding users in finding appropriate information.

UC07: MUSEUM CURATORS

This type of user is undeniably demanding technologies, mainly digital, to make their job functions more efficient, reducing time and cost variables associated with them. Therefore, **enabling technologies, datasets, and physical equipment** are relevant solutions for showcasing objects not visible to the general public, for the collaborative exploration and

analysis of large and complex 3D scanning data, for enhancing the vision of the real object enriched by digital content and make information more accessible, for managing digital collections related to the creation, management, preservation, and visualization of digital collections.

While **training**, **orientation, guidance and consultancy** appear relevant to implement standardized workflows and optimal reproduction processes for artworks, reducing manual post-processing and improving skills in communication for virtual reconstruction and digital experiences.

UC08: PROFESSIONAL RESEARCHERS

Most pain relievers would be addressed by solutions coming from **orientation, guidance and consultancy**. It makes sense if we take into account those ways to support them when they demand:

- Increased knowledge about emerging technologies supporting documentation and conservation of cultural heritage
- Optimized workflow process through a combination of multiple capture techniques
- Incremental method for information upgrading
- Easy and fast methods and tools for the production and interpretation of combined cultural heritage and 3D data
- Availability of interfaces allowing different users to explore and interpret collections
- Preservation framework that is verifiable, open and extensible to ensure longevity, integrity and quality of primary materials
- Service-oriented research infrastructure for repositories, tools and services integration
- Framework for enhancing access to metadata contents

However, **enabling technologies, datasets and physical equipment** would be also demanded to provide solutions to requirements such as alternative 4D modelling solutions for professionals not familiar with the BIM platform, 3D models allowing interaction with objects, the digital archive of 3D models that can reduce or increase the weight of information displayed, easy and fast methods and tools for the production and interpretation of combined cultural heritage and 3D data and finally, novel ways to engaging the general public in restoration processes.

Appendices lists

- Appendix 1 - 2023 Survey results (pain relievers)
- Appendix 2 - Reference to papers and projects
- Appendix 3 - Relation between pain relievers and services

Conclusions

The aim of Task 1.2 has been to analyse the current state of research linking causes to adverse effects and aim of Task 1.4 was to map existing users' needs associated to the digitization of cultural heritage. Both tasks are linked and provide information to organise the knowledge base and the future Competence Centre's recommendations. Indeed, the analyses of users' needs and activities are fundamental for a holistic understanding of a Cultural Heritage and define a risk mitigation strategy as well as requirements for conservation, preservation and valorisation purposes. The activities involved desk work on reports, publications and other pertinent documents, together with fieldwork for the analysis through case studies. Also, preliminary attention has been put on Born-digital Heritage, its fundamental threats and risks to be further addressed in the future. The results contribute to implementing a Knowledge Base for CH Conservation, Preservation and Valorisation initiatives and actions.

Task 1.2 activities led to the development of a Matrix of risks identification. Such a result allowed to fill a gap existing in the field, providing a solution for a holistic analysis of risks in Cultural Heritage. Heritage professionals and institutions will be able to refer to the Matrix to analyse a Cultural Heritage asset, especially built Heritage. In this regard, the Matrix acts as a starting point for the examination of CH assets analysis. Further research can be assessed by crossing the identification of the risks with those connected with the CH assets materials properties (e.g. the material of the building or artefact as partly addressed by the ICOMOS in the ICOMOS-ISCS: Illustrated glossary on stone deterioration patterns[19]). This implementation of the cultural asset identification will help assess each damage and risk mitigation strategy following the Natural and Anthropic divisions.

Task 1.4 activities led to the development of a matrix bringing together the main user categories of digital cultural heritage, their associated expertise and role in conservation, preservation and valorisation, the purpose of digitization as well as the associated type of heritage. The result of the analysis of the matrix, based on existing literature review, was a list of 25 users' needs, which was then validated through a survey with stakeholders. The detailed description of this analysis is reported in D1.2 "Initial report on users' needs". Starting from these users' needs, Task 1.4 focused on evaluating and examining users' pains and gains to discover the "pain relievers" within the context of the future Value Proposition of the Competence Centre and to better address the services and activities that it will provide.

With the objective of aligning the identified pain relievers with the activities offered by the Competence Centre, the analysis has been performed by type of user category, providing insights for the provision of tailored solutions and services to groups of users which face

---

[19] Cfr.
https://www.icomos.org/publications/monuments_and_sites/15/pdf/Monuments_and_Sites_15_ISCS_Glossary_Stone.pdf

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

common barriers. Also in this case, pain relievers were shared with the 4CH community and beyond to validate the research outputs. Even if not exhaustive, the survey indicates that pain relievers were addressing the identified users' needs.

This report does not claim to be exhaustive but is intended to represent analysis and identification of the Risks with a particular focus on building heritage and users' needs, with an impact on the main purposes of the Competence Centre: conservation, preservation and valorisation.

Appendices

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

Appendix 1 – 2023 Survey results (pain relievers)

The following Tables summarise the responses received to the 2023 survey, which had the objective of validating the proposed pain relievers. Percentage of respondent evaluating the pain reliever with a high ranking rate (4 o 5 in a scale of 5), medium ranking rate (3) and low ranking rate (1 or 2) are shown.

UN01 - OPTIMIZED, COST-EFFICIENT AND TIME-SAVING PROCEDURES FOR DATA CAPTURING AND PROCESSING				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Updatable digital platform for data archiving and storage to support documentation, management and conservation	Public and/ or private heritage institutions responsible for managing monuments and sites	100%	0%	0%
Increase knowledge on digital technologies and standards	Public and/ or private heritage institutions responsible for managing monuments and sites	80%	20%	0%
Optimization and integration of technologies to create digital models with different levels of accuracy for surveying and monitoring projects	Professionals and SMEs providing services or products for preservation, conservation and restoration	75%	0%	25%
Single and friendly interface to access data and information provided by different digital imaging techniques	Professionals and SMEs providing services or products for preservation, conservation and restoration	100%	0%	0%
Fast digitization technologies aimed at the production of multimedia content for knowledge sharing	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	100%	0%	0%
Semi-automatic or automatic 3D models	Companies from the Creative Industry	50%	50%	0%

generation through content reuse for video game designers	producing heritage-based content, Apps, games, education and tourism service			
Standardized workflows and optimal reproduction processes for artworks, reducing manual post-processing	Museum curators	N/A	N/A	N/A

UN02 - SOLUTIONS FOR ADAPTING CONTENT AIMING TO AN INCLUSIVE, ACCESSIBLE AND BARRIER-FREE MUSEUM				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
New technologies to enhance inclusive tourism and full accessibility to cultural heritage	General and educational users and visitors, tourists	N/A	N/A	N/A

UN03 - CREATING INTERACTIVE MUSEUM EXPERIENCES TO BETTER CONNECT VISITORS				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Methodologies aimed at bringing users into the design process for the creation of new cultural heritage products or services	Professionals and SMEs providing services or products for preservation, conservation and restoration	75%	25%	0%
Digital technologies and online applications to promote, interact and interpret cultural heritage	General and educational users and visitors, tourists	N/A	N/A	N/A
Improved skills in communication criteria for virtual reconstruction and digital experiences	Museum curators	N/A	N/A	N/A

UN04 - THE NEED FOR SOCIETY TO BE ACTIVELY INVOLVED IN CULTURAL HERITAGE ACTIVITIES, NOT ONLY AS AN OBSERVER BUT ALSO AS A CREATOR

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Recommendations and methods for communication and crowdsourcing platforms and tools	Professionals and SMEs providing services or products for preservation, conservation and restoration	25%	25%	50%
Tools and methods to facilitate contact with cultural institutions and improve communication activities to include local knowledge in heritage transmission	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	100%	0%	0%
To undergo immersive, personalized and active experiences through high-quality views and 3D reconstructions combining educational aspects	General and educational users and visitors, tourists	N/A	N/A	N/A
Inclusion of collaborative and participatory approaches to enrich metadata	Museum curators	N/A	N/A	N/A

UN05 - ENHANCING AND MAKING ACCESSIBLE UNDERWATER OR INACCESSIBLE HERITAGE

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Computational platform to perform complex analysis and monitoring based on time-series data	Public and/ or private heritage institutions responsible for managing monuments and sites	60%	20%	20%
Technologies for digital models	Professionals and SMEs providing	100%	0%	0%

acquisition in hard to access environment	services or products for preservation, conservation and restoration			
Virtual and augmented reality tools to explore underwater heritage	General and educational users and visitors, tourists	N/A	N/A	N/A
Digital technologies for showcasing objects not visible to the general public	Museum curators	N/A	N/A	N/A

UN06 - THE NEED FOR COMPREHENSIVE RISK ASSESSMENT METHODS FOR CULTURAL HERITAGE AFFECTED BY CLIMATE CHANGE AND NATURAL HAZARDS				
Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Predictive modelling tools based on low-cost fine scale data models	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	80%	20%	0%
Dedicated operational services and applications for heritage and landscapes monitoring	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%
Informed decision support systems based on data driven approaches	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%

UN07 - SPREADING KNOWLEDGE ON REMOTE SENSING APPLICATIONS FOR CULTURAL HERITAGE SITES				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Increase knowledge on different technologies for heritage conservation, including sensors, gateways and storage for continuous monitoring and control of environmental parameters	Public and/ or private heritage institutions responsible for managing monuments and sites	80%	20%	0%
Training and skills acquisition on remote sensing imagery for heritage monitoring	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	60%	40%	0%
Increase knowledge of emerging technologies supporting documentation and conservation of cultural heritage	Professional researchers	81%	19%	0%

UN08 - COMMON PROTOCOLS, IMPLEMENTATION GUIDELINES AND SHARING OF LESSONS LEARNED FOR REGENERATION AND ADAPTIVE REUSE OF HISTORIC CITY CENTRES				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Increase knowledge of good practices and examples of regeneration initiatives	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	75%	0%	25%

UN09 - CREATING IMMERSIVE, POPULATED, INTERACTIVE RECONSTRUCTIONS OF ARCHAEOLOGICAL SITES TO ENHANCE USERS EXPERIENCES				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Improve knowledge of the selection of options available to ensure optimal choice of methods	Public and private heritage institutions responsible for managing monuments and sites	80%	20%	0%
Increase knowledge on the use and potential of virtual reality and gaming to disseminate and investigate archaeological sites	Professionals and SMEs providing services or products for preservation, conservation and restoration	100%	0%	0%

UN10 - THE NEED FOR HIGH-RESOLUTION INTERACTIVE 3D VISUALIZATION TOOLS				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
3D viewer to promote and allow non-expert users to engage with cultural heritage datasets	General and educational users and visitors, tourists	N/A	N/A	N/A
Realistic spatial database system that considers the user's line-of-sight in information retrieval	General and educational users and visitors, tourists	N/A	N/A	N/A
Visualization infrastructure for the collaborative exploration and analysis of	Museum curators	N/A	N/A	N/A

large and complex 3D scanning data				
Alternative 4D modelling solutions for professionals not familiar to BIM platform	Professional researchers			

UN11 - SMART MONITORING SYSTEMS WITH MINIMALLY INVASIVE INSTALLATION AND ANALYSIS SYSTEMS TO IDENTIFY DETERIORATION PROCESSES

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Affordable, customizable, user-friendly solutions based on non-invasive and non-destructive technology	Professionals and SMEs providing services or products for preservation, conservation and restoration	100%	0%	0%

UN12 - FACILITATE DIGITAL MODELS SHARING AND INFORMATION EXCHANGE

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Common framework for cultural heritage 3D documentation and models that supports interdisciplinarity	Public and/ or private heritage institutions responsible for managing monuments and sites	60%	40%	0%
Improve metadata quality of digital cultural content	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%
Common framework for cultural heritage 3D documentation and models that supports interdisciplinarity	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%

Tools and platforms facilitating heritage resources sharing and reuse for educational purposes	General and educational users and visitors, tourists	N/A	N/A	N/A
Facilitate navigation through large and complex collection to enhance users experience of using digital libraries	General and educational users and visitors, tourists	N/A	N/A	N/A
Semi-automatic description and matching of existing catalogues for architects and archaeologists	Professional researchers	72%	22%	6%
Optimized workflow process through combination of multiple capture techniques	Professional researchers	88%	9%	3%

UN13 - HIGHLY ACCURATE DIGITAL SURROGATES FOR CONSERVATION METHOD SELECTION AND SIMULATION OF AGEING EFFECTS				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Optimal conservation methodologies according to different criteria through automatic digitization and documentation	Professionals and SMEs providing services or products for preservation, conservation and restoration	100%	0%	0%

UN14 - REDUCED SPECIALISED EQUIPMENT KNOWLEDGE FOR DIAGNOSIS STUDIES				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**

Automatic data pre-processing, warning systems and tools for actions recommendations	Professionals and SMEs providing services or products for preservation, conservation and restoration	100%	0%	0%

UN15 - THE NEED TO HAVE A DIGITAL REPLICA FOR STUDIES AND CONSERVATION PURPOSES

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
3D models allowing interaction with objects	Professional researchers	91%	6%	3%

UN16 - TIME UPGRADABLE 3D MODELLING

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Incremental method for information upgrading	Professional researchers	N/A	N/A	N/A

UN17 - VISUALLY ORGANIZE 3D DIGITAL ARCHIVES BY THE DISPLAY OF DIFFERENT LEVELS OF INFORMATION

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Enriched 3D models for different experts, users profiles and disciplines	Public and/ or private heritage institutions responsible for managing monuments and sites	80%	20%	0%

Pain reliever	User category			
Web system to manage different scales of detail and information sharing among actors through portable devices	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%
Structured digital archive of 3D models that can reduce or increase the weight of information displayed according to the purpose	Professional researchers	N/A	N/A	N/A
Easy and fast methods and tools for the production and interpretation of combined cultural heritage and 3D data	Professional researchers	84%	16%	0%

UN18 - PROVISION OF INFRASTRUCTURE AND SERVICES FOR DATA SHARING, ACCESS AND RE-USE				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Cross domain portal to standardize searching options	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	80%	20%	0%
New systems of representation and data management for different type of materials collected and processed	Professionals and SMEs providing services or products for preservation, conservation and restoration	100%	0%	0%
Inclusion of open data and crowdsourcing methods in digital resources	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	100%	0%	0%
Ubiquitous access to digital cultural heritage content	General and educational users and visitors, tourists	N/A	N/A	N/A
Open access data modality, tools for	General and educational users and	N/A	N/A	N/A

sharing museum resource and to make multimedia lessons	visitors, tourists			
Ubiquitous access to digital cultural heritage content	Professional researchers	88%	13%	0%
Digital libraries enhanced by annotation collaboratory facilities for cooperative and collaborative knowledge working	Professional researchers	94%	6%	0%
Data portal that enables professionals to provide access to their resources (datasets, collections)	Professional researchers	88%	13%	0%

UN19 - AVAILABILITY OF TOOLS TO GATHER AND INTEGRATE DIVERSE DIGITAL MATERIALS, ARCHIVE THEM APPROPRIATELY AND MAKE THE INFORMATION ACCESSIBLE				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Digital archiving platform to facilitate the interaction between users from different specialties	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%
Platform for data integration facilitating information accessibility to the public	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%
Tools to guide users in finding appropriate information	General and educational users and visitors, tourists	N/A	N/A	N/A
Improve metadata integration and retrieval effectiveness	Professional researchers	91%	9%	0%

Platforms enabling data integration of different disciplines supporting all the phases of restoration	Professional researchers	91%	9%	0%

UN20 - GENERATING AND CUSTOMIZING VISUALIZATION THAT ALLOWS USERS TO DYNAMICALLY AND CREATIVELY EXPERIENCE DIGITAL CONTENTS				
Pain reliever	**User category**	**High ranking rate**	**Medium ranking rate**	**Low ranking rate**
Intuitive and friendly tools allowing interactive inspections and dissemination based on mixed reality	Professionals and SMEs providing services or products for preservation, conservation and restoration	67%	0%	33%
Personalization technologies which provide users with guides that enhance their cultural experience	Professionals and SMEs providing services or products for preservation, conservation and restoration	50%	50%	0%
Virtual tour of the geological heritage through mobile to enhance tourism quality	General and educational users and visitors, tourists	N/A	N/A	N/A
Interoperable digital workflows to enhance the vision of the real object enriched by digital content and make information more accessible	Museum curators	N/A	N/A	N/A
Architecture for managing digital collections related to the creation, management, preservation, and visualization of digital collections	Museum curators	N/A	N/A	N/A
Availability of interfaces allowing different users to explore and interpret collections	Professional researchers	78%	19%	3%

Low-cost method based on AR technologies for digital heritage representation	Professional researchers	66%	22%	13%
New techniques supporting visual inspections and raw data intuitive access	Professional researchers	75%	22%	3%

UN21 - LONG-TERM PRESERVATION FRAMEWORK FOR LARGE VOLUMES OF DIGITAL DATA

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Preservation framework that is verifiable, open and extensible to ensure longevity, integrity and quality of primary materials	Professional researchers	91%	9%	0%
Service-oriented research infrastructure for repositories, tools and services integration	Professional researchers	91%	9%	0%

UN22 - AVAILABILITY OF DIGITAL ARCHIVING STANDARDS

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Methods for making digital archive platforms accessible and useful to public	Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitization	100%	0%	0%
Framework for enhancing access to metadata contents	Professional researchers	81%	19%	0%

UN23 - REUSE AND RECONTEXTUALIZATION ASSESSMENT STANDARDS

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Methods for reuse assessment of the digital library community	Museum curators	N/A	N/A	N/A

UN24 - FACILITATE NETWORKING AND SHARE RESOURCES IN THE TOURISTIC SECTOR THROUGH A COMMON COMMUNICATION SYSTEM BASED ON DIGITAL INFORMATION

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Communication system that facilitates tourist routes and thematic routes across the territory	Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	100%	0%	0%

UN25 - BENEFITS AND PROVIDES OPPORTUNITIES FOR SCIENTIFIC RESEARCH BUT ALSO ENABLES THE 'PUBLIC TO EXPLORE COLLECTIONS FOR INSPIRATION, LEARNING AND ENJOYMENT' AND 'TO RESEARCH, SHARE AND INTERPRET"

Pain reliever	User category	High ranking rate	Medium ranking rate	Low ranking rate
Technologies to help engage general public in restoration processes	Professional researchers	72%	28%	0%
Increase acceptance and adoption of 3D imaging to develop mass digitisation	Professional researchers	75%	16%	9%

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

Appendix 2 – Reference to papers and projects

DHUR-02	Agosti M., Orio N.,"User requirements for effective access to digital archives of manuscripts",2012,"Journal of Multimedia","7","2",,"217","222",,"10.4304/jmm.7.2.217-222","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84861912809&doi=10.4304%2fjmm.7.2.217-222&partnerID=40&md5=cfe90a58ffc0e2b0c501081d5f1a67fe"
DHUR-03	Aiello D., Fai S., Santagati C.,"VIRTUAL MUSEUMS AS A MEANS for PROMOTION and ENHANCEMENT of CULTURAL HERITAGE",2019,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","42","2/W15",,"33","40",,"10.5194/isprs-archives-XLII-2-W15-33-2019","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85072175610&doi=10.5194%2fisprs-archives-XLII-2-W15-33-2019&partnerID=40&md5=f2ebac887d7b04119404d8e984e89139"
DHUR-04	Aitken B., Innocenti P., Ross S., Konstantelos L.,"User requirements for a next generation digital preservation framework: Analysis and implementation",2010,"Archiving 2010 - Preservation Strategies and Imaging Technologies for Cultural Heritage Institutions and Memory Organizations, Final Program and Proceedings",,,,"48","52",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-79956149530&partnerID=40&md5=e1b86fc755ee93d7296aef1203a14c5d"
DHUR-05	Alemu G.,"Metadata Enrichment for Digital Heritage: Users as Co-Creators",2018,"International Information and Library Review","50","2",,"142","156",,"10.1080/10572317.2018.1449426","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85047945777&doi=10.1080%2f10572317.2018.1449426&partnerID=40&md5=38e5d392f342b312e480dc1a42847e4a"
DHUR-06	Alexakis E., Kapassa E., Touloupou M., Kyriazis D., Georgopoulos A., Moropoulou A.,"Computer-aided innovative methodology for management and personalized representation of big data in cultural heritage",2018,"IMCIC 2018 - 9th International Multi-Conference on Complexity, Informatics and Cybernetics, Proceedings","2",,,"151","154",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-85050199247&partnerID=40&md5=8772c03aa695c118e24bceef61f6d2b0"
DHUR-07	Alma'aitah W.Z., Talib A.Z., Osman M.A.,"Opportunities and challenges in enhancing access to metadata of cultural heritage collections: a survey",2020,"Artificial Intelligence Review","53","5",,"3621","3646",,"10.1007/s10462-019-09773-w","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85074502832&doi=10.1007%2fs10462-019-09773-w&partnerID=40&md5=649a4208dec58a37b573f056187d1e9f"
DHUR-19	Battini C.,"New systems for the management of data. the case study of the chapter house of santa maria novella in florence",2013,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","40","5W1",,"21","25",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84924363776&partnerID=40&md5=a5e43739a35c76ee10d7058c40a72321"
DHUR-20	Bitelli G., Balletti C., Brumana R., Barazzetti L., D'Urso M.G., Rinaudo F., Tucci G.,"Metric documentation of cultural heritage: Research directions from the Italian gamher project",2017,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","42","2W5",,"83","90",,"10.5194/isprs-archives-XLII-2-W5-83-2017","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85030218848&doi=10.5194%2fisprs-archives-XLII-2-W5-83-2017&partnerID=40&md5=56b964913b46ef4e678dff53f14d53f8"
DHUR-21	Bruno N., Rechichi F., Achille C., Zerbi A., Roncella R., Fassi F.,"Integration of historical GIS data in a HBIM system",2020,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","43","B4","427","434",,"10.5194/isprs-archives-XLIII-B4-2020-427-2020","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85091556498&doi=10.5194%2fisprs-archives-XLIII-B4-2020-427-2020&partnerID=40&md5=87e53cc0288a0b6f4586e85ba771e356"
DHUR-22	Bruno N., Roncella R.,"A restoration oriented HBIM system for cultural heritage documentation: The case study of parma cathedral",2018,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","42","2",,"171","178",,"10.5194/isprs-archives-XLII-2-171-2018","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85048364331&doi=10.5194%2fisprs-archives-XLII-2-171-2018&partnerID=40&md5=6827d7c720eafd9c45313a7766436b03"
DHUR	Bugalia N., Kumar S., Kalra P., Choudhary S.,"Mixed reality based interaction system for digital heritage",2016,"Proceedings - VRCAI 2016: 15th ACM SIGGRAPH Conference on Virtual-Reality

-23	Continuum and Its Applications in Industry","1",,,"31","37",,"10.1145/3013971.3014000","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85009736015&doi=10.1145%2f3013971.3014000&partnerID=40&md5=83726d9c7a21c593a043cd87fb8f5238"
DHUR-24	Calisi D., Tommasetti A., Topputo R.,"Architectural historical heritage: A tridimensional multilayered cataloguing method",2011,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","38","5W16","599","606",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84924739095&partnerID=40&md5=8a219caf324c852ea518dadfce268629"
DHUR-25	Capece S., Chivăran C.,"The sensorial dimension of the contemporary museum between design and emerging technologies*",2020,"IOP Conference Series: Materials Science and Engineering","949","1", 012067,"","",,"10.1088/1757-899X/949/1/012067","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85096880582&doi=10.1088%2f1757-899X%2f949%2f1%2f012067&partnerID=40&md5=a494238f66b6ff1d52d2288d8ec55195"
DHUR-28	Cayla N.,"An Overview of New Technologies Applied to the Management of Geoheritage",2014,"Geoheritage","6","2",,"91","102",,"10.1007/s12371-014-0113-0","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84901778742&doi=10.1007%2fs12371-014-0113-0&partnerID=40&md5=16bc84564180c78a6c7d96d4c8584a47"
DHUR-32	Charbonneau N., Burgess J., Robichaud L.,"Using 4D modelling in a university-museum research partnership: The CASE of the ALPHONSE RAYMOND HISTORIC FACTORY COMPLEX",2015,"2015 Digital Heritage International Congress, Digital Heritage 2015",,, 7419579,"603","610",,"10.1109/DigitalHeritage.2015.7419579","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84965176741&doi=10.1109%2fDigitalHeritage.2015.7419579&partnerID=40&md5=306df72d7a3aead2cc009e6637129f24"
DHUR-38	Claudio G., Luca G., Luce L.M.,"Interaction design for cultural heritage. A robotic cultural game for visiting the museum's inaccessible areas.",2017,"Design Journal","20","sup1","S3925","S3934",,"10.1080/14606925.2017.1352895","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85070552315&doi=10.1080%2f14606925.2017.1352895&partnerID=40&md5=63fc9375e5313ee5debc892e5c193a54"
DHUR-39	Clini P., Nespeca R., Ruggeri L.,"Virtual in real. Interactive solutions for learning and communication in the national archaeological museum of Marche",2017,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","42","5W1","647","654",,"10.5194/isprs-Archives-XLII-5-W1-647-2017","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85020724278&doi=10.5194%2fisprs-Archives-XLII-5-W1-647-2017&partnerID=40&md5=c5efe21f609166c7e5aef90199a490bc"
DHUR-42	Cousins J., Chambers S., Van Der Meulen E.,"Uncovering cultural heritage through collaboration",2008,"International Journal on Digital Libraries","9","2",,"125","138",,"10.1007/s00799-008-0041-1","https://www.scopus.com/inward/record.uri?eid=2-s2.0-56049116653&doi=10.1007%2fs00799-008-0041-1&partnerID=40&md5=a0d0c530b9e94a72203af0799c64e079"
DHUR-44	Cuca B., Hadjimitsis D.G.,"Space technology meets policy: An overview of Earth Observation sensors for monitoring of cultural landscapes within policy framework for Cultural Heritage",2017,"Journal of Archaeological Science: Reports","14",,,"727","733",,"10.1016/j.jasrep.2017.05.001","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85019842454&doi=10.1016%2fj.jasrep.2017.05.001&partnerID=40&md5=ddd800fdd51eae1e9148005ccf96df91"
DHUR-47	Darling J.M., Vanoni D.J., Levy T.E., Kuester F.,"Enhancing the digital heritage experience from field to museum: User-centered system design of an augmented reality tablet application for cultural heritage",2013,"Proceedings of the DigitalHeritage 2013 - Federating the 19th Int'l VSMM, 10th Eurographics GCH, and 2nd UNESCO Memory of the World Conferences, Plus Special Sessions fromCAA, Arqueologica 2.0 et al.","1",,, 6743782,"453","",,"10.1109/DigitalHeritage.2013.6743782","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84896777527&doi=10.1109%2fDigitalHeritage.2013.6743782&partnerID=40&md5=140e3c4b8b84cf07553ce54408c872c7"
DHUR-48	Deuschel T., Heuss T., Humm B.,"The digital online museum: A new approach to experience virtual heritage",2014,"CEUR Workshop Proceedings","1306",,,"38","48",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84919807912&partnerID=40&md5=07020659acf91c338a1494dc9242dca9"
DHUR-49	Di Stefano C., Battisti F.,"Caravaggio in Rome: A QoE-based proposal for a virtual gallery",2018,"3DTV-Conference","2017-June",,,"1","4",,"10.1109/3DTV.2017.8280423","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85046336753&doi=10.1109%2f3DTV.2017.8280423&partnerID=40&md5=e303db6a776872690431c3a5d2bfb76c"
DHUR	Doerr M., Tzompanaki K., Theodoridou M., Georgis Ch., Axaridou A., Havemann S.,"A repository for 3D model production and interpretation in culture and beyond",2010,"VAST 2010 - 11th

-50	International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage",,,,"97","104",,"10.2312/VAST/VAST10/097-104","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84868010581&doi=10.2312%2fVAST%2fVAST10%2f097-104&partnerID=40&md5=b1a2ea31ad81e384cef74a410d43dc05"
DHUR-51	Donato V., Biagini C., Bertini G., Marsugli F.,"Challenges and opportunities for the implementation of h-bim with regards to historical infrastructures: A case study of the ponte giorgini in castiglione della pescaia (grosseto - Italy)",2017,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","42","5W1",,"253","260",,"10.5194/isprs-Archives-XLII-5-W1-253-2017","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85020712126&doi=10.5194%2fisprs-Archives-XLII-5-W1-253-2017&partnerID=40&md5=1bda12b7ee9fbb7711d323d9f1074a11"
DHUR-53	Dorner D.G., Liew C.L., Yeo Y.P.,"A textured sculpture: The information needs of users of digitised New Zealand cultural heritage resources",2007,"Online Information Review","31","2",,"166","184",,"10.1108/14684520710747211","https://www.scopus.com/inward/record.uri?eid=2-s2.0-34047263613&doi=10.1108%2f14684520710747211&partnerID=40&md5=3d9474d09cf05d70ba26592f14b1cf02"
DHUR-54	Doumat R., Egyed-Zsigmond E., Pinon J.-M.,"Digitized ancient documents ··· What's next?",2009,"Document Numerique","12","1",,"31","51",,"10.3166/dn.12.1.31-51","https://www.scopus.com/inward/record.uri?eid=2-s2.0-77950847451&doi=10.3166%2fdn.12.1.31-51&partnerID=40&md5=319120a8068cc5159bd33209ac17c5e6"
DHUR-56	Dragoni M., Tonelli S., Moretti G.,"A knowledge management architecture for digital cultural heritage",2017,"Journal on Computing and Cultural Heritage","10","3",15,"","",,"10.1145/3012289","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85026845459&doi=10.1145%2f3012289&partnerID=40&md5=c23b2ccada391125e2cd334ce3e012fe"
DHUR-57	Drap P., Seinturier J., Chambelland J.-C., Gaillard G., Pires H., Vannini G., Mucciotti M., Pruno E.,"Going to Shawbak (Jordan) and getting the data back: Toward a 3D GIS dedicated to medieval archaeology",2009,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","38","5W1","","",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84961313065&partnerID=40&md5=4c86c649d7dcaab2adc5ad9669ad33a7"
DHUR-58	Dunne S., Lerkenfeld M.,"Digital archiving: A call for user inspired digital archiving of cultural heritage",2010,"EuroITV'10 - Proceedings of the 8th International Interactive TV and Video Conference",,,,"27","29",,"10.1145/1809777.1809784","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84889234900&doi=10.1145%2f1809777.1809784&partnerID=40&md5=7a318ae2d9a84e579497462a357736ff"
DHUR-59	El-Behaedi R., Ghoneim E.,"Flood risk assessment of the Abu Simbel temple complex (Egypt) based on high-resolution spaceborne stereo imagery",2018,"Journal of Archaeological Science: Reports","20",,,"458","467",,"10.1016/j.jasrep.2018.05.019","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85047869952&doi=10.1016%2fj.jasrep.2018.05.019&partnerID=40&md5=f48435b8d21fdc431f17eaf6d900e907"
DHUR-60	Esmaeili H., Thwaites H., Woods P.C.,"A Conceptual Human-Centered Approach to Immersive Digital Heritage Site/Museum Experiences: The Hidden Waterfall City",2018,"Proceedings of the 2018 3rd Digital Heritage International Congress, Digital Heritage 2018 - Held jointly with the 2018 24th International Conference on Virtual Systems and Multimedia, VSMM 2018",,,8810110,"","",,"10.1109/DigitalHeritage.2018.8810110","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85072166722&doi=10.1109%2fDigitalHeritage.2018.8810110&partnerID=40&md5=f1c4280e8e5ccc8674c365c7a6ced4b3"
DHUR-61	Esposito F.,"Symbolic machine learning methods for historical document processing",2013,"DocEng 2013 - Proceedings of the 2013 ACM Symposium on Document Engineering",,,,"1","2",,"10.1145/2494266.2494291","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84887324559&doi=10.1145%2f2494266.2494291&partnerID=40&md5=098fb41e6a356c74bf9ae9c378d227db"
DHUR-62	Estermann B.,"Are memory institutions ready for open data and crowdsourcing? Results of a pilot survey from switzerland",2013,"Proceedings of the 9th International Symposium on Open Collaboration, WikiSym + OpenSym 2013",,,29,"","",,"10.1145/2491055.2491075","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84888161407&doi=10.1145%2f2491055.2491075&partnerID=40&md5=2f5146ac9f2dd2ff179a966575a1d654"
DHUR-63	Fadli F., AlSaeed M.,"Digitizing vanishing architectural heritage The design and development of Qatar historic buildings information modeling [Q-HBIM] platform",2019,"Sustainability (Switzerland)","11","9",2501,"","",,"10.3390/su11092501","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85066923237&doi=10.3390%2fsu11092501&partnerID=40&md5=b406246468d8e99640377ecf17123980"

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

DHUR-64	Farnand S., Jiang J., Frey F.,"Current practices in fine art reproduction: Project summary",2013,"Archiving 2013 - Final Program and Proceedings",,,,"48","53",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84883185713&partnerID=40&md5=da8cafb1dbe0dc76cccb61cd4ae7aead"
DHUR-65	Ferrara V., Macchia A., Sapia S., Lella F.,"Cultural heritage open data to develop an educational framework",2014,"IISA 2014 - 5th International Conference on Information, Intelligence, Systems and Applications",,, 6878775,"166","170",,"10.1109/IISA.2014.6878775","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84906730099&doi=10.1109%2fIISA.2014.6878775&partnerID=40&md5=0118ee0aefd9a75237f7bd74e6c36a5a"
DHUR-66	Ferrara V., Macchia A., Sapia S.,"Reusing cultural heritage digital resources in teaching",2013,"Proceedings of the DigitalHeritage 2013 - Federating the 19th Int'l VSMM, 10th Eurographics GCH, and 2nd UNESCO Memory of the World Conferences, Plus Special Sessions fromCAA, Arqueologica 2.0 et al.","2",,, 6744792,"409","412",,"10.1109/DigitalHeritage.2013.6744792","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84896749479&doi=10.1109%2fDigitalHeritage.2013.6744792&partnerID=40&md5=ba550b9e9a4e7bcdd078d5b2f7c72070"
DHUR-68	Ferro N., Silvello G.,"From users to systems: Identifying and overcoming barriers to efficiently access archival data",2016,"CEUR Workshop Proceedings","1611",,,"","",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84977589704&partnerID=40&md5=9089d5518d912662b3858d81635ae27d"
DHUR-70	Frangakis N., Lim V., Tanco L.M., Smatana P., Hreno J., Picinali L., Simeone L., Amditis A.,"PLUGGY: A pluggable social platform for cultural heritage awareness and participation",2018,"CEUR Workshop Proceedings","2235",,,"21","30",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-85062416694&partnerID=40&md5=2eceb325653f6cd1b1b5eb868af58064"
DHUR-71	Fryer J.G., Chandler J.H., El-Hakim S.F.,"Recording and modelling an aboriginal cave painting: With or without laser scanning?",2005,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","36","5/W17",,"","",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049525377&partnerID=40&md5=7826ca66a48fa288274ec6e8d51f2001"
DHUR-73	Gardiner K., Carswell J.D.,"Viewer-based directional querying for mobile applications",2004,"Proceedings - 4th International Conference on Web Information Systems Engineering Workshops, WISEW 2003: 3rd International Workshop on Web and Wireless Geographical Information Systems, W2GIS 2003, 1st Web Services Quality Workshop, WQW 2003 and 1st Workshop on Multichannel and Mobile Information Systems, MMIS 2003",,, 1286789,"83","91",,"10.1109/WISEW.2003.1286789","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84947929382&doi=10.1109%2fWISEW.2003.1286789&partnerID=40&md5=47342046f3bbb3617f6be5dcf371f1fc"
DHUR-77	Gillespie D., La Pensée A., Cooper M.,"USER-appropriate viewer for high resolution interactive engagement with 3D digital cultural artefacts",2013,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","40","5W2",,"271","276",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84924286351&partnerID=40&md5=c7d8ba055d35536d6ca3449fa638756f"
DHUR-78	Gitto S., Geri F.,"The versatility of augmented reality for the enhancement of cultural heritage.",2020,"IOP Conference Series: Materials Science and Engineering","949","1", 012077,"","",,"10.1088/1757-899X/949/1/012077","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85096859677&doi=10.1088%2f1757-899X%2f949%2f1%2f012077&partnerID=40&md5=fd5ea558edb69215f86642531eab1bcc"
DHUR-82	Gualandi M.L., Scopigno R., Wolf L., Richards J., Buxeda i Garrigos J., Heinzelmann M., Hervas M.A., Vila L., Zallocco M.,"ArchAIDE - archaeological automatic interpretation and documentation of cEramics",2016,"2016 Eurographics Workshop on Graphics and Cultural Heritage, GCH 2016",,,,"203","206",,"10.2312/gch.20161408","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054137065&doi=10.2312%2fgch.20161408&partnerID=40&md5=0ed99bb70f5b39267b1c1c427efa6a3d"
DHUR-83	Güleç Özer D., Nagakura T., Vlavianos N.,"Augmented reality (AR) of historic environments: Representation of parion theater, Biga, Turkey",2016,"A/Z ITU Journal of the Faculty of Architecture","13","2",,"185","193",,"10.5505/itujfa.2016.66376","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84984985757&doi=10.5505%2fitujfa.2016.66376&partnerID=40&md5=427e42d17c1c789e17e9dbe8aea8538f"
DHUR-84	Haddad N.A.,"From hand survey to 3D laser scanning: A discussion for non-technical users of heritage documentation",2013,"Conservation and Management of Archaeological Sites","15","2",,"213","226",,"10.1179/1350503313Z.00000000056","https://www.scopus.com/inward/record.uri?eid=2-s2.0-

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

	84893842111&doi=10.1179%2f1350503313Z.00000000056&partnerID=40&md5=4f23705e1bfa94a9a49945d0d742f11a"
DHUR-85	Hall M.M., Fernando S., Clough P.D., Soroa A., Agirre E., Stevenson M.,"Evaluating hierarchical organisation structures for exploring digital libraries",2014,"Information Retrieval","17","4",,"351","379",,"10.1007/s10791-014-9242-y","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84904969709&doi=10.1007%2fs10791-014-9242-y&partnerID=40&md5=3729a782b31f991ac2561c465088f940"
DHUR-86	Hassani F.,"Documentation of cultural heritage techniques, potentials and constraints",2015,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","40","5W7",,"207","214",,"10.5194/isprsarchives-XL-5-W7-207-2015","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84974574132&doi=10.5194%2fisprsarchives-XL-5-W7-207-2015&partnerID=40&md5=476d14ebde77e8f4749b13f602c08dac"
DHUR-92	Jäger-Klein C., Kryeziu A., Ymeri Hoxha V., Rant M.,"A digital pre-inventory of architectural heritage in kosovo using Docu-Tools®",2017,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","42","2W5","383","388",,"10.5194/isprs-archives-XLII-2-W5-383-2017","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85030254520&doi=10.5194%2fisprs-archives-XLII-2-W5-383-2017&partnerID=40&md5=5d0dbc504c30863daaa00150b6019e8d"
DHUR-95	Johnson E., Liew C.L.,"Engagement-oriented design: a study of New Zealand public cultural heritage institutions crowdsourcing platforms",2020,"Online Information Review","44","4",,"887","912",,"10.1108/OIR-10-2019-0329","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85084993895&doi=10.1108%2fOIR-10-2019-0329&partnerID=40&md5=231b687885756a6ed40b8a2053c6e4ce"
DHUR-99	Jordan J., Angelopoulou E., Maier A.,"A Novel Framework for Interactive Visualization and Analysis of Hyperspectral Image Data",2016,"Journal of Electrical and Computer Engineering","2016",,2635124,"","",,"10.1155/2016/2635124","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84994037066&doi=10.1155%2f2016%2f2635124&partnerID=40&md5=cc457eff631ad4908913a3bad018c68f"
DHUR-101	Jusof M.J., Rahim H.R.A.,"Revealing visual details via high dynamic range gigapixels spherical panorama photography: The Tempurung Cave natural heritage site",2014,"Proceedings of the 2014 International Conference on Virtual Systems and Multimedia, VSMM 2014",,,7136690,"193","200",,"10.1109/VSMM.2014.7136690","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84988230815&doi=10.1109%2fVSMM.2014.7136690&partnerID=40&md5=907a419da095452f26473d5ca4e6d020"
DHUR-102	Kaldeli E., Menis-Mastromichalakis O., Bekiaris S., Ralli M., Tzouvaras V., Stamou G.,"Crowdheritage: Crowdsourcing for improving the quality of cultural heritage metadata",2021,"Information (Switzerland)","12","2",64,"1","18",,"10.3390/info12020064","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85100753879&doi=10.3390%2finfo12020064&partnerID=40&md5=381ce94c2ed217b5fc4fcce294839f83"
DHUR-107	Khan S., Rosa S., Germak C.,"Exploring new functionalities in cultural heritage spaces - Designing different museum trails with low cost technologies",2018,"Proceedings of International Design Conference, DESIGN","5",,,"2251","2262",,"10.21278/idc.2018.0357","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054958583&doi=10.21278%2fidc.2018.0357&partnerID=40&md5=fefa2b142690650a0a5d8ed8af257e42"
DHUR-108	Kim M.H., Rushmeier H., Ffrench J., Passeri I., Tidmarsh D.,"Hyper3D: 3D graphics software for examining cultural artifacts",2014,"Journal on Computing and Cultural Heritage","7","3",14,"","",,"10.1145/2567652","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84979835776&doi=10.1145%2f2567652&partnerID=40&md5=c6b11afd8a5f6736eb1dc09a79d17800"
DHUR-110	Konstantakis M., Aliprantis J., Teneketzis A., Caridakis G.,"Understanding user eXperience aspects in cultural heritage interaction",2018,"ACM International Conference Proceeding Series",,,,"267","271",,"10.1145/3291533.3291580","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85060865172&doi=10.1145%2f3291533.3291580&partnerID=40&md5=56f8b2c129becd94a80adf5c9a1f6089"
DHUR-116	Larue F., di Benedetto M., Dellepiane M., Scopigno R.,"From the digitization of cultural artifacts to the web publishing of digital 3D collections: An automatic pipeline for knowledge sharing",2012,"Journal of Multimedia","7","2",,"132","144",,"10.4304/jmm.7.2.132-144","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84861876160&doi=10.4304%2fjmm.7.2.132-144&partnerID=40&md5=b41ac45dcddef9717325e4b42e9cfe38"
DHUR-119	Lercari N., Shiferaw E., Forte M., Kopper R.,"Immersive Visualization and Curation of Archaeological Heritage Data: Çatalhöyük and the Dig@IT App",2018,"Journal of Archaeological Method and Theory","25","2",,"368","392",,"10.1007/s10816-017-9340-4","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85021286452&doi=10.1007%2fs10816-017-9340-4&partnerID=40&md5=1afd00b370bd9bd9c8f2d76af665ad0c"

129

DHUR-122	Lo Turco M., Giovannini E.C.,"Towards a phygital heritage approach for museum collection",2020,"Journal of Archaeological Science: Reports","34",, 102639,"","",,"10.1016/j.jasrep.2020.102639","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85095790456&doi=10.1016%2fj.jasrep.2020.102639&partnerID=40&md5=f753aaeb2e9842fe332bfb2446578d58"
DHUR-126	Lu Z.,"Improving viewer engagement and communication efficiency within non-entertainment live streaming",2019,"UIST 2019 Adjunct - Adjunct Publication of the 32nd Annual ACM Symposium on User Interface Software and Technology",,,,"162","165",,"10.1145/3332167.3356879","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85074858311&doi=10.1145%2f3332167.3356879&partnerID=40&md5=2a1d781ffa113adce84f889a33c1706d"
DHUR-129	Maietti F., Di Giulio R., Piaia E., Medici M., Ferrari F.,"Enhancing Heritage fruition through 3D semantic modelling and digital tools: The INCEPTION project",2018,"IOP Conference Series: Materials Science and Engineering","364","1", 012089,"","",,"10.1088/1757-899X/364/1/012089","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049373201&doi=10.1088%2f1757-899X%2f364%2f1%2f012089&partnerID=40&md5=56f55d80075a8a8bc9b966352ec46390"
DHUR-130	Maietti F., Medici M., Piaia E.,"An inclusive approach to Digital Heritage: Preliminary achievements within the INCEPTION project",2017,"GCH 2017 - Eurographics Workshop on Graphics and Cultural Heritage",,,,"145","150",,"10.2312/gch.20171306","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85087333453&doi=10.2312%2fgch.20171306&partnerID=40&md5=d7f6a6016a0dc556e59f7879913f9fa2"
DHUR-131	Marasco A., Balbi B.,"Designing accessible experiences for heritage visitors through virtual reality",2019,"e-Review of Tourism Research","17","3",,"426","443",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-85078103933&partnerID=40&md5=e00953fbcba25254968a1064ec0c81e1"
DHUR-132	Martínez-Graña A.M., Goy J.L., Cimarra C.A.,"A virtual tour of geological heritage: Valourising geodiversity using google earth and QR code",2013,"Computers and Geosciences","61",,,"83","93",,"10.1016/j.cageo.2013.07.020","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84883438227&doi=10.1016%2fj.cageo.2013.07.020&partnerID=40&md5=a55622312bc7380bc4c1faf53e22f957"
DHUR-139	Muglia C., Kelly E.J., O'gara G., Stein A., Thompson S., Wolcott L.,"How we talk about assessment: A new framework for digital libraries",2019,"Serials Librarian","76","1-4",,"208","212",,"10.1080/0361526X.2019.1586050","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85066152279&doi=10.1080%2f0361526X.2019.1586050&partnerID=40&md5=477eff804234be71b0cefff4e5f763e4"
DHUR-147	O'Gara G.M., Woolcott L., Joan Kelly E., Muglia C., Stein A., Thompson S.,"Barriers and solutions to assessing digital library reuse: preliminary findings",2018,"Performance Measurement and Metrics","19","3",,"130","141",,"10.1108/PMM-03-2018-0012","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054562348&doi=10.1108%2fPMM-03-2018-0012&partnerID=40&md5=b3bf59d02d6230af1baeb23b547642a2"
DHUR-152	Pattuelli M.C.,"Modeling a domain ontology for cultural heritage resources: A user-centered approach",2011,"Journal of the American Society for Information Science and Technology","62","2",,"314","342",,"10.1002/asi.21453","https://www.scopus.com/inward/record.uri?eid=2-s2.0-78951493272&doi=10.1002%2fasi.21453&partnerID=40&md5=b4d48adedeb0532660440795e2717f69"
DHUR-156	Pierdicca R., Paolanti M., Frontoni E.,"eTourism: ICT and its role for tourism management",2019,"Journal of Hospitality and Tourism Technology","10","1",,"90","106",,"10.1108/JHTT-07-2017-0043","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061356943&doi=10.1108%2fJHTT-07-2017-0043&partnerID=40&md5=0ddc352a688daeb8182108775e215305"
DHUR-157	Pietroni E., Adami A.,"Interacting with virtual reconstructions in museums: The etruscanning project",2014,"Journal on Computing and Cultural Heritage","7","2", 9,"","",,"10.1145/2611375","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84979823981&doi=10.1145%2f2611375&partnerID=40&md5=9b853364b69de03b5bcf9e91645d25cc"
DHUR-160	Poux F., Valembois Q., Mattes C., Kobbelt L., Billen R.,"Initial user-centered design of a virtual reality heritage system: Applications for digital tourism",2020,"Remote Sensing","12","16", 2583,"","",,"10.3390/RS12162583","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85090081466&doi=10.3390%2fRS12162583&partnerID=40&md5=f32347fa216462434a541dcbb820a9b4"
DHUR	Praticò S., Solano F., Di Fazio S., Modica G.,"Machine learning classification of mediterranean forest habitats in google earth engine based on seasonal sentinel-2 time-series and input image

-161	composition optimisation",2021,"Remote Sensing","13","4", 586,"1","28",,"10.3390/rs13040586","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85100818706&doi=10.3390%2frs13040586&partnerID=40&md5=c4b82480321384b2b73d6b9dd1d0388d"
DHUR -171	Seifert C., Bailer W., Orgel T., Gantner L., Kern R., Ziak H., Petit A., Schlötterer J., Zwicklbauer S., Granitzer M.,"Ubiquitous access to digital cultural heritage",2017,"Journal on Computing and Cultural Heritage","10","1", 4,"","",,"10.1145/3012284","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85018192900&doi=10.1145%2f3012284&partnerID=40&md5=3c06998477f23998c77e9ff7f426c58f"
DHUR -172	Semeraro G., Lops P., De Gemmis M., Musto C., Narducci F.,"A Folksonomy-based recommender system for personalized access to digital artworks",2012,"Journal on Computing and Cultural Heritage","5","3", 11,"","",,"10.1145/2362402.2362405","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84979834448&doi=10.1145%2f2362402.2362405&partnerID=40&md5=3e6e4f4132d46e42f3e22f94ba2bea83"
DHUR -174	Shin J.-E., Woo W.,"Design guidelines for a location-based digital heritage storytelling tool to support author intent",2018,"Proceedings of the 2018 3rd Digital Heritage International Congress, Digital Heritage 2018 - Held jointly with the 2018 24th International Conference on Virtual Systems and Multimedia, VSMM 2018",,, 8810102,"","",,"10.1109/DigitalHeritage.2018.8810102","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85072405344&doi=10.1109%2fDigitalHeritage.2018.8810102&partnerID=40&md5=2eec814dc8b16252d04ca3ead1add880"
DHUR -180	Song M., Elias T., Martinovic I., Mueller-Wittig W., Chan T.K.Y.,"Digital heritage application as an edutainment tool",2004,"Proceedings VRCAI 2004 - ACM SIGGRAPH International Conference on Virtual Reality Continuum and its Applications in Industry",,,,"163","167",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-10044290743&partnerID=40&md5=8c722bf748f7745a082dedd75a1b9c8c"
DHUR -181	Song M., Elias T., Müller-Wittig W., Chan T.K.Y.,"Interacting with the virtually recreated Peranakans",2003,"Proceedings of the 1st International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia, GRAPHITE '03",,,,"223","228+302",,"10.1145/604471.604515","https://www.scopus.com/inward/record.uri?eid=2-s2.0-32244442492&doi=10.1145%2f604471.604515&partnerID=40&md5=ab2a4931dea4b77bc793df57f4a367ce"
DHUR -192	Trichopoulos G., Aliprantis J., Konstantakis M., Caridakis G.,"Artists: A virtual reality cultural experience personalized artworks system: The "children concert" painting case study",2018,"CEUR Workshop Proceedings","2811",,,"146","152",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-85101190953&partnerID=40&md5=9ddba200f5b491f8e865dcb38e05a600"
DHUR -196	Valdelomar J.T., Brandtner J., Kucera M., Wallner M., Sandici V., Neubauer W.,"4D investigation of Digital Heritage: An interactive application for the auxiliary fortress of Carnuntum",2015,"2015 Digital Heritage International Congress, Digital Heritage 2015",,, 7419457,"81","84",,"10.1109/DigitalHeritage.2015.7419457","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84965118615&doi=10.1109%2fDigitalHeritage.2015.7419457&partnerID=40&md5=0b6b76287e3d714234fae9e06e7db85a"
DHUR -197	Valtolina S., Mazzoleni P., Franzoni S., Bertino E.,"A semantic approach to build personalized interfaces in the cultural heritage domain",2006,"Proceedings of the Workshop on Advanced Visual Interfaces","2006",,,"306","309",,"10.1145/1133265.1133328","https://www.scopus.com/inward/record.uri?eid=2-s2.0-34247156527&doi=10.1145%2f1133265.1133328&partnerID=40&md5=9fe02547a874db8a3af71d4634eea169"
DHUR -199	Van Den Akker C., Van Erp M., Aroyo L., Van Nuland A., Van Der Meij L., Legêne S., Schreiber G.,"From information delivery to interpretation support: Evaluating cultural heritage access on the Web",2013,"Proceedings of the 5th Annual ACM Web Science Conference, WebSci'13","volume",,,"431","440",,"10.1145/2464464.2464491","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84883080513&doi=10.1145%2f2464464.2464491&partnerID=40&md5=f70ab4926a4da79904f2e92a1f2f767d"
DHUR -203	Vinella F.L., Lykourentzou I., Papangelis K.,"Motivational Principles and Personalisation Needs for Geo-Crowdsourced Intangible Cultural Heritage Mobile Applications",2020,"UMAP 2020 Adjunct - Adjunct Publication of the 28th ACM Conference on User Modeling, Adaptation and Personalization",,,,"362","369",,"10.1145/3386392.3399284","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85089262282&doi=10.1145%2f3386392.3399284&partnerID=40&md5=c3d764f84b5715c1b687a6dd1ce35691"
DHUR -205	Vosinakis S., Avradinis N.,"Virtual agora: Representation of an ancient greek agora in virtual worlds using biologically-inspired motivational agents",2016,"Mediterranean Archaeology and Archaeometry","16","5 Special Issue",,"29","41",,"10.5281/zenodo.204964","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85034625037&doi=10.5281%2fzenodo.204964&partnerID=40&md5=a5fa21dbe9736a37dd0f8a9c51462d78"

DHUR-207	Walsh D., Clough P., Foster J.,"User categories for digital cultural heritage",2016,"CEUR Workshop Proceedings","1611",,,"","",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84977499179&partnerID=40&md5=f0ac2ca74d26932039f03c1d736a9676"
DHUR-225	Algee L., Bailey J., Owens T.,"Viewshare and the kress collection: Creating, sharing, and rapidly prototyping visual interfaces to cultural heritage collection data",2012,"D-Lib Magazine","18","11-12",,"","",,"10.1045/november2012-algee","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84872141159&doi=10.1045%2fnovember2012-algee&partnerID=40&md5=32cc6c5134fa67e5bccf9c7c87c3ea86"
DHUR-226	Aloia N., Binding C., Cuy S., Doerr M., Fanini B., Felicetti A., Fihn J., Gavrilis D., Geser G., Hollander H., Meghini C., Niccolucci F., Nurra F., Papatheodorou C., Richards J., Ronzino P., Scopigno R., Theodoridou M., Tudhope D., Vlachidis A., Wright H.,"Enabling European archaeological research: The ARIADNE E-infrastructure",2017,"Internet Archaeology",,"43",,"","",,"10.11141/ia.43.11","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85018426356&doi=10.11141%2fia.43.11&partnerID=40&md5=11275072cb25f4025cf9d6e8cd8f2127"
DHUR-234	Bruno N., Roncella R.,"HBIM for conservation: A new proposal for information modeling",2019,"Remote +B209:B239Sensing","11","15",1751,"","",,"10.3390/rs11151751","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85070444006&doi=10.3390%2frs11151751&partnerID=40&md5=3a81d1e86d968c3f38efedd5a1d7feb4"
DHUR-237	Dimitriou N., Drosou A., Tzovaras D.,"Scan4Reco: Towards the digitized conservation of cultural heritage assets via spatiotemporal (4D) reconstruction and 3D printing",2016,"2016 Eurographics Workshop on Graphics and Cultural Heritage, GCH 2016",,,,"53","56",,"10.2312/gch.20161382","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85021716557&doi=10.2312%2fgch.20161382&partnerID=40&md5=738d93b6a521509c3137be403cb15a26"
DHUR-238	Fernie K., Griffiths J., Stevenson M., Clough P., Goodale P., Hall M., Archer P., Chandrinos K., Agirre E., De Lacalle O.L., De Polo A., Bergheim R.,"PATHS: Personalising access to cultural heritage spaces",2012,"Proceedings of the 2012 18th International Conference on Virtual Systems and Multimedia, VSMM 2012: Virtual Systems in the Information Society",,,6365960,"469","474",,"10.1109/VSMM.2012.6365960","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84872008736&doi=10.1109%2fVSMM.2012.6365960&partnerID=40&md5=f3ef11eb83c22b1e42ecc758e7450b0f"
DHUR-240	Freire N., Isaac A., Robson G., Howard J.B., Manguinhas H.,"A survey of Web technology for metadata aggregation in cultural heritage",2018,"Information Services and Use","37","4",,"425","436",,"10.3233/ISU-170859","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85040344933&doi=10.3233%2fISU-170859&partnerID=40&md5=87e13e9c063f80278250ce65d02b6feb"
DHUR-241	Fu X., Zhu Y., Xiao Z., Xu Y., Ma X.,"RestoreVR: Generating Embodied Knowledge and Situated Experience of Dunhuang Mural Conservation via Interactive Virtual Reality",2020,"Conference on Human Factors in Computing Systems - Proceedings",,,3376673,"","",,"10.1145/3313831.3376673","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85091267432&doi=10.1145%2f3313831.3376673&partnerID=40&md5=5f5c1fa6fd3f7ed9f670c8fe4e5a9726"
DHUR-246	Hess M.,"Online survey about current use of 3D imaging and its user requirements in cultural heritage institutions",2015,"2015 Digital Heritage International Congress, Digital Heritage 2015",,,7419517,"333","338",,"10.1109/DigitalHeritage.2015.7419517","https://www.scopus.com/inward/record.uri?eid=2-s2.0-84965146918&doi=10.1109%2fDigitalHeritage.2015.7419517&partnerID=40&md5=b707aba0cb8b390e765ecb58422d2455"
DHUR-251	Meghini C., Scopigno R., Richards J., Wright H., Geser G., Cuy S., Fihn J., Fanini B., Hollander H., Niccolucci F., Felicetti A., Ronzino P., Nurra F., Papatheodorou C., Gavrilis D., Theodoridou M., Doerr M., Tudhope D., Binding C., Vlachidis A.,"ARIADNE: A research infrastructure for archaeology",2017,"Journal on Computing and Cultural Heritage","10","3",3064527,"","",,"10.1145/3064527","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85027490568&doi=10.1145%2f3064527&partnerID=40&md5=62723b5979a49bdb672d6597ed2ef437"
DHUR-255	Partarakis N., Antona M., Zidianakis E., Stephanidis C.,"Adaptation and content personalization in the context of multi user museum exhibits",2016,"CEUR Workshop Proceedings","1621",,,"5","10",,,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-84984819373&partnerID=40&md5=128b6677b6a063cfe47adcb9cd7a13af"

4CH Competence Centre for the Conservation of Cultural Heritage
D1.4 Final report on user needs

DHUR-256	Pereira Z., Morgado A., Gomes Pereira L.,"Comparison of different approaches to create architectural archives",2004,"International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives","35",,,"552","557",,,"https://www.scopus.com/inward/record.uri?eid=2-s2.0-41549160685&partnerID=40&md5=1acb73783826f474e0ce4ed0fcb02056"
DHUR-257	Perles A., Pérez-Marín E., Mercado R., Segrelles J.D., Blanquer I., Zarzo M., Garcia-Diego F.J.,"An energy-efficient internet of things (IoT) architecture for preventive conservation of cultural heritage",2018,"Future Generation Computer Systems","81",,,"566","581",,"10.1016/j.future.2017.06.030","https://www.scopus.com/inward/record.uri?eid=2-s2.0-85026728227&doi=10.1016%2fj.future.2017.06.030&partnerID=40&md5=c83df7044106a93f8fa03b8076d9926a"
DHUR-260	Schmidt R., Lindley A., King R., Jackson A., Wilson C., Steeg F.,"The planets IF - A framework for integrated access to preservation tools",2010,"ACM International Conference Proceeding Series",,,,"","",,"10.1145/2039263.2039273","https://www.scopus.com/inward/record.uri?eid=2-s2.0-80054779665&doi=10.1145%2f2039263.2039273&partnerID=40&md5=fa67f91daa608313db63596a915f0715"

CODE	TITLE OF PROJECT	LINK TO DOCUMENT
EU-01	Inclusive Cultural Heritage in Europe through 3D semantic modelling	https://cordis.europa.eu/project/id/665220/results
EU-04	Accessible Resources for Cultural Heritage EcoSystemsv	1) https://www.arches-project.eu/wp-content/uploads/2019/07/EnglishGuide_Hyperlinks.pdf 2) https://www.arches-project.eu/deliverables/
EU-05	The Internet Of Historical Things And Building New 3D Cultural Worlds	https://cordis.europa.eu/project/id/665066/results
EU-06	Multimodal Scanning of Cultural Heritage Assets for their multilayered digitization and preventive conservation via spatiotemporal 4D Reconstruction and 3D Printing	https://cordis.europa.eu/project/id/665091/results https://scan4reco.iti.gr/public-deliverables
EU-08	Emotive Virtual cultural Experiences through personalized storytelling	https://emotiveproject.eu/
EU-09	Pluggable Social Platform for Heritage Awareness and Participationv	https://www.pluggy-project.eu
EU-12	Meaningful Personalization of Hybrid Virtual Museum Experiences Through Gifting and Appropriation	https://gifting.digital/experience-design/ https://gifting.digital/organisational-change/
EU-14	Advanced VR, iMmersive serious games and Augmented REality as tools to raise awareness and access to European underwater CULTURal heritagE.	https://cordis.europa.eu/project/id/727153/results

EU-17	Visual and textual content re-purposing FOR(4) architecture, Design and video virtual reality games	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bee79d19&appId=PPGMS
EU-19	Augumented RealiTy Supported adaptive and personalized Experience in a museum based oN processing real-time Sensor Events	https://cordis.europa.eu/project/id/270318
EU-24	Cultural Heritage Experiences through Socio-personal interactions and Storytelling	http://www.chessexperience.eu; https://cordis.europa.eu/project/id/270198
EU-26	Expanding the Research and Innovation Capacity in Cultural Heritage Virtual Reality Applications	3D Reconstruction as a Service – Applications in Virtual Cultural Heritage	SpringerLink
EU-28	Safeguarding Cultural Heritage through Technical and Organisational Resources Management	Safeguarding Cultural Heritage through Technical and Organisational Resources Management	STORM Project	H2020	CORDIS	European Commission (europa.eu)
EU-37	HEritage Resilience Against CLimate Events on Site	http://www.heracles-project.eu/sites/default/files/pages/documents/d1.2-1-55.pdf http://www.heracles-project.eu/sites/default/files/pages/documents/d1.2-56-110.pdf
EU-42	Remote Sensing Science Center for Cultural Heritage	
EU-44	Regeneration and Optimisation of Cultural heritage in creative and Knowledge cities	https://rockproject.eu/documents-list
EU-54	Robots for Exploration, Digital Preservation and Visualization of Archeological Sites	1) http://hdl.handle.net/11573/924701 2) http://www.rovina-project.eu/system/papers/pdfs/000/000/029/original/rovina16aich.pdf?1468591891
EU-61	A New Portable Spectral Camera System for the Cultural Heritage Conservation Market	https://xpecam.com
EU-62	LEarning of Archaeology through Presence	https://www.upf.edu/web/leap/grup-usuaris-leap
EU-80	3D acquisition, processing and presentation of prehistoric European rock-art	D1.1: https://cordis.europa.eu/project/id/600545/reporting

| EU-81 | Large displays in museums | https://www.researchgate.net/profile/Joel-Lanir/publication/258023251_The_Influence_of_a_Location-Aware_Mobile_Guide_on_Museum_Visitors%27_Behavior/links/00463526a1e8f88513000000/The-Influence-of-a-Location-Aware-Mobile-Guide-on-Museum-Visitors-Behavior.pdf |
| EU-99 | Smart Monitoring of Historic Structures | https://cordis.europa.eu/project/id/212939 |

Appendix 3 – Relation between pain relievers and services

The following tables summarize the analysis made to align the solutions with the pain relievers. Those services highlighted in darker yellow represent the most relevant service for that type of pain reliever while the lighter yellow refers to those services that are relevant.

Associated user need (number)	UC01: PUBLIC AND/ OR PRIVATE HERITAGE INSTITUTIONS RESPONSIBLE FOR MANAGING MONUMENTS AND SITES — Pain reliever	Services — CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN01	Updatable digital platform for data archiving and storage to support documentation, management and conservation			■ dark		▨ light	▨ light	▨ light
UN01	Increase knowledge of digital technologies and standards		▨ light	▨ light	■ dark	▨ light		
UN05	Computational platform to perform complex analysis and monitoring based on time-series data				▨ light		■ dark	▨ light
UN07	Increase knowledge of different technologies for heritage conservation, including sensors, gateways and storage for continuous monitoring and control of environmental parameters				▨ light	■ dark	▨ light	

Associated user need (number)		UC01: PUBLIC AND/ OR PRIVATE HERITAGE INSTITUTIONS RESPONSIBLE FOR MANAGING MONUMENTS AND SITES	Services						
			CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
			Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
	UN09	Improve knowledge on the selection of options available to ensure optimal choice of methods				☐ (orange)	☐ (orange)		
	UN12	Common framework for cultural heritage 3D documentation and models that supports interdisciplinarity		☐ (light)			☐ (orange)		☐ (orange)
	UN17	Enriched 3D models for different experts, users profiles and disciplines			☐ (orange)	☐ (light)	☐ (light)		

Associated user need (number)	UC02: DECISION-MAKERS AND NATIONAL PUBLIC BODIES (I.E. MINISTRIES) PROMOTING POLICIES AND STRATEGIES FOR CONSERVATION, PRESERVATION AND DIGITIZATION / Pain reliever	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN06	Predictive modelling tools based on low-cost fine scale data models					░	█	░
UN06	Dedicated operational services and applications for heritage and landscapes monitoring	█		░		░		
UN06	Informed decision support systems based on data-driven approaches	█		░		░		░
UN07	Training and skills acquisition on remote sensing imagery for heritage monitoring				░	█		
UN12	Improve metadata quality of digital cultural content						░	█
UN12	Common framework for cultural heritage 3D documentation and models that supports interdisciplinarity		█	█				█
UN17	Web system to manage different scales of detail and information sharing among actors through portable devices						█	░

Associated user need (number)	UC02: DECISION-MAKERS AND NATIONAL PUBLIC BODIES (I.E. MINISTRIES) PROMOTING POLICIES AND STRATEGIES FOR CONSERVATION, PRESERVATION AND DIGITIZATION	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN18	Cross domain portal to standardize searching options			■			■	
UN19	Digital archiving platform to facilitate the interaction between users from different specialties					■	■	■
UN19	Platform for data integration facilitating information accessibility to the public						■	■
UN22	Methods for making digital archive platforms accessible and useful to public		■	■	■			

Associated user need (number)	Pain reliever	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN01	Optimization and integration of technologies to create digital models with different levels of accuracy for surveying and monitoring projects				(light)		■	
UN01	Single and friendly interface to access data and information provided by different digital imaging techniques						■	(light)
UN03	Methodologies aimed at bringing users into the design process for the creation of new cultural heritage products or services		(light)	■		(light)		
UN04	Recommendations and methods for communication and crowdsourcing platforms and tools		■	■	(light)			
UN05	Technologies for digital models acquisition in hard to access environment					■	■	
UN09	Increase knowledge on the use and potential of virtual reality and gaming to disseminate and investigate archaeological sites			■	(light)			
UN11	Affordable, customizable, user-friendly solutions based on non-invasive and non-destructive technology					(light)	■	
UN13	Define optimal conservation methodologies according to different criteria through automatic digitization and documentation					■		(light)

UC03: PROFESSIONALS AND SMES PROVIDING SERVICES OR PRODUCTS FOR PRESERVATION, CONSERVATION AND RESTORATION

Associated user need (number)	UC03: PROFESSIONALS AND SMES PROVIDING SERVICES OR PRODUCTS FOR PRESERVATION, CONSERVATION AND RESTORATION	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN14	Automatic data pre-processing, warning systems and tools for action recommendations		�				■	
UN18	New systems of representation and data management for different types of materials collected and processed						■	
UN20	Intuitive and friendly tools allowing interactive inspections and dissemination based on mixed reality			▢	▢		■	
UN20	Personalization technologies which provide users with guides that enhance their cultural experience				▢		■	

Associated user need (number)	UC04: ASSOCIATIONS, NGOS, LOCAL COMMUNITIES AND CITIZENS AIMING AT MAINTAINING AND COMMUNICATING CULTURAL HERITAGE	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
	Pain reliever	Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN01	Fast digitization technologies aimed at the production of multimedia content for knowledge sharing			■			▫	
UN04	Tools and methods to facilitate contact with cultural institutions and improve communication activities to include local knowledge in heritage transmission		■					
UN08	Increase knowledge of good practice and examples of regeneration initiatives			■				
UN18	Inclusion of open data and crowdsourcing methods in digital resources	■						▫
UN24	Communication system that facilitates tourist routes and thematic routes across the territory						■	

	UC05: COMPANIES FROM THE CREATIVE INDUSTRY PRODUCING HERITAGE-BASED CONTENT, APPS, GAMES, EDUCATION AND TOURISM SERVICE	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
Associated user need (number)	*Pain reliever*	Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN01	Semi-automatic or automatic 3D models generation through content reuse for video game designers					🟧	🟧	

Associated user need (number)	UC06: GENERAL AND EDUCATIONAL USERS AND VISITORS, TOURISTS — Pain reliever	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN02	New technologies to enhance inclusive tourism and full accessibility to cultural heritage			▤			■	
UN03	Digital technologies and online applications to promote, interact and interpret cultural heritage						■	▤
UN04	To undergo immersive, personalized and active experiences through high-quality views and 3D reconstructions combining educational aspects				▤		■	
UN05	Virtual and augmented reality tools to explore underwater heritage						■	
UN10	3D viewer to promote and allow non-expert users to engage with cultural heritage datasets				▤		■	
UN10	Realistic spatial database system that considers the user's line-of-sight in information retrieval			■			■	
UN12	Tools and platforms facilitating heritage resources sharing and reuse for educational purposes						■	
UN12	Facilitate navigation through large and complex collection to enhance users experience of using digital libraries						■	
UN18	Ubiquitous access to digital cultural heritage content	■	■	■				

		Services							
	UC06: GENERAL AND EDUCATIONAL USERS AND VISITORS, TOURISTS	CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING		SUPPORT IN INNOVATION AND PROJECTS	
Associated user need (number)	*Pain reliever*	Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training		Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN18	Open access data modality, tools for sharing museum resource and to make multimedia lessons	▓	▓	▓					
UN19	Tools to guide users in finding appropriate information	▓							
UN20	Virtual tour of the geological heritage through mobile to enhance tourism quality							▓	

Associated user need (number)	Pain reliever	CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN01	Standardized workflows and optimal reproduction processes for artworks, reducing manual post-processing				■	■		
UN03	Improved skills in communication criteria for virtual reconstruction and digital experiences					■		
UN04	Inclusion of collaborative and participatory approaches to enrich metadata							■
UN05	Digital technologies for showcasing objects not visible to the general public				▫		■	
UN10	Visualization infrastructure for the collaborative exploration and analysis of large and complex 3D scanning data						■	
UN20	Interoperable digital workflows to enhance the vision of the real object enriched by digital content and make information more accessible			■			■	
UN20	Architecture for managing digital collections related to the creation, management, preservation, and visualization of digital collections						■	
UN23	Methods for reuse assessment of the digital library community	■		■				▫

UC07: MUSEUM CURATORS — Services

Associated user need (number)	Pain reliever	CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
	UC08: PROFESSIONAL RESEARCHERS — Services	Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN07	Increase knowledge of emerging technologies supporting documentation and conservation of cultural heritage			■	■	░		
UN10	Alternative 4D modelling solutions for professionals not familiar to BIM platform						■	
UN12	Semi-automatic description and matching of existing catalogues for architects and archaeologists		■	■				░
UN12	Optimized workflow process through a combination of multiple capture techniques				■			
UN15	3D models allowing interaction with objects						■	
UN16	Incremental method for information upgrading			░	■			
UN17	Structured digital archive of 3D models that can reduce or increase the weight of information displayed according to the purpose						■	
UN17	Easy and fast methods and tools for the production and interpretation of combined cultural heritage and 3D data				■		■	
UN18	Ubiquitous access to digital cultural heritage content	░	■	■				

Associated user need (number)	Pain reliever	Services						
		CONSULTANCY AND ORIENTATION				**TRAINING AND CAPACITY BUILDING**	**SUPPORT IN INNOVATION AND PROJECTS**	
		Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN18	Digital libraries enhanced by annotation collaboratory facilities for cooperative and collaborative knowledge working				□			■
UN18	Data portal that enables professionals to provide access to their resources (datasets, collections)	■						■
UN19	Improve metadata integration and retrieval effectiveness							■
UN19	Platforms enabling data integration of different disciplines supporting all the phases of restoration							■
UN20	Availability of interfaces allowing different users to explore and interpret collections				■			
UN20	Low-cost method based on AR technologies for digital heritage representation					■		
UN20	New techniques supporting visual inspections and raw data intuitive access				□	■		
UN21	Preservation framework that is verifiable, open and extensible to ensure longevity, integrity and quality of primary materials				■			
UN21	Service-oriented research infrastructure for repositories, tools and services integration				■			■
UN22	Framework for enhancing access to metadata contents				■		□	

Associated user need (number)	UC08: PROFESSIONAL RESEARCHERS	Services						
		CONSULTANCY AND ORIENTATION				TRAINING AND CAPACITY BUILDING	SUPPORT IN INNOVATION AND PROJECTS	
	Pain reliever	Contacts/help	Communication	Dissemination and knowledge sharing	Orientation, guidance and consultancy	Training	Enabling technologies, datasets, physical equipment	Collaborative research, networking
UN25	Technologies to help engaging general public in restoration processes				�		�	
UN25	Increase acceptance and adoption of 3D imaging to develop mass digitisation		▓	▓	▒			