



4.2.2.4 Material weathering

Gypsum and limestone are the main building materials used throughout the Palace. The gypsum in particular, an extremely sensitive material, has been badly eroded, due to its solubility in water thus producing changes in its mechanical properties.

4.2.2.4.1 Mineral Gypsum Decay and Degradation

The decay of the building and ornamental elements of the historic monuments is a result of the combination of several factors, among which the chemical dissolution dominates. This process takes place within the interface of stone/water, both in macroscopic and microscopic scale within the pores and incoherencies (see Figures 81,82,83). Therefore, a systematic approach for confronting the results of this effect must imply a depth knowledge of:

- a. The nature of the solid material that has to be preserved (mineral gypsum),
- b. The liquid phase which may contain a critical number of dissolved ions and consist, at least at an initial state, the unsaturated solution/solvent, and finally,
- c. The interface between the solid and the liquid phases.



Figures 81, 82: Crack & Deformation; Secondary mineral gypsum from the “King’s Megaron” showing a network of thin cracks. Cracks due to mechanical stress from the “North Entrance”.

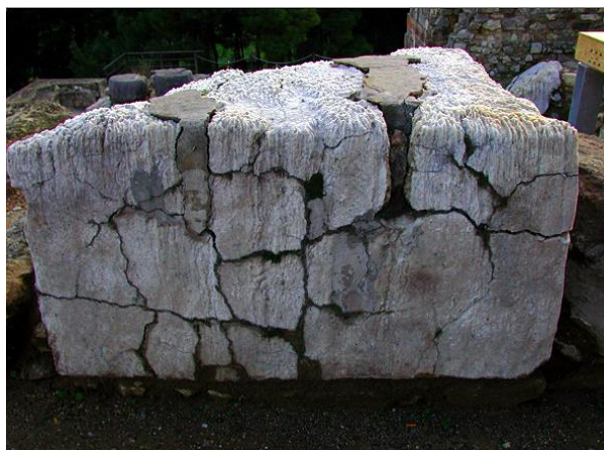


Figure 83: Detachment; Secondary gypsum block located at the East Wing of the Knossos Palace.



The following photos show surface details with typical phenomena due to decay and degradation of mineral gypsum in different areas of the monument.



Figure 84: Delamination; Exfoliation of microcrystalline mineral gypsum slab, Knossos Palace



Figure 85: Disintegration; Loss of cohesion between gypsum crystal aggregates leading to crumbling. Selenite block located near the “West Magazines”, Knossos Palace.



Figure 86: Erosion; Typical formation of microkarst cavities on the surface of secondary gypsum from Knossos. Dissolution pits, grooves and runnels, collectively called karren.

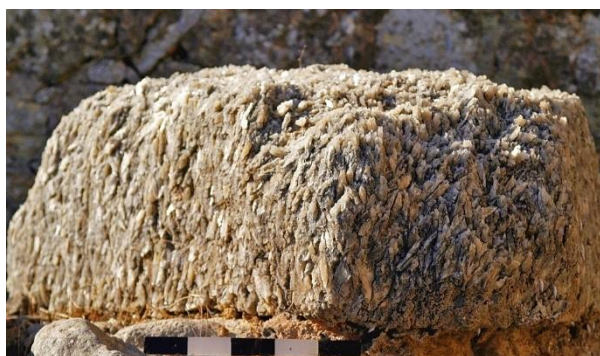


Figure 87: Encrustation; Deposition of dissolved and recrystallized gypsum on the surface of a marly limestone from the West Court, Palace of Knossos.



4.2.2.4.2 The Water – Gypsum system

The majority of the decay phenomena regarding the preservation of mineral gypsum of the Knossos Palace, are related to the presence of water. The dominant effects are the disintegration and the erosion both leading to the loss of the original material and the formation of accumulations of secondary gypsum.

The erosion of mineral gypsum and the consequent loss of the original material, leads to the uncontrolled canalization of the rain water, especially in the cases where different architectural elements are in contact. Characteristic images of the degraded gypsum at Knossos Palace are shown in Figures 88-92:



Figure 88. Eroded (dissolved) gypsum slabs from the “King’s Megaron”, Palace of Knossos.



Figure 89. The dissolved gypsum elements are preserved in a lower level comparing to the cement mortar that was initially used for the fixation of the gypsum fragments, “King’s Megaron”, Palace of Knossos.



Figure 90. Rain water is channeled through the discontinuities to the substrate on which the gypsum elements are founded. The water flow contributes to further erosion and loss of material of the original parts of the monument, “King’s Megaron”, Palace of Knossos



Figure 91. The results of the uncontrolled rain water drainage can be summarized as: erosion of the iron rebar, further degradation of the concrete building and ornamental elements, salt efflorescence, “Pillar Crypts”, Palace of Knossos



Figure 92. Salt efflorescence, growth of higher plantation and rain water accumulation (after the rainfall on the 31st of October 2016), "Pillar Crypts", Palace of Knossos.

Additionally, extreme weather phenomena for Crete, such as the snowstorm of January 8th 2017, contribute significantly to the accumulation and circulation of water in the monument and should be also taken into account (see Figures. 93, 94).



Figures 93 and 94: Snow accumulation during the recent intense snowfall on January 8th 2017, Palace of Knossos.

Solutions to limit the effects of the rain water and its related effects have to be considered in the HERACLES project.

In Figure 95 are indicated the reported examples as red spots.

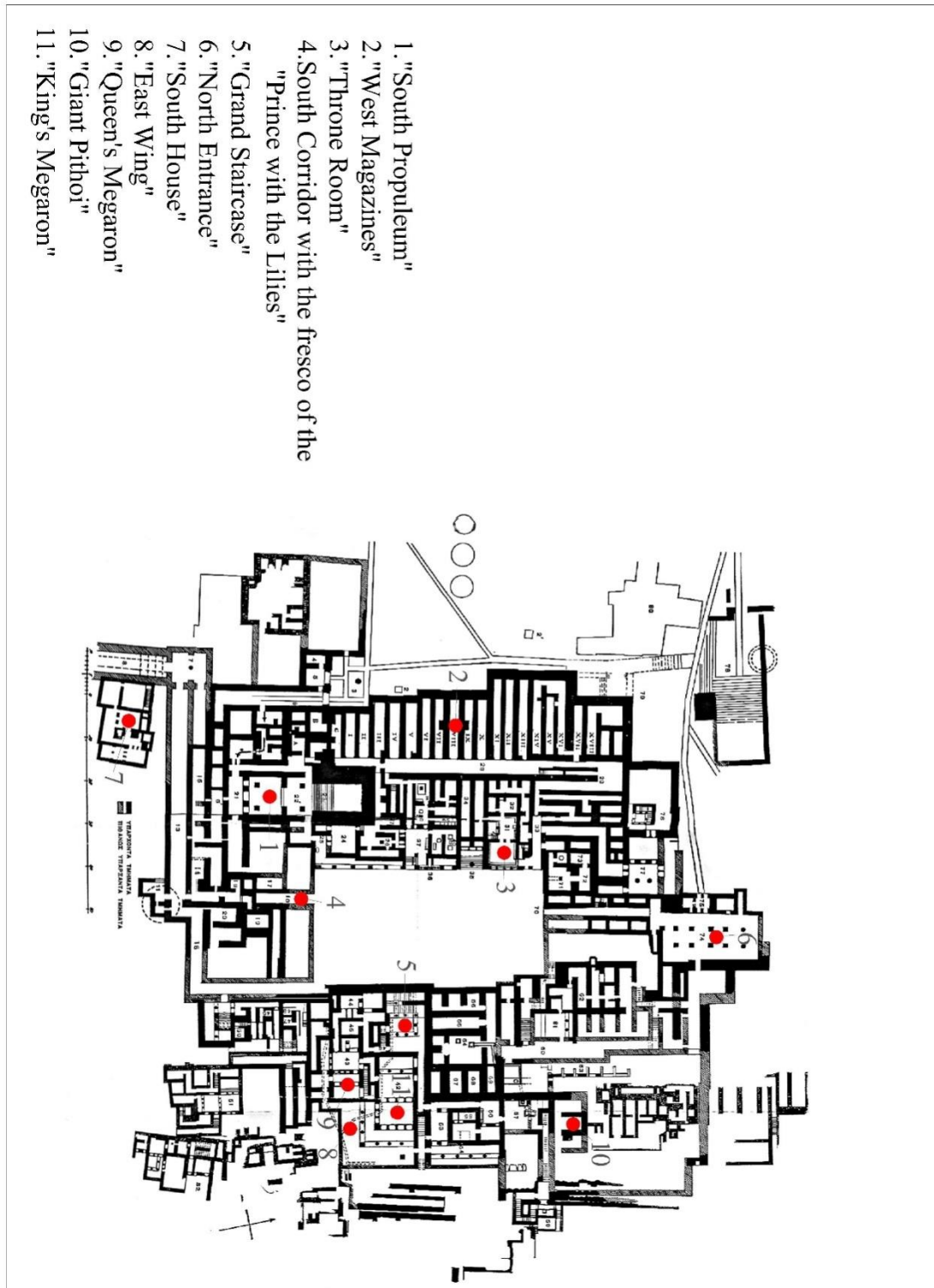


Figure 95: Knossos map. The examples presented above refer to the spots denoted with red spots



4.2.2.5 Air Pollution

At North of the archaeological site are located the city of Heraklion, the harbour, the airport and at N.W. the local installations of the Public Power Corporation, whose pollutants affect the corrosion of the materials constituting the monument (see Figure 96)

The contribution of possible pollutant sources has to be taken into account. In the north coast of the island of Crete, it has been reported that, on a yearly basis, the N/NW accounts for about 61%, the W for 13%, the S/SW for 18% and the others for the remaining 8% of the pollutant events. In order to face the evidenced problems and to preserve the materials used in the Knossos palace (limestone, gypsum stone, mortar clay, lime plasters, clay of pithoi), the air pollution according to the nature and the concentration of pollutants and salts, has to be investigated.

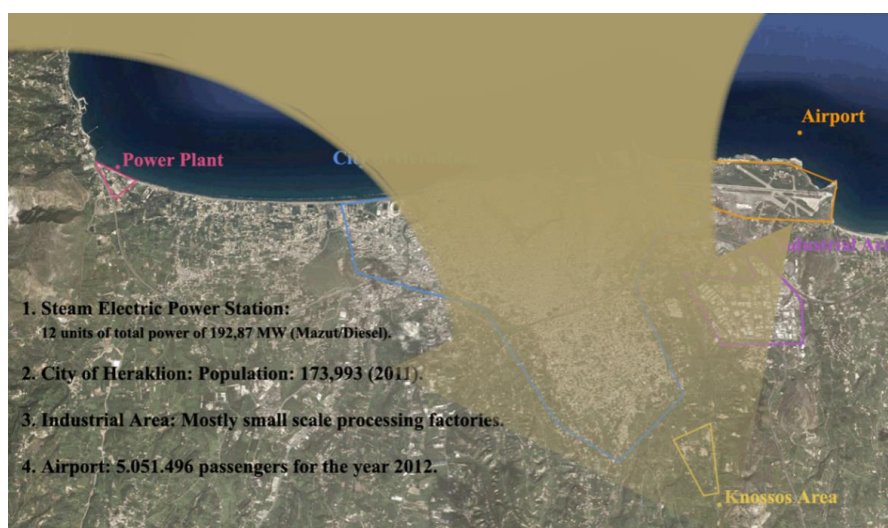


Figure 96: Potential pollutant sources located north of the Knossos archaeological site.

4.3 Summary

A list of the climatic parameters that affect the HERACLES test beds is visualized in Table 1. Of course, not all the climatic parameters affect the test beds in the same way, for instance, intense rainfall in Gubbio may result to flooding and landslides while in Knossos in material weathering, as described in detail in the previous sections.

**Table 1: Climate parameters, risks and impacts**

| Climate parameters | Climate change risk | Physical, social and cultural impacts on cultural heritage |
|---------------------------------------|---|--|
| Atmospheric moisture change | Flooding (sea, river) | Relative humidity cycles/shock causing splitting, cracking, flaking and dusting of materials and surfaces |
| | Intense rainfall | Eutrophication accelerating microbial decomposition of organics |
| | Changes in water table levels | Corrosion of metals |
| | Changes in soil chemistry | Physical changes to porous building materials |
| | Ground water changes | Damage due to faulty or inadequate water disposal systems |
| | Changes in humidity cycles | Crystallisation and dissolution of salts caused by wetting and drying affecting standing structures, archaeology, wall paintings, frescos and other decorated surfaces |
| | Increase in time of wetness | Erosion of inorganic and organic materials due to flood waters |
| | Sea salt chlorides | Biological attack of organic materials by insects, moulds, fungi, invasive species such as termites |
| | | |
| Temperature | Diurnal, seasonal, extreme events (heat waves, snow loading) Changes in freeze-thaw and ice storms, and increase in wet frost | Changes in freeze-thaw and ice storms, and increase in wet frost |
| | | Deterioration due to thermal stress |
| | | Damage due to increased pest frequency (e.g. wooden materials) |
| | | Damage from freeze-thaw cycles or frost |
| | | Damage inside bricks, stones, concretes and ceramics |
| Sea level rises | Coastal flooding Sea water incursion | Overheating of buildings and artefacts, which leads to inappropriate alterations to materials |
| | | Erosion or loss of materials and structures on the sites |
| | | Saltwater intrusion of subsurface structures |
| | | Permanent inundation of resources in low-lying areas |
| | | Coastal erosion/loss |
| Wind | Wind-driven rain Wind-transported salt Wind-driven sand Winds, gusts and changes in direction | Intermittent introduction of large masses of 'strange' water to the site, which may disturb the metastable equilibrium between artefacts and soil |
| | | Penetrative moisture into porous cultural heritage materials |
| | | Static and dynamic loading of historic or archaeological structures |
| | | Structural damage and collapse |
| | | Deterioration of surfaces due to erosion |
| Desertification | Drought Heat waves Fall in water table | Increasing wave energy in coastal structures (increasing stress) |
| | | Erosion |
| Climate and pollution acting together | pH precipitation Changes in deposition of pollutants | Salt weathering |
| | | Stone recession by dissolution of carbonates |
| | | Blackening of materials |
| | | Corrosion of metals |
| Climate and biological effects | Spread of existing and new species of insects Increase in mould growth Changes in lichen colonies on buildings Decline of original materials | Influence of bio-colonialization |
| | | Reduction in availability of native species for repair and maintenance of buildings |
| | | Changes in the natural heritage values of cultural heritage sites |
| | | Changes in appearance of landscapes |
| | | Changes in the livelihood of traditional settlements |
| | | Changes in inhabited structures as sources |

The list of principal climate change risks and impacts on cultural heritage HERACLES test beds summarised in Table 1, follows to the structure presented in Background Document UNESCO WORLD HERITAGE CENTRE, selecting the items of interest and adding some others.



5 SOCIO-ECONOMIC ISSUES INFLUENCING USERS' NEEDS

The importance of valuing cultural heritage (CH) through its various impacts was succinctly stated in the London Declaration of the 2004 European Commission Conference on Sustaining Europe's Cultural Heritage. "... CH plays an essential role in the global position of Europe, and in enhancing the integration process of new enlarged Europe's with its complex diversity and that it has considerable impact in many areas of economic and regional development, sustainable tourism, job creation, improving skills through technological innovation, environment, social identity, education and construction..."(European Commission 2004, see Borelli 2012).

The heritage management could create opportunities and threats, and can impose constraints on decision making. Most of these impact factors are beyond the direct control of CH managers, but nevertheless, affect heritage site strategies, final impacts and outcomes. Furthermore, many of the factors are inter-related, for example, local economy could affect heritage site funding or the policy context could affect the legislative framework.

Each site operates in a local, national as well as in a much wider European and global context. The policy context, is well established both on a national as well as on European level and represents another important determinant for potential outcomes and impacts on heritage sites. The definition of what constitutes "heritage" is a dynamic concept, following the social and economic transformation and evolution. Ashworth and Howard (1999) note that "Heritage is whatever people want to conserve, preserve, protect or collect" and local society considers heritage as an important aspect of the cultural context.

In order to identify users' needs and requirements according to the social, economic and cultural dimensions, a questionnaire was defined and sent to the two partners that in HERACLES represent the end-users, i.e. the mayor of Gubbio and the director of the Ephorate of Antiquities of Heraklion. Nevertheless, they have different institutional roles, and in order to compare same national levels influencing the decision making process, the questionnaire was extended also to two stakeholders, such as the director of the Ducale Palace in Gubbio (representing the Superintendence comparable to the Ephorate) and the vice-Mayor of Heraklion. We decided to administrate the interviews to the users that are partners of the project, as they are also the owners/manager of the cultural heritage assets on which the HERACLES project interventions are carried on. This allows to involve them not only in this phase, but also during the entire lifecycle of the activities. In this way it is also possible to collect some feedbacks during the project life, collecting users reactions and opinions. Involving other kinds of users in other contexts could be explored in an exploitation phase as preparatory activity of next projects proposals

The provided answers suggest needs, as well social, economic and cultural parameters that are necessary to be considered in the decisional process related to the risks mitigation and management and in the monitoring and restoring phases of the cultural heritage assets, as well in the design process of the platform released by the HERACLES project.

Indeed, as already explained in 700395 HERACLES GA (Part B, p. 29), "Natural and social systems of different sites/regions present different characteristics, too, and will be subjected to different pressures (including Climate change), generating differences in adaptive capacities. A strong point of the HERACLES approach is to take advice of the real knowledge acquired on specific cases, by networking and sharing the different experiences among different communities (researchers, operators, governmental authorities, decision makers, industries)."



Consequently, the analysis has to consider how decision makers proceed and how they take into account socio-economic issues when planning their actions. For this purpose it is necessary to establish if socio-economic actors are engaged in the discussion. In particular, it is important to assess IF, HOW and WHEN civil society, economic stakeholders, schools, universities, etc, actively discuss with policy makers, providing their ideas and feeling about the needs to preserve the CH assets.

As well, is it important to clarify how the decision making process takes into account the potential socio-cultural impact of their decision concerning monitoring or restoration actions for reducing risks.

A short remind of some characteristics of Gubbio and Heraklion is provided below. Then a section that explains the method used for collecting the users' needs (i.e. the needs for supporting the decision making process of policy-makers according to social and economic implications), is presented.

5.1 Short description of the two sites

Gubbio

The cultural identity and values of the citizens of Gubbio are strongly related to the geography of the territory, to its cultural and economic asset. The economy is mainly based on the cultural and religious tourism, which represents the historical identity for the population of Gubbio. All the activities connected with the museums and monuments fruition and maintenance are relevant. The touristic services, such as hotels, restaurants, but also food satellite activities and handicraft production, are important. Moreover, the town has an important cement industry and a strong historical culture and knowledge related to bricklayers and stonemasons. The ancient Walls surrounding the ancient city, the Consoli Palace and all the significant monuments represent the memory but also the future for the life of the population, as these are at the basis of the citizens' common feeling of being part of a community. Economy is therefore strongly related to the territorial and CH assets and it is connected with the feeling of belonging of the citizens. In addition, agriculture is a very relevant sector in the economy of Gubbio and currently it is deeply connected with the tourism of the area.

Heraklion

Heraklion is the largest urban centre in Crete, the capital of the region; it represents the most important place for the cultural, social and economic development of Crete. The population of the municipality of Heraklion is approximately 150.000 people. It is a very dynamic town, due to the natural and cultural touristic attractions and the main occupations of the inhabitants are tourism, agriculture and commerce. In fact, the presence of very attractive sea locations and the importance of its museums, monuments and archaeological sites make Heraklion as a place where culture, economy, and daily life are strongly related. The particularity of Heraklion is that it includes areas characterised by different levels of anthropogenic pressures. The sites of interest for HERACLES are the archaeological site of Knossos and the coastal Venetian fortifications with the sea fortress of "Koules" (Rocca a Mare) in Heraklion. (http://www.interkriti.org/crete/introduction_to_crete.html).

The macro economy, at regional, national and international level, has a direct major effect on tax revenues, disposable income and consequently on funding priorities of the public sector which can be considered the stakeholder in the case of the Knossos and Koules sites. Moving



from macro to micro level, in both Knossos Palace and Koules site the more important aspects can be summarized in site quality, significance and dimensions. The quality of the heritage site and the visiting experience can be determined by a number of factors, the level of preservation among them. Site maintenance and its level of restoration/preservation are included in the site management activities. The level of restoration and how it is associated with the actual and perceived authenticity of the site are of great significance especially in the case of the Knossos Palace.

Traditionally, the Palace of Knossos has been and continues to be a significant feature in the lives of the citizens, as well as for the visitors of the city of Heraklion. This great significance is reflected in several aspects and values of the contemporary society. Despite the fact that the Minoan civilization is an abstract concept for most of the modern inhabitants of the Heraklion area, it constitutes one of the fundamental identity values not only for the people of the nearby regions but for the whole island of Crete. Hence, the palace of Knossos, being the centre of the Minoan civilization, is one of the most important icon of the local cultural identity. In more tangible terms, even the geographical location of the Knossos site represents and is used as a reference point, a landmark, by the people of Heraklion.

Focusing on the specific area of Knossos, it becomes evident that within the closed vicinity of the site, the modern urban development has a direct impact on the monument. The people living in the proximity of the Knossos palace have a more complex value system, since they have developed several economic activities closely connected to the tourist flow of the site.

The dimension can act as a guide to the potential impact of a CH site. Larger sites have the potential to induce a greater impact than smaller sites, because of their ability to support a greater throughput of visitors, sustain larger potential capital costs, higher staff requirements and other running costs.

The above social and economic factors have a strong influence on the sites of Knossos and Koules and on the management decision making context. To place the heritage sites in their own context helps in identifying what impacts should be evaluated. CH sites have a greater potential to influence and to have an impact on both a micro and a macro context. In particular, Knossos and Koules are contributing to the local economy through increased number of visitors, capital expenditures as well as the development of the collateral activities.

In order to improve the social value of the monuments, Ephorate is trying to highlight the importance and unique character of the monuments for the culture heritage of the Country, as numerous visitors visit the sites and increase the cultural and educational value for the local and international society, by implementing cultural activities within the sites.

Finally, current market conditions dictate that only a limited number of decisions should be taken in the field of CH without considering economic issues. On the other hand, another point of view states that the increasing use of economics as the dominant evaluation tool for heritage conservation could undermine the cultural rationales in favour of purely economic arguments.

5.2 The method used

A variety of methodologies such as questionnaires, interviews, focus groups, storytelling, etc. or their combinations, can be used for collecting information related with the end-user's requirements in the different perspectives and contexts (such as economic, social, cultural). In particular, the needs will be described, mainly extracting some parameters from the questionnaires. Then, it can be evaluated in the designing phase, if and how include these needs in the decision support system that HERACLES will provide.



In the literature, questionnaires play a relevant role for collecting user needs, work practices, attitudes and expectations. Questionnaires are usually composed by a mix of 'closed' questions with fixed responses and 'open' questions (which allow to include also a story telling approach and to provide further information). In that way, the open answers allow to use the narrative technique, that naturally supports the collection of requirements (C. E. Acosta and L. A. Guerrero 2006) and is important for narrative refinements (J. Winslade et al. 1998).

The closed questions use a Likert scale from 1 to 5 to evaluate the level of importance arising from the answers. In particular, the minimum of the scale has value 1 and the maximum assumes a value equal to 5. The following Table 2 contains the values scale and the corresponding terms used for the analysis of the answers in the next sections, indicating the importance level. The Likert scale is a psychometric scale commonly involved in research that employs questionnaires.

Table 2: Likert scale elements description

| Likert scale for level of importance | Description of the level of importance | Term used during the analysis for indicating the level of importance |
|--------------------------------------|--|--|
| 1 | NOTHING | None |
| 2 | A LITTLE | Minor |
| 3 | ENOUGH | Medium |
| 4 | MUCH | Great |
| 5 | A LOT | Maximum |

5.3 The analysis from Gubbio

5.3.1 *The Mayor*

The analysis of the Gubbio Mayor's answers underlines that in the decision making process for monitoring and preservation/restoration actions it is of maximum importance (A LOT – level 5) to consider:

- Civil society consultation.
- Economic and territorial stakeholders involvement (considering the employment and business improvement for institutions and enterprises of the area).
- School, culture and university engagement.

All these three parameters have been considered of the same importance (A LOT-level 5) also for the actions to be undertaken in the future.

At present, and also in the future, the maximum importance (A LOT – level 5) is given to the consultation and engagement of the civil society, economic stakeholders, schools, university and cultural environments in general.

With respect to the issues that influence the decision process about “IF and HOW” a monitoring and/or a restoration action has to be performed, the answers of the Mayor of Gubbio provide us the following suggestions:



The risk level for the safety of the citizens (risk of collapse produced by atmospheric factors, structural risk in case of disasters such as floods and/or earthquakes, etc.): this parameter has the maximum importance (A LOT-level 5) in the decision making process. The Mayor of Gubbio emphasizes the role “of the mayor as chief executive of the local Civil Protection”. Therefore he considers that to take into account the risk factors for the population and for the activities in the area, is a primarily part of his obligation. Moreover, he considers the citizens as the first holders of the CH assets themselves, being the policy-makers “only” the citizens representatives. This is particularly relevant for places as Gubbio where part of the resident population is located specifically in the historical area, affected by risks, starting from flood and earthquakes, sadly recurring also recently, throughout history. Such attitude is also dictated by the ethics of the responsibility, pertinent to the policy-makers office.

The level of risk for public safety is a parameter that is considered a priority (A LOT-level 5) in the evaluation process, being the Mayor also the chief executive for the local civil protection (management and decisions).

The identity value of the CH according to the social milieu (environment) of the Gubbio area: this parameter has the maximum importance (A LOT- level5) in the decision making process. From a social point of view, Gubbio is identifiable with its historic centre and its historical evolution helps to understand its importance since the town is perfectly preserved in accordance with its medieval original structure with few changes over the centuries. The CH is perceived as an icon in which the population and/or the economy of Gubbio are identified. From the questionnaire the Mayor affirms that the citizens of Gubbio, as well as an important part of the productive assets and cultural realities of the town, are identified in its historic centre. This has produced the consolidation of a social and a cultural identity in this old town in which the economic and cultural activities (tourism, handicraft, etc...) and the lives of the citizens are also deeply-rooted. Gubbio town represents the symbol of the social and the political identity of an entire community. The town jealously guards its treasures in traditions, culture, handicrafts (including the art of the stone masons) and folklore. For example, the celebrations in honour of the Saints and protectors of the city (*Festa dei Ceri*) are renewed every year, since centuries.

The identity value of the CH has the maximum importance (A LOT –level 5). In fact, the decision making process (in preservation/conservation/restoration) should involve parameters able to take into account the symbolic value that the CH assets hold for the local community and for its Identity.

The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and/or cultural associations, etc.): according to the interviewed, this parameter has the maximum importance (A LOT – level 5) in the decision-making process. This factor is combined with the concept of an active conservation of the historical heritage, provided that the final uses have purposes of high profile, able to ennoble the CH asset itself and to add value to the good itself and as a part of a whole.

In the decision making process the intended use of the CH represents a critical issue. The maximum importance (A LOT-level 5) is related to the high-profile targets that can add value to the CH asset itself and as part of a whole (meaning as part of the socio-economic and cultural context).



The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities: the interviewed indicated that the economic value has a great influence (MUCH – level 4). The site's value should be considered in a wider context. The historic centre is the most visited part of the town by tourists, who lead annually hundreds of thousands of arrivals and presences with induced effects on the economy, quantifiable in many millions of euro. Added value has to be brought to the CH goods through a philological restoration, carried on by craftsmen culturally and operationally prepared and supported by suitable professionalism.

The economic value of the CH asset has a great importance (MUCH-level 4) in the decision-making process of monitoring or restoration actions.

The availability of funds to be used for the works of monitoring and/or restoration: the availability of funds to be used for monitoring and restoration actions is a priority and it has a maximum influence (A LOT – level 5) in the decision-making process, as ad hoc funds are essential, considering the continuous and progressive budget cuts by central government to local authorities. Consequently, it implies, the impossibility of any intervention by local administrations without using extraordinary measurements, distorting their own financial plan.

The availability of funds to be used for monitoring/preservation/restoration actions is of maximum importance (A LOT-level 5). It represents a necessary condition before evaluating the other parameters in the decision-making process.

The potential benefits in terms of business and image return for any sponsor who want fund any monitoring and / or restoration action: this factor may greatly (MUCH – Level 4) influence the decision-making process; it is a further evaluation element (not exhaustive) that must be assessed case by case, in view of future (and uninterested) collaborations.

The potential benefits in terms of business and image return for any sponsor has a great importance (MUCH – Level 4). Potential advantages from sponsor involvement can introduce a further important evaluation parameter (not exhaustive) but it must be assessed case by case, in view of future (and uninterested) collaborations.

The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area of Gubbio (through the use of videos and teaching materials): also the educational value of sharing the knowledge of the monitoring and restoration phases with universities and schools in Gubbio, assumes the maximum importance (A LOT – level 5) for the interviewed. To follow "how" a restoration of a historical good runs, allows the community to know and trace the local history in its various developments, as the good represents always a canvas showing the steps of the various civilizations, cultures and technologies, and fosters the sense of belonging to the community itself. This also allows to preserve the knowledge of the restoration techniques.

The educational value has the maximum importance (A LOT – level 5). It is important to share knowledge and educational activities for passing on/preserving techniques that become part of the CH of the place.



Suggestions:

The HERACLES platform can be a very useful support for public owners of a large number of cultural heritage buildings and artefacts, as the Municipality of Gubbio, and other Municipalities are.

As first task, the platform should centralize the collection and handling of technical/historical information about the design, the structural behaviour, the materials used, by providing an always updated knowledge of the status of each monument/asset.

Furthermore, the platform should provide an accurate and dynamic assessment of the risks affecting the monuments, supporting the decision making process, helping in setting the priorities and suggesting the appropriate solutions based on the best practices. This will be particularly important in order to plan and implement a scheduled preventive maintenance, fully agreed with the local Superintendence office of MIBACT, in order to properly ensure the conservation, keeping abreast of the latter development of material for preserving and restoring.

About the crisis events, through its capability to collect and manage multi-source information, HERACLES platform could help too, by providing complete and updated early warnings, situational awareness and supporting decision in case of extreme events.

5.3.2 The Director of the Ducale Palace

The analysis of the answers of the Ducale Palace director underlines that in the decision making process for monitoring and restoration actions it is of:

Maximum importance (A LOT – Level 5):

- School, culture and university engagement

Great importance (MUCH – level 4):

- Economic and territorial stakeholders involvement (considering the employment and business improvement for institutions and enterprises of the area).

Medium importance (ENOUGH – level 3):

- Civil society consultation.

These values are also referred to the monitoring and/or restoration actions to be undertaken in the future.

At present, and also in the future, the maximum importance (A LOT – level 5) can be given to the engagement of schools, university and culture environments, while a great importance (MUCH – level 4) has given to that one from the economic stakeholders, and a medium importance (ENOUGH-level 3) have consultation of the civil society

With respect to the issues that influence the decision process about “IF and HOW” a monitoring and/or a restoration action will be performed, the director of the Ducale Palace provided the answers that follow:

The risk level for the safety of citizens (risk of collapse produced by atmospheric factors, structural risk in case of disasters such as floods and/or earthquakes, etc.): according



to the director of the Ducale Palace the security of the citizens is the principle that should guide any choice, especially when human lives are involved (A LOT – level 5).

The level of risk for public safety is a priority issue (A LOT – level 5) to evaluate during the decision making process for planning the actions to be performed.

The Identity value of the CH according to the social milieu (environment) of the Gubbio area: the director of the Ducale Palace underlined that in a self-referential community, such as that one of Gubbio, the identity value of the asset has a great importance (MUCH – level 4). People is never indifferent to its past and history, basing on them every choice and their guidelines for building the future.

The identity value of the cultural site or object has a great influence (MUCH – level 4) in the decision making process because people take into account their history for every choice, present and future.

The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and/or cultural associations, etc.): according to the interviewed these parameters have a medium importance (ENOUGH – level 3); in her opinion, the exact definition of the use of the site may determine possible fluctuations in scoring. In fact, in a "closed" community, as that one of Gubbio, the destination for residential or aggregation purposes could be more important than for cultural ones, since the town offers already several facilities for these latter.

In the decision making process the intended use of the cultural site or object has a medium (ENOUGH – level 3) importance, in particular residential or aggregation purposes may result more interesting than the cultural ones.

The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities: great importance (MUCH – level 4) has been assigned by the interviewed to the value linked to the economic point of view. She asserts that the "closed" economy of Gubbio needs any incentive for creating new jobs and the economic indicator has indeed an important value.

In the decision-making process the economic point of view has a great importance (MUCH-level 4), mainly related to the possibility of new job creation.

The availability of funds to be used for the works of monitoring and/or restoration: the interviewed gives a great importance (MUCH – level 4) to the availability of funds that, according to her, represent a constraint determining the scale of the intervention; in this sense it directly impacts on other issues such as employment/production etc.

The availability of funds has a great importance (MUCH- level 4) in the decision-making process as it impacts on other important issues (employment/production) that are essential for the economic development of Gubbio.

The potential advantage for business and feedback in terms of image for any sponsors who can fund any monitoring and/or restoration action: according to the interviewed, the potential advantages have a medium impact (ENOUGH – level 3). The benefits for any sponsor does not particularly influence the decision-making process. However, they can provide



impacts in terms of image for Gubbio, for its thousand years old history, for his urban pattern exceptionally preserved, for the vitality of people that always participate in the important decisions for their future.

The potential advantage for business and feedback in terms of image for any sponsors has a medium importance (ENOUGH-level 3) with respect to potential advantages, but less in the decision making process.

The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area of Gubbio (through the use of videos and teaching materials): the involvement of young people is of medium importance (ENOUGH – level 3), but it is not essential in the evaluation process. However, it is important to involve them within the prevention, conservation and protection best practices, in order to make them guarantors and promoters of these, over time.

The educational value has a medium importance (ENOUGH –level 3) mainly for the involvement and growth of young people.

5.4 The analysis from Heraklion

5.4.1 The Director of Ephorate

The analysis of the answers of the Heraklion Ephorate of Antiquities director underlines that, during the decision-making process relating to the monitoring and/or a restoration action, it is of:

A medium importance (ENOUGH – level 3):

- Civil society consultation.
- Economic and territorial stakeholders involvement. (considering the employment and business improvement for institutions and enterprises of the area)

A minor importance (A LITTLE – level 2):

- School, culture and university engagement.

The same level of values has been also referred to the monitoring and/or restoration actions to be undertaken in the future.

At present, and also in the future, a medium importance (ENOUGH – level 3) can be given to the suggestion from the civil society and economic stakeholders, and minor importance (A LITTLE – level 2) has engagement of schools, university and culture environments in general.

With respect to the issues that influence the decision process about “IF and HOW” a monitoring and/or a restoration action will be performed, the answers of the director of Heraklion Ephorate provide us the following suggestions:

The risk level for the safety of citizens (risk of collapse produced by atmospheric factors, structural risk in case of disasters such as floods and / or earthquakes, etc.): according to the interviewed the level of risk of the CH asset has the maximum influence (A LOT – level 5) in the decision making process and the public safety is the priority in the decision-making process, for prioritising the actions to be carried out.



The level of risk for public safety is a priority issue (A LOT- level 5) during the decision making process in order to plan the actions to be performed.

The identity value (i.e. the cultural site/object as an icon that identifies population or the economy of the place) of the cultural site or object for the social groups of the Heraklion area: the identity value has the maximum influence on the decision-making process (A LOT – level 5). The interviewed underlined that decisions have to be taken according to the importance of the monument. Mainly, conservation actions are performed in order to avoid collapses and maintenance actions can take place in order to preserve the monument in a good condition.

The identity value of the cultural site or object has the maximum influence (A LOT-level 5)- in the decision making process in order to plan the actions to be performed.

The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and / or cultural associations, etc.): medium importance (ENOUGH - level 3) has been assigned by the interviewed to the intended or actual use of the cultural site or good. According to her, “taking into account the use of the property is not a priority” in the decision-making process.

In the decision-making process the actual use of the cultural site or object has a medium importance (ENOUGH-level 3); it is less important with respect to the previously identified parameters.

The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities: minor importance (A LITTLE – level 2) has been given by the interviewed to the value from the economic point of view. In particular, it was underlined that restoration actions are based especially on the value of the monument and on the public safety issues, but in the case of EU funding projects the impact on the local economy and employment is also taken into account.

The economic value with respect to employment and business has minor importance (A LITTLE – level 2) in the decision making process because local funds to be used for the works of monitoring and/or restoration are assigned according to the monuments value and to the public safety issues.

The availability of funds to be used for monitoring and/or restoration actions: the interviewed assigned a great importance (MUCH – level 4) to the availability of funds to be used for monitoring and/or restoration actions. She underlined that Ephorate proposes an action list to the Ministry of Culture, prioritising the monuments on the basis of their value and of their preservation state. Successively, the Ministry of Culture assigns a budget and the local Ephorate decides the distribution on the basis of the proposed ranking.

The availability of funds is of great importance (MUCH – level 4) in the decision making process. Funds to be used for monitoring and/or restoration actions are assigned with respect to the value and conditions of the monuments.

The potential advantage for business and feedback in terms of image for any sponsors who can fund any action of monitoring and/or restoration: also this aspect is considered of great importance (MUCH – level 4) from the interviewed. She underlined that the process of



funds allocation starts with a potential sponsor that addresses to the Ministry his offer; then the Ministry assigns to the local Ephorate the execution of the works.

Great importance (MUCH – level 4) in the decision making process is given to the availability of funds given by sponsor. The potential sponsors have to follow a procedure: they have to address to the Ministry their offer for the approval and the Ministry assigns to the local Ephorate funds for the execution of the work.

The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area of Heraklion and Crete (through the use of videos and teaching materials): according to the interviewed, the educational value of knowledge sharing has a medium importance (ENOUGH –level 3). She specified that any educational value of updating knowledge is taken into consideration as potential good practice, but does not directly affect the decision-making process.

The educational value doesn't directly affect the decision-making process, but it has a medium importance (ENOUGH –level 3) as a practice for knowledge sharing with universities and schools.

Suggestions.

The interviewed believes that the platforms could be useful for prioritising the problems and for making available more details about the state of the monuments, providing a clear view of the risks that the monuments face, helping to find appropriate solutions.

5.4.2 The Vice- Mayor of Heraklion

The analysis of the Heraklion vice-Mayor underlines that, in the decision-making process for monitoring and preservation/restoration actions, are of :

Medium importance (ENOUGH – level 3):

- Economic and territorial stakeholders involvement (considering the employment and business improvement for institutions and enterprises of the area)
- School, culture and university engagement

Minor importance (A LITTLE – level 2):

- Civil Society consultation

Anyway, different values have been assigned to them for the different phases to be undertaken in the future, where the values attributed to the parameters are changing accordingly:

Great importance (MUCH - level 4):

- Civil society consultation.
- Economic and territorial stakeholders involvement. (considering the employment and business improvement for institutions and enterprises of the area)
- School, culture and university engagement.



At present a medium importance (ENOUGH-level 3) is given to the economic and territorial stakeholders involvement (considering the employment and business improvement for institutions and enterprises of the area) and to the school, culture environments and university engagement, while a minor importance (LITTLE –level2) is given to the Civil Society consultation. Nevertheless, for the future an increased involvement of all these actors is foreseen (up to a level of 4 – MUCH).

With respect to the issues that influence the decision process about “IF and HOW” a monitoring and/or a restoration action will be performed, the vice mayor of Heraklion provided the answers that follow:

The risk level for the safety of citizens (risk of collapse produced by atmospheric factors, structural risk in case of disasters such as floods and/or earthquakes, etc.): for the interviewed it is of medium importance (ENOUGH –level 3). He asserts that restoration is a competence which relies exclusively on the Ministry for Culture. As far as the Municipality is concerned, public safety is always a priority, as it surely is for monitoring decisions.

The level of risk for public safety is of medium importance (ENOUGH –level 3) during the decision making process for planning the actions to be performed, that anyway, are not directly in charge of the Municipality.

The identity value (i.e. the cultural object as an icon that identifies population or the economy of the place) of the cultural site or object for the social groups of the Heraklion area: the identity value has a great importance ((MUCH – level 4). For the current Administration, the City's brand and identity are directly linked to the cultural heritage: any decision, therefore, is taken having that on mind.

The identity value of the cultural site or object has a great importance (MUCH- level 4) in the decision making process.

The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and/or cultural associations, etc.): medium importance (ENOUGH – level 3) has been assigned by the interviewed to this parameter. According to him, the cultural sites and objects rarely belong to cities. This is why they are negotiating with the Ministry the possibility to use some sites or that the sites could be conferred to the city.

In the decision-making process the actual use of the cultural site or object is a factor of medium importance (ENOUGH – level 3) to consider but it cannot represent a priority, since is not the town hall to make decision on that matter.

The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities: a great importance (MUCH – level 4) has been attributed by the interviewed to the economic value. However, he underlined that, unfortunately, at local level the economic benefits of the management of cultural and archaeological sites are almost not existing, since the State is controlling directly the revenues. The interviewed added also that recently, and mainly at local level, new policies and strategies are being developed to improve this aspect.

In the decision-making process a great importance (MUCH-level 4) has been assigned to the value by the economic point of view, even if it is not directly managed by the municipality.



The availability of funds to be used for monitoring and/or restoration actions: the interviewed assigned a medium importance (ENOUGH- level 3) to the availability of funds to be used for monitoring and/or restoration actions. In particular, he underlined the necessity to have more EU, State, and private funds.

In the decision-making process the availability of funds has a medium importance (ENOUGH-level 3). There is the necessity of more EU, State and private funds.

The potential advantage for business and feedback in terms of image for any sponsors who can fund any action of monitoring and/or restoration: the interviewed did not provided any indication on the importance level. Anyway, he underlined that the decision-making process doesn't take really into account the potential advantages for business and feedback in terms of image for any sponsor.

In the decision-making process, the potential advantage for business and feedback in terms of image for any sponsor doesn't represent a priority.

The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area of Heraklion (through the use of videos and teaching materials): the interviewed assigned the maximum importance (A LOT – level 5) to the educational value of knowledge sharing with universities and schools. According to him the cooperation among all the Administration levels and the scientific and academic institutions is intense and productive in this field.

The educational value affects at maximum level (A LOT – level 5) the decision-making process. The cooperation with scientific and academic institutions is very important and productive.

5.5 Analysis summary

This section summarises and compares the answers content from the questionnaires. In order to compare the visions from the two different Countries, and from different/similar institutional positions, the following two tables respectively provide a synthesis and a comparison of the answers of the interviewed, aiming to understand what are the similarities and the differences, according to their roles.

The results are presented coupling in each table the interviewed having similar institutional positions. In the Table 3 the Municipalities opinions are presented

Table 3: Answers from the Mayor of Gubbio and the vice Mayor of Heraklion (both Municipalities)

| QUESTION | ANSWER FROM THE MAYOR OF GUBBIO | ANSWER FROM THE VICE MAYOR OF HERAKLION |
|---|---|--|
| At present, when you need to decide whether and how to carry out a monitoring and/or a restoration action, the decision-making process | <u>Maximum importance:</u> • Civil society consultation. | <u>Minor importance:</u> • Civil Society consultation. |
| | <u>Maximum importance:</u> • Economic and territorial stakeholders (employment and business improvement for institutions) | <u>Medium importance:</u> • Economic and territorial stakeholders (employment and business improvement for |



| | | |
|--|---|--|
| usually includes one or more of the following options: | and enterprises of the area) involvement. | institutions and enterprises of the area) involvement. |
| | <p><u>Maximum importance:</u></p> <ul style="list-style-type: none"> • The school, culture and university engagement. | <p><u>Medium importance:</u></p> <ul style="list-style-type: none"> • The school, culture and university engagement. |
| When, <u>in the future</u> , you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options: | <p><u>Maximum importance:</u></p> <ul style="list-style-type: none"> • Civil society consultation. | <p><u>Great importance:</u></p> <ul style="list-style-type: none"> • Civil society consultation. |
| | <p><u>Maximum importance:</u></p> <ul style="list-style-type: none"> • Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) involvement. | <p><u>Great importance:</u></p> <ul style="list-style-type: none"> • Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) involvement. |
| | <p><u>Maximum importance:</u></p> <ul style="list-style-type: none"> • The school, culture and university engagement. | <p><u>Great importance:</u></p> <ul style="list-style-type: none"> • The school, culture and university engagement. |
| When you have to decide if and how a monitoring and/or a restoration action will be implemented, how much the following issues influence your decision? | <i>Compare the answers according to the subcriteria listed below</i> | <i>Compare the answers according to the subcriteria listed below</i> |
| 1) The level of risk for public safety (potential problems of collapse, structural risk in case of disasters such as floods and/or earthquakes, etc.). | The level of risk for public safety is a parameter that is considered a priority (A LOT - level 5) in the evaluation process, being the mayor also the chief executive for the local civil protection (management and decisions). | The level of risk for public safety is of medium importance issue (ENOUGH - level 3) during the decision making process for planning the actions to be performed. |
| 2) The identity value (i.e. the cultural object as an icon that identifies the population, or the economy of the place) of the cultural site or object for the social milieu (environment) of the area. | The identity value of the CH has the maximum importance (A LOT - level 5). In fact the decision making process (in preservation/conservation/restoration) should involve parameters able to take into account the symbolic value that the CH assets hold for the local community and for its Identity. | The identity value of the cultural site or object has a great importance (MUCH - level 4) in the decision making process. |
| 3) The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can | In decision making process the intended use of the CH represents a critical issue. The maximum importance (A LOT - level 5) is related to the high-profile targets that can add value to the CH asset itself and as part | In the decision-making process the actual use of the cultural site or object is a factor of medium importance (ENOUGH - level 3) to consider but it cannot represent a |



| | | |
|--|--|--|
| host activities and/or cultural associations, etc.) | of a whole (meaning as part of the socio, economic and cultural context). | priority, since is not the town hall to make decision on that matter. |
| 4) The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities. | The economic value of the CH asset has a great importance (MUCH - level 4) in the decision-making process of monitoring or restoration. | In the decision-making a great importance (MUCH - level 4) has been assigned to the value by the economic point of view, even if it is not directly managed by the municipality. |
| 5) The availability of funds to be used for the works of monitoring and/or restoration. | The availability of funds to be used for the works of monitoring and/or restoration is of the maximum importance (A LOT - level 5). It represents a necessary condition for evaluating the other parameters in the decision-making process. | In the decision-making process the availability of funds is medium important (ENOUGH - level 3). There is the necessity of more funds by EU, State and private. |
| 6) The potential advantage for business and feedback in terms of image for any sponsors who can fund any action of monitoring and/or restoration. | The potential benefits in terms of business and image return for any sponsor has a great importance (MUCH - level 4). Potential advantages from sponsor involvement can introduce a further important evaluation parameter (not exhaustive) but it must be assessed case by case, in view of future (and uninterested) collaborations. | No value provided – but a comment: In the decision-making process, the potential advantage for business and feedback in terms of image for any sponsor doesn't represent a priority. |
| 7) The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area (through the use of videos and teaching materials). | The educational value has the maximum importance (A LOT - level 5) in decision-making process. It is important to share knowledge and educational activity for passing on/preserving techniques that become part of the CH of the place. | The educational value affects at maximum level (A LOT - level 5) the decision-making process. The cooperation with scientific and academic institutions is very important and productive. |
| Suggestion for the platform | The HERACLES platform can be: - a <u>very useful support for public owners</u> of a large number of cultural heritage buildings and artefacts, <u>as the Municipality</u> of Gubbio, and other Municipalities are. -As first task, <u>the platform should centralize the collection and handling of technical/historical information about the design, the structural behaviour, the materials used,</u> | No suggestion was provided for the platform. <i>It is due to the fact that the Municipality of Heraklion is not partner of HERACLES project and for this reason is not involved at a deeper level as the Municipality of Gubbio is.</i> |



| | | |
|--|---|--|
| | <p>-by <u>providing an always updated knowledge of the status of each monument.</u></p> <p>-Furthermore, the platform <u>should provide an accurate and dynamic assessment of the risks affecting the monuments,</u></p> <p>-<u>supporting the decision making process,</u></p> <p>-<u>helping in setting the priorities and</u></p> <p>-<u>suggesting the appropriate solutions based on the best practices.</u> This will be particularly important in order to plan and implement a scheduled preventive maintenance, fully agreed with the local Superintendence office of MIBACT, in order to properly ensure the conservation, keeping abreast of the latter development of material for preserving and restoring.</p> <p>-<u>About the crisis events,</u> through its capability to collect and manage multi-source information, HERACLES platform could help too, by <u>providing complete and updated early warnings, situational awareness and supporting decision in case of extreme events.</u></p> | |
|--|---|--|

In the next Table 4, the opinions of the Superintendences are presented, summarising needs and suggestions given by the Director of the Ephorate of Antiquities of Heraklion and of the Director of the Ducale Palace in Gubbio.

Table 4: Answers from the Director of Palazzo Ducale e from the director of Ephorate (both Superintendences)

| QUESTIONS | ANSWERS FROM THE DIRECTOR OF THE DUCALE PALACE | ANSWER FROM THE DIRECTOR OF EPHORATE |
|--|--|---|
| <p><u>At present, when you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options:</u></p> | <p><u>Medium importance:</u> Civil Society consultation</p> | <p><u>Medium importance:</u> Civil society consultation</p> |
| | <p><u>Great importance:</u> Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) involvement.</p> | <p><u>Medium importance:</u> Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) involvement.</p> |
| | <p><u>Maximum importance:</u></p> | <p><u>Minor importance:</u></p> |



| | | |
|---|---|--|
| | The school, culture and university engagement. | The school, culture and university engagement. |
| When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options: | <u>Medium importance:</u> Civil Society consultation | <u>Medium importance:</u> Civil society consultation |
| | <u>Great importance:</u> Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) consultation. | <u>Medium importance:</u> Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) consultation. |
| | <u>Maximum importance:</u> The school, culture and university engagement. | <u>Minor importance:</u> The school, culture and university engagement. |
| When you have to decide if and how a monitoring and / or a restoration action will be implemented, how much the following issues influence your decision: | <i>Compare the answers according to the subcriteria listed below</i> | <i>Compare the answers according to the subcriteria listed below</i> |
| 1) The level of risk for public safety (potential problems of collapse, structural risk in case of disasters such as floods and/or earthquakes, etc.). | The level of risk for public safety is a priority issue (A LOT - level 5) during the decision making process for planning the actions to be performed. | The level of risk for public safety is a priority issue (A LOT - level 5) in the decision making process in order to plan the actions to be performed. |
| 2) The identity value (i.e. the cultural object as an icon that identifies the population, or the economy of the place) of the cultural site or object for the social milieu (environment) of the area. | The identity value of the cultural site or object has a great influence (MUCH - level 4) in the decision making process because people take into account their history for every choice present and future. | The identity value of the cultural site or object has the maximum influence (A LOT - level 5) in the decision making process in order to plan the actions to be performed. |
| 3) The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and/or cultural associations, etc.) | In decision making process the intended use of the cultural site or object has a medium importance (ENOUGH - level 3), in particular residential or aggregation purposes may result more interesting than the cultural ones. | In the decision-making process the actual use of the cultural site or object has a medium importance (ENOUGH - level 3); it is less important with respect to the previously identified parameters. |
| 4) The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities. | In the decision-making process the economic point of view has a great importance (MUCH - level 4) mainly related to new job creation. | The economic value respect to employment and business has minor importance (A LITTLE - level 2) in the decision making process because local funds to be used for the works of monitoring and/or restoration are assigned with respect to the |



| | | |
|---|---|--|
| | | value of the monuments and public safety. |
| 5) The availability of funds to be used for the works of monitoring and / or restoration. | The availability of funds has a great importance (MUCH - level 4) in the decision-making process as it impacts on other important issues (employment/production) that are important for the economic development of Gubbio. | The availability of funds is of great importance (MUCH - level 4) in the decision making process. Funds to be used for monitoring and/or restoration actions are assigned with respect to the value and conditions of the monuments. |
| 6) The potential advantage for business and feedback in terms of image for any sponsors who can fund any action of monitoring and / or restoration. | The potential advantage for business and feedback in terms of image for any sponsors has a medium importance (ENOUGH – level 3) with respect to potential advantages, but less in the decision making process. | Great importance (MUCH - level 4) in the decision making process is given to the availability of funds given by sponsor. The potential sponsors have to follow a procedure. They have to address to the Ministry for the approval of his offer and then the Ministry assigns to the local Ephorate the execution of the work. |
| 7) The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area (through the use of videos and teaching materials). | The educational value is of medium importance (ENOUGH - level 3) mainly for the involvement and growth of young people. | The educational value doesn't directly affect the decision-making process, but it has a medium importance (ENOUGH - level 3) as a good practice for knowledge sharing with universities and schools. |
| Suggestion for the platform | No suggestion was provided: <i>It is due to the fact that the Director of Ducale Palace of Gubbio (as Superintendence) is not partner of HERACLES project and for this reason is not involved at a deeper level as the Ephorate of Heraklion is.</i> | The Ephorate Director believes that: -the <u>platform could be useful for prioritising the problems and making available more details about the state of the monuments,</u> - <u>providing a clear view of the risks that the monuments face,</u> - <u>helping to find appropriate solutions</u> |

The administrated questionnaires collect information and provide some useful indications, but they cannot have a statistical meaning, since a significant sample was not selected and it was out of the scope of the present project. In fact, the principal aim was to collect some indications helping to analyse different points of view, according to the different roles and to the different national and local contexts.

The different answers and related values, were collected according to the Likert scale, as indicated above. A rank of priorities of users' needs, anyway based on the average values from the answers of respondents, is provided in the following table (Table 5):



Table 5: .Users' need priorities bases on the average values from the answers of respondents.

| Questions | Priorities of users' needs | Label in Kiviati diagram |
|--|----------------------------|--------------------------|
| The level of risk for public safety (potential problems of collapse, structural risk in case of disasters such as floods and / or earthquakes, etc.). | 4,50 | N |
| The identity value (i.e. the cultural object as an icon that identifies the population, or the economy of the place) of the cultural site or object for the social groups of the area. | 4,50 | O |
| When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options? VALUE: Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) consultation. | 4,00 | H |
| When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options?: VALUE: The school, culture and university engagement | 4,00 | I |
| The availability of funds to be used for the works of monitoring and / or restoration. | 4,00 | L |
| The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area (through the use of videos and teaching materials). | 4,00 | M |
| When you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options? VALUE: Economic and territorial stakeholders involvement (employment and business improvement for institutions and enterprises of the area). | 3,75 | E |
| When you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options? VALUE: The school, culture and university engagement. | 3,75 | F |
| When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options? VALUE: Civil society consultation. | 3,75 | G |
| When you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options? Civil Society consultation | 3,50 | B |
| The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and / or cultural associations, etc.) | 3,50 | C |



| | | |
|--|------|---|
| The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities. | 3,50 | D |
| The potential advantage for business and feedback in terms of image for any sponsors who can fund any action of monitoring and / or restoration. | 3,00 | A |

However, same average values can be produced from very different values ranges, indicating the convergence/divergence of opinions that need to be analysed. This is a very interesting aspect, allowing to evaluate the different role feedbacks and the different legislative and cultural contexts to be considered in the decision making processes.

The range of values for the answers, according to the Likert scale, are schematically represented using a Kiviati diagram that is a useful way to display multivariate observations and to locate similar and dissimilar points, as shown in Figure 97.

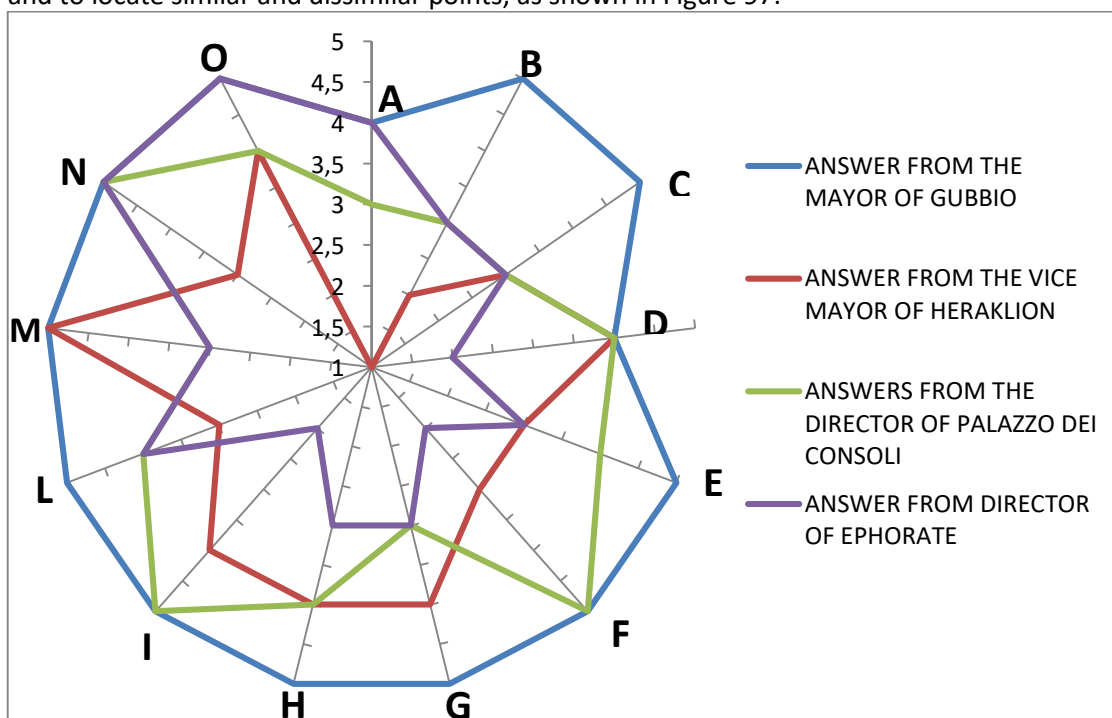


Figure 97: Kiviati diagram obtained from the administrated questionnaires

Here, the list of the questions and the corresponding label, is reported:

A: The potential advantage for business and feedback in terms of image for any sponsors who can fund any action of monitoring and / or restoration.

B: When you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options? Civil Society consultation

C: The intended or actual use of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and / or cultural associations, etc.)

D: The value by the economic point of view (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities.

E: When you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options? VALUE: Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) involvement.



F: When you need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process usually includes one or more of the following options? VALUE: The school, culture and university engagement.

G: When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options? VALUE: Civil society consultation.

H: When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options? VALUE: Economic and territorial stakeholders (employment and business improvement for institutions and enterprises of the area) consultation.

I: When, in the future, you will need to decide whether and how to carry out a monitoring and / or a restoration action, the decision-making process will include one or more of the following options? VALUE: The school, culture and university engagement

L: The availability of funds to be used for the works of monitoring and / or restoration.

M: The educational value of knowledge sharing (related to monitoring and restoration phases) with universities and schools in the area (through the use of videos and teaching materials).

N: The level of risk for public safety (potential problems of collapse, structural risk in case of disasters such as floods and / or earthquakes, etc.).

O: The identity value (i.e. the cultural object as an icon that identifies the population, or the economy of the place) of the cultural site or object for the social groups of the area.

The analysis shows that the four respondents have a common vision (independently from their role and the national and local context) on some parameters that should be prioritised in the decision making process. Indeed, all agree (with a range of values between 4 and 5, and the average value equal to 4.5) about the importance of “**the identity value** of the cultural site or object for the social milieu of the area” (question O in Figure 97).

Another important point of opinion convergence is “**The level of risk for public safety** (potential problems of collapse, structural risk in case of disasters such as floods and / or earthquakes, etc.)” (question N in Figure 97), with a range of values in the Likert scale between 3 and 5, and the average value equal to 4.5. In this case, all respondents consider the level of risk of the maximum importance in the decision making process, with the exception of the vice Mayor of Heraklion, who provides a value equal to 3. This result is connected with the differences in the decision making process. In fact, in Italy the Mayor is also the chief executive of the local Civil Protection in case of disaster, and therefore he considers this issue as a priority connected with his role and his own direct responsibility. In Greece the reference framework is different.

The **educational value of knowledge sharing** and the **engagement in the future of universities, schools, and of the world of culture in the decision making process** have been considered important with an average value equal to 4 for the two specific questions M and I. However, the ranges of values are different for these two questions. In particular, the range of values for the question M is from 3 to 5, while for the question I is from 2 to 5. The respondent providing the value of 2, is the director of the Ephorate of Heraklion. Even if she considers that the educational value has a medium importance (level 3), in her opinion the involvement of schools, cultural world and universities it is not necessary, as the decision making process in Greece is strongly hierarchical.

Of course, the **economic issues** were also evaluated with a high priority (average value equal to 4) for the two specific questions H and L.” For both cases the range of values of is from 3 to 5.



The involvement of :

- **Civil Society** (questions B at present; G in the future)
- **economic and territorial stakeholders** (questions E at present; H in the future)
- **schools, of the world of culture and universities** (questions F at present; I in the future)

in Italy is considered more important than in Greece, in the decision making process. However, in Greece the need to improve the engagement of the different specified actors is arising (please, refers to question B, E, F (at present) and G, H, I (in the future)).

During the decision making process, an average value equal to 3.5 is given to the importance of evaluating:

- “The **intended or actual use** of the cultural site or object (e.g. in the case of buildings they can be used for residential purposes, or can host activities and / or cultural associations, etc.)” (question C of Figure 97)
- “The **value by the economic point of view** (employment and business improvement for institutions and enterprises of the area) connected with the monitoring and restoration activities.” (question D of Figure 97)

The Mayor of Gubbio gives the maximum importance (level 5) to the question C and a great importance (level 4) to the question D. The other respondents are aligned on lower values.

Finally “The potential advantage for business and feedback in terms of image for any **sponsors who can fund any action** of monitoring and / or restoration.” (question A of Figure 97) is a parameter of medium importance (average value equal to 3), but the answers are different. Indeed, the Mayor of Gubbio and the director of Ephorate believe that it is greatly important; on the contrary the vice Mayor of Heraklion considers it of minor importance.

Taking into account the influence that the cultural Identity value played in the past for the preservation and the development of the sites object of the HERACLES study and also the results of the sociological analysis, it is possible to make an important consideration that could have a more general significance:

- more a Community is conscious of the importance of its own roots and history, more it will be responsible and actively involved in the conservation of its own cultural heritage and of the values of the community itself.

This is a very important aspect that must be taken into account and that is strictly related to the education, too. The **educational value** of the knowledge sharing will have a beneficial effect on the preservation and on passing on the own cultural heritage.

Indeed, it will be essential to develop the consciousness of the importance of the own CH because it will represent a **guarantee for its protection and preservation**.

6 - RISK AND DISASTER MANAGEMENT OF CULTURAL HERITAGE SITES

6.1 The Risk equation

RISK is the **PROBABILITY** that a **THREAT (HAZARD)** will *exploit* a **VULNERABILITY** to cause **harm** to an **ASSET (COST OF CONSEQUENCES)**. [International Charter Website, 2015]

Risk can be expressed as the following function:

Risk = function of [Threat (Hazard), Vulnerability, Asset(Cost of consequences)]



Threat vs Hazard

The difference or relationship between a hazard and a threat is as follows:

Threat: has the potential to harm others

Hazard: Source, action and situation with potential to cause harm

For example, a volcano is a hazard, and if the volcano erupts, the lava is a threat to people downhill, and the ash cloud is a threat to airplanes (i.e. the potential hazard has materialized into something tangible - a threat).[AllInterview.com, 2017]

Furthermore, the risk is the likelihood of being injured by the threat caused by the hazard. If the volcano is dormant, the lava threat is zero and the risk of being burned by lava is also zero. If the volcano erupts, the lava threat is no longer zero, and the risk depends (amongst other things) on how close you are to the eruption.

Threat is the frequency of potentially adverse events. For example the threat rate of southern California earthquakes greater than 4 on the Richter Scale is 21 per year. The threat rate of hurricanes hitting Florida is 1.4 per year.

Threat rates can be categorized into "global threat rates" and "local threat rates." The local threat rate is strictly dependent on the local conditions of the territory, the specific status of the site, and the management/conservation strategies and actions (these last depending also on the policy and economic constraints). This means that in general the local threat rate could be different from the global threat rate. Organization, geography, status, political stance or any other factor may expose it to more or less threat than that of the global rate.

Vulnerability is the likelihood of success of a particular threat category against a particular asset, or the degree to which people, property, resources, systems, and cultural, economic, environmental, and social activity is susceptible to harm, degradation, or destruction on being exposed to a threat.

Asset in the HERACLES project will be a cultural heritage site, structure, building and the consequences to an Asset could be measure in terms of cost.

Cost would then be the total cost of the impact of a particular threat experienced by a vulnerable target. It is suggested that the total cost includes both the economic loss as well as social and cultural loss.

Risk is a function of threats exploiting vulnerabilities to damage or destroy assets. Thus, threats (actual, conceptual, or inherent) may exist, but if there are no vulnerabilities then there is little/no risk. Similarly, it is possible to have a vulnerability, but if there is no threat, then little/no risk derives.

Accurately assessing threats and identifying vulnerabilities is critical to understanding the risk to CH assets. Understanding the difference between threats, vulnerabilities, and risk is the first step.

6.2 - Risk management

Risk management refers to a coordinated set of activities and methods, which is used to direct an organization and to control the many risks that can affect its ability to achieve its objectives. According to the Introduction to ISO 31000 2009, the term risk management also refers to the architecture that is used to manage risk. This architecture includes risk management principles, a risk management framework, and a risk management process. [ISO 31000 2009 website]



Risk management encompasses activities related to making risk-informed decisions, prioritizing evaluations of risk, prioritizing risk reduction activities, and making program decisions associated with managing a portfolio of facilities. Risk management includes the environmental, social, cultural, ethical, political, and legal evaluations during all parts of the process. Related to cultural heritage sites, these should include potential structural and non-structural measures, but also include such activities as routine and special inspections, instrumental monitoring and its evaluation, structural analyses, site investigations, development and testing of emergency action plans and many other activities.

Risk analysis is the first component of risk management. It is the portion of the process in which the potential hazards and failure modes, structural performance, and adverse consequences are identified and for which a quantitative or qualitative estimate of the likelihood of occurrence and magnitude of consequence of these potential events are made. A critical first step of a risk analysis related to a cultural heritage site, is the identification of the specific hazards or potential failure modes that are most likely for the site. The frequency of occurrence that could initiate potential failure/degradation, that might cause adverse consequences, is to be estimated and considered as part of a risk analysis.

Risk assessment related to a cultural heritage site is the process of examining the safety and risk of a specific cultural site towards potential hazards, making specific recommendations, and recommending decisions using risk analysis, risk estimates, and other information that have the potential to influence the decision. The risks need to be assessed by the responsible authority/stakeholder for the cultural heritage site. The assessment needs to consider all factors (likelihood, consequences, cost, environmental impacts, etc.) and may also use evaluation criteria established by the stakeholder. Decisions may include additional or enhanced monitoring, additional investigations and/or studies/evaluations /analyses, remedial actions or no additional actions.

Risk analysis is typically a quantitative process (i.e. the outputs and inputs to a risk assessment are numeric). However, risk may also be expressed qualitatively. Risk analyses can provide valuable input to decisions made at various stages of a project or for varying purposes or in the HERACLES project for the cultural heritage sites. The risk analysis can include decisions made for a single cultural heritage site or within a portfolio of cultural heritage sites. The first step common to all types of risk analyses is the identification of the site-specific potential hazards or failure modes. For a given cultural heritage site, all the relevant types of hazards that may be experienced, should be considered when identifying potential hazards or failure modes.

Risk analysis is the process of prioritizing risks based on the *probability* of the occurring risk and the *impact* it would have on the asset, or used in the HERACLES project on a cultural heritage site.

There are two primary methods of risk analysis usable:

- Qualitative Risk Analysis
- Quantitative Risk Analysis

The main difference between *qualitative* and *quantitative risk analysis* is that the former uses a relative or descriptive scale to measure the probability of occurrence whereas quantitative analysis uses a numerical scale/ranking.

For example, a qualitative analysis would use a scale of "Low, Medium, High" to indicate the likelihood of a risk event occurring. A quantitative analysis will determine the probability of each risk event occurring. For example, Risk #1 has an 80% chance of occurring, Risk #2 has a 27% chance of occurring, and so on. Figure 98 shows the holistic vision of the Risk



management, where the relationship between Risk Analysis, Risk Assessment and Risk Management are highlighted [Federal Guidelines for Dam Risk Management FERC, Version 3.0, 2012].



Figure 98: Relationship between Risk Analysis, Risk Assessment and Risk Management

Following is a brief description of the different terms used in the Figure 98:

Risk Control: Risk control is the method of how to evaluate potential losses and take actions to reduce or eliminate the identified threats.

Risk Evaluation: Risk Evaluation is the determination of risk management priorities through establishment of qualitative and/or quantitative relationships between benefits and associated risks.

Failure Mode and Effects Analysis (FMEA): an FMEA is the first step of a system reliability study. It involves reviewing as many components, assemblies, and subsystems as possible, to identify failure modes, and their causes and effects. [Wikipedia, 2017]

Risk Estimation: Risk estimation is the method of identifying the potential risks and estimate the probability that the exposure of it will have an adverse effect.

Risk Reduction: Risk reduction is the method of reducing the severity of the loss or the likelihood of the loss from occurring.



6.2.1 Risk Assessment Matrix (RAM)

A Risk Assessment Matrix (RAM) is a tool to support the identification and assessment of the risks for which there is a need to develop a response. RAM is probably one of the most widespread tools for risk evaluation. They are mainly used to determine the size of a risk and whether or not the risk is sufficiently controlled. [CGE Risk Management solutions 2017]

There are two dimensions to a risk matrix. It looks at how severe and likely an unwanted event/hazard is. These two dimensions create a matrix. The combination of probability and severity will give any event/hazard a place on a risk matrix.

The first step in developing a RAM is to define the rating scales for likelihood and impact. In a qualitative analysis, likelihood or probability is measured using a relative scale. Below is an example “Likelihood Scale definition or probability”, and the related rating (Table 6).

Table 6: Rating Probability Description

| Rating | Probability | Description: |
|--------|-----------------|---|
| 1 | Highly Unlikely | Highly unlikely to occur. May occur in exceptional situations. |
| 2 | Unlikely | Most likely will not occur. Infrequent occurrence in the past. |
| 3 | Possible | Possible to occur. |
| 4 | Likely | Likely to occur. Has occurred in the past. |
| 5 | Very Likely | Highly likely to occur. Has occurred in the past and conditions exist for it to occur also in the future. |

Below is an example “Impact or Severity Scale definition”, in which the rating and Cost examples are shown (Table 7).

Table 7: Rating Severity and Cost Example description

| Rating | Severity | Cost Example |
|--------|-----------|-----------------------------------|
| 1 | No Impact | No damage cost |
| 2 | Minor | 10 – 100 000 € in damage cost |
| 3 | Medium | 100 000 - 1 mill € in damage cost |
| 4 | Major | 1 – 10 mill € in damage cost |



| | | |
|---|-----------|---------------------------|
| 5 | Extensive | >10 mill € in damage cost |
|---|-----------|---------------------------|

These scales are very dependent on the specific details of the application, and Figure 99 shows a Risk Assessment Matrix categorizing the risks as Not Acceptable (Red), As Low As Reasonably Practicable (ALARP) (Yellow) or Acceptable (Green).

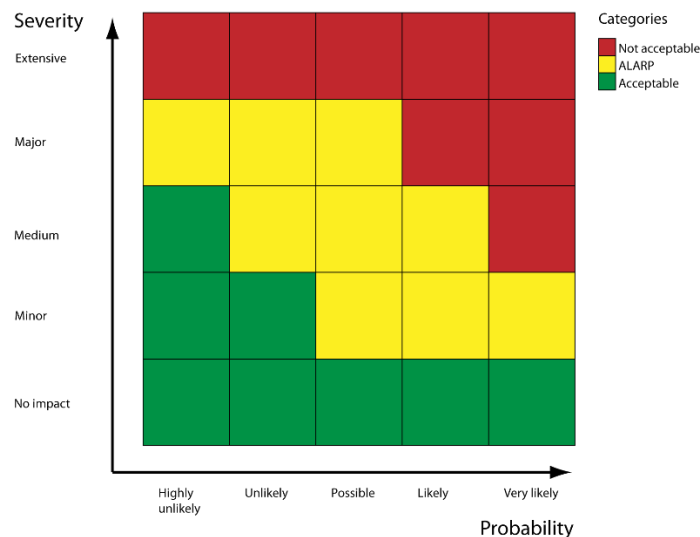


Figure 99: Risk Assessment Matrix

For example, if a risk event/hazard has a *Possible Likelihood* of occurring and a *Major Severity*, it would be considered a *Moderate Risk* using the RAM shown above.

By summarising, risk matrices have at least three areas.

- The low probability, low severity area (usually green) that indicates the risk of an event/hazard that is not high enough, or that it is sufficiently controlled. No action is usually taken.
- The high probability, high severity (usually red) which indicates an event/hazard that needs a lot of measures to bring the probability or severity down.
- The medium category (usually yellow) is in between these two areas. Any event/hazard that falls in this area is usually judged to be an area that needs to be monitored, but is controlled as low as reasonably practicable (or ALARP). Essentially, it means to keep the risk at an acceptable level.

It is important to understand that a risk matrix is best suited for ranking events/hazards. The risk matrix is made up of two ordinal rating scales, with mostly qualitative descriptions along its axes. It can only give a qualitative score that indicates in which category an event/hazard falls.

6.2.2 Strategies for giving scores in a Risk Assessment Matrix

Ranking an event/hazard on a risk matrix can be done in three ways, for example for cultural heritage sites:

- Worst case scenario. This is built by taking the worst situation that could occur. For instance in the case of an earthquake, there will be severe damage. Essentially, when looking at the worst case scenario, all the barriers are ignored and only the Hazard,



Top event and Consequences are considered. These types of incidents might occur in reality, but they will most likely be the exception, not the rule. However, recent earthquakes in Italy (2016-2017), with severe damage to cultural heritage sites, can be considered an example of worst case scenario.

- Current situation. The second strategy tries to evaluate the severity and probability of the average event/hazard. This strategy takes into account all the barriers that are currently implemented, for example strengthening the cultural heritage sites buildings, etc.
- Future situation. The last strategy tries to make an estimate of how the risk might go down after improvements to barriers, as described above, or implementation of new barriers. It aims at foreseeing “average behaviour” of the future incidents.

Although the risk matrix has several drawbacks, it is still one of the standard tools used in most risk assessments. If the risk matrix is used in the correct and reliable way, it can add quite some understanding of the risk for a cultural heritage site, and guide how to apply the most effective improvement and risk reduction measures.

6.3 Disaster management cycle

Risk and Disaster Management would be an effective and useful method in the efforts to identify ways and means to protect cultural heritage sites from the consequences of climate change/natural disaster. However, the existing methodology needs to be adapted to fit into the field of cultural heritage protection.

Figure 100 shows the Disaster Management Cycle, with the four steps, (1) Mitigation, (2) Preparation, (3) Response and (4) Recovery.

The event or disaster in case of cultural heritage, maybe a devastating event like an earthquake, with dramatic consequences for the cultural heritage site. Even though the earthquake is not triggered by climate change, it can cause structural damage to the buildings which may further increase vulnerability of the cultural heritage assets and make them more prone to the hazards directly caused by climate change. For example, fractures in the structure make deterioration induced by water excess, strong winds or drought faster and more intensive. Other long-term effects and deterioration over time, is the influence of wind, waves, floods, etc. on the site. Figure 101 gives a very clear overview of Disaster Management Cycle with the indication of the single steps, such as hazard/risk analysis, risk assessment, etc.



Figure 100: Disaster Management cycle [https://www.quora.com/What-is-disaster-management-cycle]

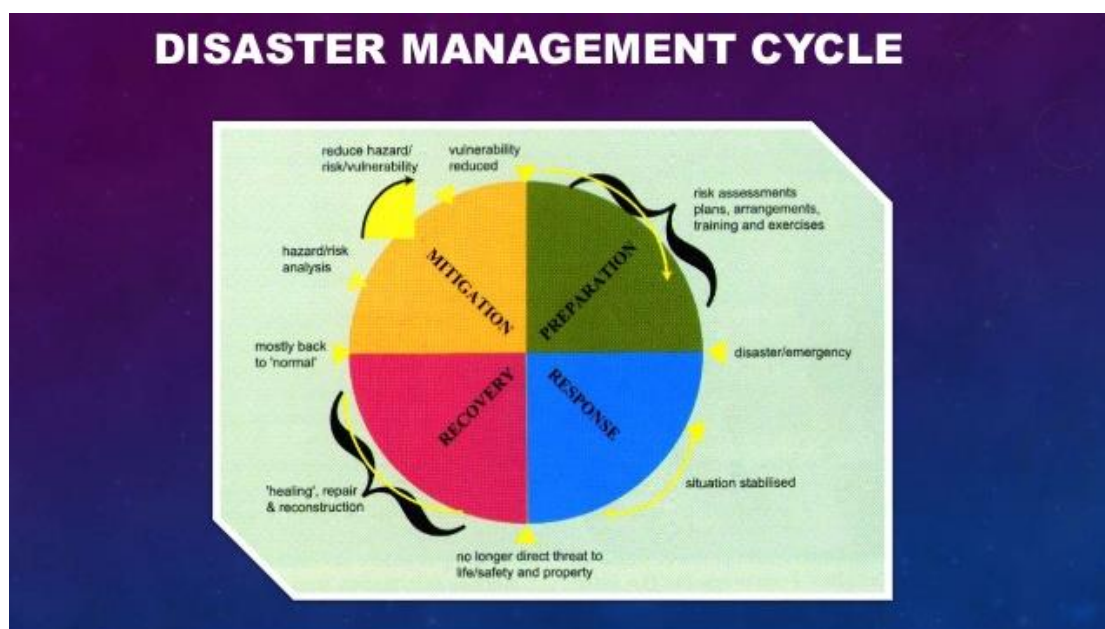


Figure 101: details of the Disaster Management Cycle

6.4 Climate change and cultural heritage sites

Climate change, also called global warming, refers to the rise in average surface temperatures on Earth. An overwhelming scientific consensus is concerned with the fact that climate change is due primarily to the human use of fossil fuels, which releases carbon dioxide and other greenhouse gases into the air. The gases trap heat within the atmosphere, which can have a range of effects on ecosystems, including rising sea levels, severe weather events, and droughts that render landscapes more susceptible to wildfires. [National Geographic, 2016]

There is broad-based agreement within the scientific community that climate change is real.

In the Italian legislation a clear and precise reference to the relationship between conservation of cultural heritage and climate change lacks. It is well known that Europe will be more resilient to the effects of climate change through the work of all Member States who will have to commit in reducing their territorial vulnerability.

This criticality, present also in other European Countries has led the European Commission to undertake a number of initiatives that, in April 2013, came to fruition with the adoption of the **“European Strategy for Climate Change”** and with the subsequent Council conclusions of June 13th, 2013 **“A Strategy European Adaptation to Climate Change”**.

Starting from the European Commission approach, it resulted mandatory to implement a strategy between the various sectors and levels of government involved, to address adequately the consequences of the impacts of climate change, to ensure that adaptation measures are effective and timely.

In 2014, the Italian Ministry of the Environment has published the **National Adaptation Strategy to Climate Change**. This strategy involves several sectors of the productive life, starting from agriculture to transportation. Among these sectors, it is cultural heritage, representing a critical issue. The ministry provides several suggestions and advices: continuous monitoring, routine maintenance (to be preferred to restoration) and collecting data to support decisions at both the national and regional levels



In Greece, a more specific addition to the Greek Legislation related to climatic change is to consider the guidelines of the **European and Mediterranean Major Hazards Agreement (EUR-OPA) Report on the “Vulnerability of Cultural Heritage To Climate Change”**. In this report, guidelines for the assessment of the climatic change risk as regards to cultural heritage are provided.

A thorough risk evaluation in respect to the impacts due to the climatic change is essential for the effective preservation of the Cultural Heritage monuments.

Also in the USA, the U.S. Environmental Protection Agency, the US National Aeronautics and Space Administration, and the US National Oceanic and Atmospheric Administration concur that climate change is indeed occurring, and part of it is almost certainly due to human activity.

The primary cause of climate change is the burning of fossil fuels, such as oil and coal, which emits greenhouse gases into the atmosphere — primarily carbon dioxide. Other human activities, such as agricultural and deforestation, also contribute to the proliferation of greenhouse gases that cause climate change.

While some quantities of these gases are naturally occurring and represent critical factor in the Earth’s temperature control system, the atmospheric concentration of CO₂ did not rise above 300 parts per million between the advent of human civilization roughly 10,000 years ago and 1900. Today it is at about 400 ppm, a level not reached in more than 400,000 years.

Even small increases in Earth’s temperature caused by climate change can have severe effects. The earth’s average temperature has gone up 0.7 °C (1.4° F) over the past century, and it is expected to rise as much as 6 °C (11.5° F) over the next. That might not seem like a lot, but the average temperature during the last Ice Age was about 2 °C or 4° F or lower than it is today.

Rising sea levels due to the melting of the polar ice caps (again, caused by climate change) contribute to greater storm damage. Warming ocean temperatures are associated with stronger and more frequent storms. Additional rainfall, particularly during severe weather events, leads to flooding and other damages. An increase in the incidence and severity of wildfires threatens habitats, homes, and lives. Heat waves contribute to human deaths and other consequences.

Other effects could happen later this century, if warming continues.

- Sea levels are expected to rise between 18 and 59 cm by the end of the century and continued melting at the poles could add between 10 to 20 cm.
- Hurricanes and other storms are likely to become stronger.
- Species that depend on one another may become unsynchronised. For example, plants could bloom before that their pollinating insects become active.
- Floods and droughts will become more frequent. Rainfall in Ethiopia, where droughts are already common, could decline by 10 percent over the next 50 years.
- Less fresh water will be available. If the Quelccaya ice cap in Peru continues to melt at its current rate, it will be gone by 2100 by leaving thousands of people who rely on it for drinking water and electricity without a source of either.
- Some diseases will spread such as malaria carried by mosquitoes.
- Ecosystems will change — some species will move farther north or become more successful; others won’t be able to move and could become extinct. Wildlife research scientist Martyn Obbard has found that since the mid-1980s, with less ice on which to live and fish for food, polar bears have gotten considerably skinnier. Polar bear



biologist Ian Stirling has found a similar pattern in Hudson Bay. He fears that if sea ice disappears, the polar bears will as well.

Risk is the exposure to the hazard, or the likelihood of the hazard causing death and destruction or negative environmental effects.

Consequences are a measure of the severity of the damage than an event may cause.

The ways to reduce risk are to reduce or remove the hazard, reduce or remove the exposure, minimize the consequences.

The HERACLES project is looking into ways to protect cultural heritage assets from the effects of climate change, due to the increase in the hazards described above. It is suggested to identify all possible hazards threatening cultural heritage sites, and not only those which are related to climate change. The Table below lists the hazards it is suggested to include in the HERACLES cultural heritage sites risk assessments (Table 8).

Table 8: list of the possible hazards suggested to be included in the HERACLES cultural heritage sites for risk assessments

| Cultural Heritage Site "xxxxxx" | | | | | |
|--|----------------------|----------|----------|--------|-------------|
| Hazards | Likelihood to Happen | | | | |
| | Highly Unlikely | Unlikely | Possible | Likely | Very Likely |
| Wind, sea and salt | | | | | |
| Tsunamis, Hurricanes and Storms | | | | | |
| Extreme rainfall events | | | | | |
| Earthquake | | | | | |
| Landslide and debris flow | | | | | |
| Volcano, lava and ashes | | | | | |
| Floods | | | | | |
| Droughts | | | | | |
| Wild fire, smoke and fire and falling debris | | | | | |
| Avalanches | | | | | |
| Sabotage, Terrorism | | | | | |



| | | | | | |
|---|--|--|--|--|--|
| Internal Conditions/Aging | | | | | |
| Visitors, Stealing, Environmental Changes | | | | | |

In the above table, a list of possible hazards is presented together with their likelihood to happen. Of course, it can be used coherently with the hazards already indicated in the previous Section 4 for the HERACLES test beds. For what concerns the likelihood of the hazard, it will depend on the data availability. Anyway, it represent a table that can have a more general use.

6.5 Risk assessment methodology for HERACLES cultural heritage sites

This Section proposes a methodology that could be used for Risk Assessment of the HERACLES cultural heritage sites. It is proposed to do a qualitative analysis as the first step and then quantitatively as a second step, if quantitative data is available [FEMA Unit V Risk assessment]. Figure 102 identifies the steps:

Assessment Flow Chart

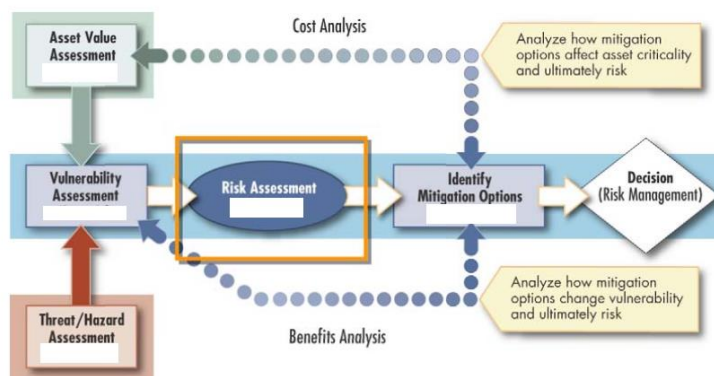


Figure 102 – HERACLES Proposed Risk Assessment Methodology

6.5.1 HERACLES Cultural Heritage Site

A Risk Assessment Exercise is proposed to be performed for each of the HERACLES cultural Heritage test beds:

1. Heraklion Venetian fortress and coastal fortifications in Greece
2. Minoan Knossos Palace in Greece
3. Town of Gubbio in Italy: historic Walls
4. Town of Gubbio, in Italy, Consoli Palace



6.5.1.1 Threat/Hazard Assessment with Likelihood to happen

The below Hazard Matrix is proposed to be made up for each HERACLES Cultural Heritage test beds.

The qualitative approach is to cross off the matrix cells for each hazard within the cell of its likelihood to happen. After crossing off each hazard, a frequency could be estimated for each hazards if data is available (below the indicated likelihood is just an example).

Table 9: frequency of possible hazards for risk assessments, as an example

| Cultural Heritage Site: XXXXX | | | | | | |
|-----------------------------------|--|----------------------|----------|----------|--------|-------------|
| Hazards | | Likelihood to Happen | | | | |
| | | Highly Unlikely | Unlikely | Possible | Likely | Very Likely |
| Estimated Frequency of Occurrence | | | | | | |
| 1. | Wind, sea and salt | | | | | X |
| 2. | Tsunamis, Hurricanes and Storms | | | X | | |
| 3. | Extreme rainfall events | | | | X | |
| 4. | Earthquake | | | | X | |
| 5. | Landslide and debris flow | | | | X | |
| 6. | Volcano, lava and ashes | | | | | |
| 7. | Floods | | | | X | |
| 8. | Droughts | | | X | | |
| 9. | Wild fire, smoke and fire and falling debris | | | | | |
| 10. | Heavy snowfall, Avalanche | X | | | | |
| 11. | Sabotage, Terrorism | X | | | | |
| 12. | Internal Conditions /Aging | | | | X | |
| 13. | Visitors, Stealing, Environmental Changes | | | X | | |

Next step is to rate every hazard with the expected severity in the Risk Assessment Matrix as shown below.



6.5.1.2 Risk Assessment Matrix

Each hazard shall be marked for its severity in the risk assessment matrix, and a damage cost estimate could be added in each cell.

The non-acceptable risk cells should be coloured red, the acceptable risk cells coloured green, and the remaining cells coloured yellow, where the risk should be kept As Low As Reasonable Practicable (ALARP).

Table 10: Risk Assessment Matrix

| Risk Assessment Matrix Cultural Heritage Site: XXXXX All Hazards Severity Rating | | | | | |
|--|--|----------|---------------------|-------------------|-------------------|
| SEVERITY | LIKELIHOOD TO HAPPEN | | | | |
| | DAMAGE COST ESTIMATE IN MILL EURO PR. HAZARD | | | | |
| | Highly Unlikely | Unlikely | Possible | Likely | Very Likely |
| Extensive | | | Earthquake Cost: | | |
| Major | | | | Wildfire Cost: | |
| Medium | | | | Wind Cost: | |
| Minor | Snowfall Cost: | | | | Internal Cost: |
| No Impact | | | | | |

The next step is to define and plan possible mitigation options and the cost of these for the red (not acceptable risks) and yellow (risks to be kept as low as possible) cells.

6.5.1.3 Mitigation Options Matrix

Most possible mitigation option is entered into the relevant cell for each hazard, and a cost of the mitigation option could be estimated together with a time span for implementation.

The Mitigation Matrix will then give a quick view of what could be implemented for mitigating the different risks for the specific cultural heritage site.

The colours, red, yellow green are kept in the cells, for indicating the risk of the different hazards.



Table 11: Mitigation Matrix

| Mitigation Matrix | | |
|-------------------------------|--|--|
| Cultural Heritage Site: XXXXX | | |
| Hazards | | Most likely Mitigation Option for Each Hazard |
| 1. | Wind, sea and salt | Paint or other structural material to cover the structures Cost: Time to implement: |
| 2. | Tsunamis, Hurricanes and Storms | |
| 3. | Extreme rainfall events | |
| 4. | Earthquake | Structural improvement of the site buildings/walls Cost: Time to implement: |
| 5. | Landslide and debris flow | |
| 6. | Volcano, lava and ashes | |
| 7. | Floods | |
| 8. | Droughts | |
| 9. | Wild fire, smoke and fire and falling debris | Separate cultural heritage site from surrounding woods and adjacent buildings or put up fire walls Cost: Time to implement: |
| 10. | Heavy snowfall, Avalanche | No mitigation necessary |
| 11. | Sabotage, Terrorism | |
| 12. | Internal Conditions/Aging | Installation of an internal air control system Cost: Time to implement: |
| 13. | Visitors, Stealing, Environmental Changes | |

6.5.2 Cost Benefits Analysis and Decision

The two next steps should be:

- Analyse how mitigation options affect asset criticality and ultimately risk
- Analyse how mitigation options change vulnerability and ultimately risk

This could be done by going through the same steps as shown above for estimating the new risk and vulnerability, after implementation of the mitigation measures.



Based on these analyses a recommended decision could be made.

7 CURRENT CH RISK MANAGEMENT IN GREECE/HERAKLION AND ITALY/GUBBIO.

7.1 Current CH risk management in Greece- Heraklion

In the Hellenic legislation, CH is considered as a public good, which everyone can have access. The protection of Cultural Heritage is ruled by the article 24 of the Constitution, within the greater framework of the environment. This article states "the protection of the natural and cultural environment constitutes a duty of the State. For the preservation of the environment, the State is obliged to take the utmost preventing and restoring measures .. (paragraph 1). Monuments, traditional areas and historical sites should be protected by the state "(paragraph 6). It is noteworthy that in the Hellenic Constitution, as in the Convention of the UNESCO World Heritage, (UNESCO 1972), protection of the natural environment and cultural heritage is placed side by side and in this way it is demonstrated their close relationship. In the Constitution, indeed, the term "cultural environment" includes not only antiquities, monuments, traditional areas and historical sites, but also other elements that the legislator could consider eligible for State protection. In addition, it should be stressed out that in the Hellenic Constitution the benefits of public goods cannot be controlled by economic and market mechanisms.

Current risk management in cultural heritage sites in Greece include the processes, tools and procedures to manage and control those risks that could have a negative impact on the archaeological sites. They include risk identification, assignment of responsibilities, risk mitigation and monitoring.

7.1.1 Risk Identification

Risk Identification is performed during the regular patrols of the monuments by the archaeological guards and by the scientific personnel of the Ephorate. The monuments are monitored every day by the guards of the archaeological sites. Furthermore, the archaeologists, engineers, architects and conservators constantly check and monitor sites and specific monuments. When a risk is identified, a report is sent to the Ephorate. It describes the risk in detail and its impact on the monument. The report is addressed to specific departments of the Ephorate, depending on the nature of the risk and the age of the monument. According to the severity and the importance of the damage, the risk is monitored by a scientific team of the Ephorate (i. e. archaeologists, engineers, architects conservators), in order to identify and take note of any damage on the monuments.

7.1.2 Risk Responsibilities

Depending on the type and severity of the damage of the monument, specific Ephorate departments and personnel/staff are involved with specific tasks in order to mitigate the possible threat. For minor damages, no permission is required by the Central Service of the Ministry of Culture and thus the Ephorate can perform urgent restoration interventions.

If the funding for the specific restoration exceeds the estimated budget for the current financial year, a proposal/project for restoration actions on the monument is drafted and submitted to the Ministry of Culture for approval.

7.1.3 Collection of information

Gathering information on the potential risks of an archaeological asset includes the following actions:

- Collection of documents, such as project reports.



- Supervising reports and other information documenting risks occurred in other cases.

In this phase, the methodological approach is also defined, including the risk management procedures.

7.1.4 Risk mitigation

Risk mitigation actions are performed either by the Ephorate itself or by subcontracting to an external source. If the risk is addressed internally, the archaeological project documentation is drafted and the exact roles of any individual or groups is described in the organization chart of the Ephorate.

By subcontracting the restoration project, the risk management and subsequent responsibility is transferred to the subcontractor. In this way, the risk is addressed by the subcontractor who is institutionally responsible and technically qualified to address it, under the supervision of the Ephorate.

Risk mitigation stage includes the structural analysis and the definition of the monitoring of the site based on the procedures of the risk management plan.

Risk elimination is carried out by addressing the source of the hazard in order to avoid its consequences. The risks are approached either by preventive actions or by a restoring action after a hazard occurrence. If a preventive risk elimination is not possible, the risk reduction is faced/addressed.

Risk reduction attempts aim to reduce the impact of the hazard, or to minimize the occurrence of the consequent events. The main parameters affecting the implemented procedures are the following: the size of the risk, the characteristic of the monument, and the duration of the necessary actions.

7.1.5 Monitoring

Monitoring is required to identify any new risks. The scope of this process is to verify whether the damage has been dealt with success and to evaluate if any further action-is required. This procedure is carried out with the same methodology of the risk identification procedure. Timetables and reports are prepared and the results of the risk identification procedures and of the risk analysis are evidenced.

In case of extreme events, the current management is carried out by the scientific team of the Ephorate (i.e. archaeologists, engineers, architects conservators), that identify and take note of any damage on the monuments. Subsequently, a report is made, which is submitted to the Ephorate and then to the Ministry, so that any necessary work will be carried out. Risk management is performed by different departments of the Ephorate according to the historical (Prehistoric and Classical/ Byzantine) period of the monument.

7.2 Limits of the current CH risk management in Greece - Heraklion

Due to the very extended area, where Knossos palace is placed, and due to the large amount of people visiting the site, the site monitoring is particularly time demanding. Limitations are also due to the lack of monitoring equipment (e.g. weather stations, structural sensors). Nevertheless, an extensive archive with details and data related to previous damages/critical issues/problems of the site and the relative restoration interventions done, exists. This archive has been also published, but it is not available in electronic format and it represents a limit in the availability and handling of the data.

In the Koules fortress there is also a very large archive with data related to previous damages/critical issues/problems of the site and the relative restoration interventions done. During the last restoration a large number of previous critical issues were addressed, even though, risks related to climatic change (e.g wave impact, sea level rise and related moisture)



are not entirely solved. Current risk management is limited to video surveillance of the interior, that is mainly for security purposes, while no monitoring sensors are installed.

7.3 Current CH risk management in Italy - Gubbio

In Italy the activities concerning the direct and indirect safeguard of Cultural Heritage is regulated with the DLgs 42/2004 "Codice dei beni culturali e del paesaggio" (Tutela del patrimonio culturale). Here are reported the Articles more focussed on the matter of interest.

This legislative decree regulates cultural heritage both public and private (Art. 10).

The **Italian Ministry MiBAC** (*Ministero dei Beni e delle Attività Culturali*) , now **MiBACT** (*Ministero dei Beni e delle Attività Culturali e del Turismo*) has the responsibility of the cultural heritage and executes its decision competences through the Superintendences (Arts. 3,4,5).

The surveillance and inspection activities concern the MIBACT (Arts. 18, 19).

The **conservation** is regulated by the Art. 29: the **conservation** is assured through a coherent, coordinated and planned activity of investigation, prevention, maintenance and restoration. **Prevention** deals with all the appropriate activities to limit the risks associated with the CH in its context. **Maintenance** deals with all the activities and interventions to control the CH conditions, and to maintain its integrity, its functional efficiency and its identity. **Restoration** deals with all the actions finalised to maintain the material integrity and to its recovery, its protection and to the transmission of its cultural values. In case of cultural heritage located in seismic areas, the restoration include the structural renovation, too. The Ministry defines guidelines, technical regulations, criteria and models for interventions in the CH domain, also together with Regions, universities and research institutes. If maintenance and restoration actions are dealing with decorated surfaces, this part will be devoted to CH restorers, as defined by the applicable regulation.

Conservation duties are the object of the Art. 30: the State, the Regions, and any other public body or institution have the obligation to guarantee the security/safety and conservation of the CH belonging to them. Private owners and holders of CH are compelled to guarantee its conservation.

Voluntary conservative intervention (Art.31): the restoration and other conservative interventions on CH, based on the initiative of the owners and holders of CH are authorised according to the Art. 21. The interventions must be authorised by the Superintendence.

Imposed conservative intervention are also considered and regulated by the Art. 32.

Conservative actions on CH belonging to the State (Art. 39): the Ministry provides to the conservation needs of public CH, even if in charge or in use to other administrations or subjects, heard these latter. Unless otherwise stated, the intervention planning and execution are undertaken by the Administration/subject, after the Ministry authorization. The Ministry will transmit the project and will communicate the starting date to the Municipality.

Conservative Interventions on goods belonging to regions or any other public body, are ruled by the Art. 40, and are generally the object of previous agreements.

The survey and the analysis of the territory transformation dynamics devoted to the identification of the risk factors and vulnerability are the object of the Art. 143. It includes landscape and CH assets as well.

During normal times, the ordinary maintenance/conservation is assured according to the above mentioned articles.



In emergency, the scenario is different. In fact, MiBAC, after the seismic event occurred in Italy in May 2012 (in Emilia Romagna region) decreed the establishment of the Crisis Unit – (**Unità di Crisi-Coordinamento Nazionale UCCN-MiBAC**) for the safeguard of the CH. This operative Unit is activated in case of emergency only, and supports the MiBAC General Secretariat for monitoring and coordinating all the activities (among them also damages estimation, movable goods recovery, etc) necessary to face the emergency from natural hazards. This is the decree n. 7/25 May 2012, and is made operative through the MiBAC General Secretariat circular n.24/2012. Subsequent amendments and implementations on this matter are the object of the MiBACT Directive December 12th, 2013 and MiBACT Directive April 23th, 2015.

Concerning risk and emergency management, another important Italian Body to mention is the **Civil Protection Department (DPC)**. The Civil Protection Department has been grounded in the offices of the Presidency of the Council of Ministers since 1982. It is a specific Italian institution created in 1982, after the seismic event in Irpinia (1980) that evidenced a serious lack of coordination in the actions to face this catastrophe. It has a guiding role, in agreement with regional and local governments, of projects and activities for the prevention, forecast and monitoring of risks and intervention procedures that are common to the whole system. The Department coordinates the response to natural disasters, catastrophes or other events which intensity and extent, should be faced with extraordinary power and means. Italian Civil Protection is a body able to mobilise and coordinate all the national resources apt to give assistance to the population in case of serious emergency. In agreement with regional governments and local authorities, is working in the drafting of legislation on the prevention of risks and regulatory measures needed to cope with disasters and minimise damage to people and property. It promotes national and international training project and activities that contribute to spread the culture of civil protection. All the public organizations take part to the activities of DPC, as well citizens, volunteers and professional associations. Among others, operating structures of the national service of CP DICOMAC (*Direzione di Comando e controllo*) include: National Body of Fire Brigades (a key component of CP), the Army, the Police, the *Carabinieri*, the National Technical Service, national research institutions as CNR, ENEA, APAT, INGV, Italian Red Cross, structures of the National Health Service, RFI, TIM, WIND, Vodaphone, etc). No specific structures concerning CH are present, even if during catastrophes collaborations with local Superintendences and experts have been established since the beginning. Since 1999, memoranda of understanding between DPC and MiBAC have been defined. In February 2012, MiBAC became an effective member the DPC Executive Committee. The DPC is also articulated at local level and each municipality has its own local Municipal Civil Protection unit. The Major is the chief executive of it. (Art.15, Legge 225, 24 Feb 1992). To support the Major technical Support Group (GTS-Gruppi Tecnici di Sostegno) have been created in September 2016 (after the seism in Central Italy), including cooperation with MiBACT unit at the regional Coordination Centre [*Presidenza del Consiglio dei Ministri*, DPC, Prot. N. 47429, 15 Sept. 2016].

Gubbio is located in Umbria that is a region rich in valuable CH both in terms of landscapes, urban and rural areas, historic and art villages, towns and cities. As well, Umbria region experimented in the past and unfortunately in the present, too, the severe consequences of natural hazard such as earthquakes, for instance the more recent chain of events occurred since August 2016, till nowadays. After the seismic events occurred in Umbria in 1997-98, the connection between Cultural Heritage and Civil Protection highlighted the need to create a body specifically dedicated to the safeguard of CH. In the framework of the Regional Centres and their specialization on risk typology, Umbria region expressed its candidature as point of reference for the topic “Civil Protection and CH safeguard”. Already from 1988 to 2004 a series of regional legislative acts led to the establishment of a **Centro Regionale di Protezione Civile**, and more recently of a **Centro Operativo Beni Culturali (COBC)** (2003-2004) interlinked with



to the previous one. These bodies were established together with MiBACT (Regional Secretariat), Umbria region, national Department of Civil Protection

The **Civil Protection Service of Umbria region**, using resources from POR-FESR 2007-2013, Project “*Obiettivo competitività e occupazione*” Asse 2 “*Ambiente e prevenzione dei rischi*” – attività a1 “*Piani e interventi per la prevenzione dei rischi naturali*” produced the “**PIANO REGIONALE COORDINATO DI PREVENZIONE MULTI-RISCHIO - REGIONAL COORDINATED PLAN FOR MULTIRISK PREVENTION**” (March 2014). The risks examined in this plan are the following:

- Seismic risk
- Meteo-hydrogeological and hydraulic risk (floods, landslides, dams, reservoirs, droughts)
- Fire risk (forest; interface)
- Technological risks
- Risks for Cultural Heritage (refers to Chapter 8 of the above mentioned document)a

Concerning the CH, the consequences on CH assets from different several risks are considered.

In the **REGIONAL COORDINATED PLAN FOR MULTIRISK PREVENTION**, actions to be carried out in emergency and not, are defined. In emergency, the COBC acts in a coordinated way with the other components of the Civil Protection Regional Centre.

Within this plan, are included:

- the ***Sistema Informatico Unico dei Beni Culturali (SIUBC)***- Unique Computer System for Cultural Heritage, collecting all the information on the positioning of the CH assets on the territory
- evaluation of hydraulic/hydrogeological risk: in particular this is the object of “***Piano Gestione del Rischio Alluvioni***”- Flood management Plan (November 2015)

All these initiatives and actions (legislative and not), as well their further improvements have been and are mainly imposed by emergency. For this reason they are still object of optimization/integration, requiring a higher degree of coordination, too.

The municipality of Gubbio as all the **Italian municipalities**, has its own **Civil Protection Plan (CPP)**. This document represents a technical, complete and easy to use instrument, allowing the City Council to identify and prioritize the actions to be performed and to plan a strategy for managing criticalities in all the emergency phases (immediately and after the events). The procedures include general indications to manage the risk scenarios and the relative communication flows.

In the Gubbio CPP, the risks of specific interest for Gubbio territory are the Hydraulic, the Hydrogeological, the Seismic, the interface Fires, Heat waves, and the Snow ones.

For the Hydraulic and Hydrogeological risks the territory is classified in alert zones of different level, including a description of the previous events, the intervention activities to plan in emergency and in ordinary conditions, as well the description of the elements at risk in terms of: population; strategic structures; economic and productive activities; roads and infrastructures.

For the seismic risk, are indicated how to manage the emergency, and is provided a schema of the priorities to follow after a seismic event, in terms of indications and procedures.

For the interface Fires, indications of the areas and structures at risk is given, together with an intervention plan concerning people and infrastructures.



For the risk due to Snow, intervention phases and preventive actions are planned and indicated.

For the risks derived from Heat waves, action plans are given according to the severity of the event.

In general, the procedures can be summarised according to the following flow:

- Damages estimation caused by the hazard event
- Risk evaluation
- Mitigation actions with the priority of the population safety

After that,

it is possible to intervene on the critical infrastructures and building, with the involvement of the MiBACT through its Superintendence where Cultural heritage structures and assets (movable and immovable) are involved.

To summarise, when a big disaster occurs involving CH assets, immediately after the crisis event the local CP has as first priority to secure the population, and only after, can make intervention of extreme urgency on CH assets, promptly communicating them to the MiBACT Superintendence of competence. Particularly, this refers to situations after a major catastrophic event like an earthquake. Very recently, after the last seism in central Italy, the Head of DPC with the Ordinance 393/2016 has provided further details for the post-seismic interventions management to temporarily secure buildings, through the assistance of the Technical Support Groups, specifically created to support the mayors. These groups are integrated with components from MiBACT, in case of CH buildings and structures involving. Anyway, these activities are only foreseen as a temporary solution for dangerous situation involving people safety.

After the emergency phase, the local authorities (Municipalities with the supervision of MiBACT) are back in charge for the activities concerning restoration and reconstruction.

7.4 Limits of current CH risk management in Italy- Gubbio

In Italy, in ordinary time, the activities concerning the ordinary safeguard of CH assets are ruled through the DLgs 42/2004, already mentioned. The responsibility is in charge of the owners/holders of the CH assets. Any actions has to be authorised by the MiBACT Superintendence of competence. In this framework, particularly with reference to the local Authorities, criticalities arise from funds availability. In fact, Italy is very rich in CH assets, movable and immovable and their safeguard needs a lot of resources. Very often the needs are higher than the availability of the necessary funds to assure the good preventive maintenance, that should be considered as the best practice to follow to avoid critical situations.

In this context, probably what needs more is to organise/dispose of a strategic plan for an early identification of potentially hazardous situation (and their related level of risk), to prioritize the interventions and to plan suitable solutions for preventive maintenance and preservation of CH assets, in order to avoid major problems in the near future.

More specifically, referring to the Gubbio test beds, no particular monitoring systems are in place in order to estimate possible hazards effects on their ancient structures. The Gubbio territory is partially mapped through the CH risk map (Carta del Rischio) delivered by ISCR, but still further improvements can be done, with the inclusion of other historical buildings, such as Consoli Palace, among others, for instance.



Moreover, a possible quasi-continuum monitoring on the evolution of possible hazards (i.e. landslides) from hydrogeological risks (due to intense rainfall/flooding), would be very important too, since these can severely affect CH structures.

For the previous intervention carried out in the Gubbio CH assets (buildings and others), the availability of an organised and easy to handle archive of data would be very useful. The possibility to integrate it with present and future info on actions to be performed on that matter, would be very important too.

8 NEED OF NEW TOOLS- HOW TO IMPROVE THE CURRENT CH MAINTENANCE: HERACLES PLATFORM DEVELOPMENT

8.1 Tools to be delivered - not only data repository, but a real supporting decision system

From the survey presented in the sections above, several limits emerge for the two different scenarios considered in HERACLES project.

For the test beds in Crete, the presence of monitoring network is limited for both the environmental and the structural/physico-chemical parameters of the CH assets. Even if an archive regarding the previous damages/problems of the monument and their restoration interventions exists, such an archive is not easy handling and digitalized.

As well, Gubbio is asking for an organized and easy to handle archive of data, to be integrated with present and future info, and furthermore, no particular monitoring systems are in place.

For both the sites, a global vision of the CH assets/structures and of the territory is missing and this does not permit to have a detailed and updated situational awareness about the risk scenarios and their possible impact on the CH. The need to have a global knowledge of the status of a CH asset and of the effects of natural and anthropogenic pressures on it is still more important nowadays. In fact, since public funding is decreasing it becomes even more important to have necessary tools for an effective prioritization/planning of the interventions. Nevertheless, this need is clearly evidenced in end-users survey.

A correct and effective strategy for the improvement of CH maintenance requires the integration of different technological and modeling tools encompassing different disciplines and methodologies ranging from observation/sensing techniques to ICT platforms, to new materials design and implementation as well as new procedures/strategies able to couple long-term maintenance/protection and risk management and mitigation.

Based on several meetings and surveys on site, evidencing the problems (as summarized in Section 4) and the risk management limits (Section 7), as well as on the socio-economic analysis carried out according to what described in Section 5, the key elements necessary for the effective implementation and exploitation of a platform can be summarised as follows.

- Monitoring/Earth observation technologies for the wide area surveillance not only of the single CH asset/monument but also of the surrounding territory. In particular, satellite and airborne observational platforms are combined with in-situ network of sensors for time-continuous and on-demand inspections/measurements. This allows to achieve a holistic vision of possible multi-risk scenarios, where aging/weathering of the CH assets is considered in combination with the risks. For example, in the cases of CH assets in an area at risk from landslides, it is necessary to have an informative scenario not only on the status of the CH asset but also on the multi-risk scenario affecting the CH site (i.e., landslides activated by extreme rains or a seismic event).



- Integration of organized information from different sensors networks present on the territory, as weather and pollution measurement stations, able to provide time-continuous information about the meteorological and environmental parameters. This informative baseline should be digitalized in order to achieve historical series to permit the building of predictive models based on them and to correlate the effect of environmental/pollution parameters to the long term deterioration/damage of the CH structures.
- Organization of the digitalized information about the CH asset/monument in a structured way regarding:
 - the geographical geo-referencing of the structure;
 - its “history” in terms of risk events affecting it and the related risk mitigation actions already performed;
 - its present status in terms of structural/material properties and integrity/deterioration/damage characteristics. The information about the status of the CH assets also is based on the measurements provided by the sensors for a diagnostic evaluation of the surface and the bulk. These measurements are realised by means of:
 - structural engineering diagnosis methods [modal analysis, vibration frequency measurements and non destructive (NDE) or partially destructive evaluation tests on materials (mechanical testing of cores)]. The different information can generate a 3D model of the structure.
 - Physico-chemical evaluation of materials constituting the CH asset/monument, and their degradation status and mechanism, with in-situ and ex-situ analysis
 - the indication of the possible actions in terms of maintenance/conservation/restoration typologies and materials necessary for the interventions; the indication should be provided on the basis of the deterioration/damage level and by accounting the economic sustainability

The above mentioned information should be provided to the end-users/stakeholders “everywhere/every-time” via internet through website and mobile connections (smartphones, tablets).

This will facilitate the access to the information also during surveys and **crisis situation**.

- The development of models able to activate “early warning”/pre-alarm/alarm indication, based on the historical information and on the information acquired from the sensors present on territory. These models will be tailored on the basis of the knowledge of the end-user involved in the related application domain. For example, on the basis of previous events, it is known that a given level of rain can activate local landslides triggering domino effects on the CH assets structural stability. With the use of different sensors in areas affected by these kind of problems (for example, in this particular case, pluviometers), it will be possible to foresee probable problems in that area. This kind of indication can be a key element to support the decision for preventing, managing and mitigating a crisis.
- The knowledge of the organised information for the territory, the single CH asset and the hazard along with the indication of the possible kinds of maintenance/preservation/restoration interventions can support the end-



users/stakeholders in prioritizing and planning the interventions: this is even more important when limited funds are available for these kind of actions.

For Gubbio, the main limitations related to the CH risk management resides in the fact that the ordinary risk management procedures suffers from the drawbacks already discussed in the section 7.4. In addition, in case of emergency, the priority actions are first focused on the population safety and mainly regards the first phases after the crisis events. It is true that an increasing attention is being placed to CH assets, as demonstrated by the recent legislation and initiatives on this matter (see section 7.3). Even though, still remain rooms for implementation.

The HERACLES platform can be a useful tool for a bidirectional information flow between the end-users /stakeholders (municipalities, Superintendences, policy and decision makers in general) and the social, economic and cultural communities present on the territory. In this frame, by using the new opportunities offered by the **social networks**, HERACLES platform could **activate a dialog with the local communities**, in order to receive opinions on the preservation needs and improvement of the CH values/assets and to communicate how the “use” of a CH asset can bring benefits to the community.

8.2 How the platform will address the limits

The HERACLES approach through the platform is to provide all the tools/solutions/services already underlined. In fact, the platform will:

- Collect and Integrate information (processed data) from satellite/airborne and in-situ sensors, ensuring a global vision of the CH structure through the geomorphological modeling of the site where it is located coupled with information about the structure itself (structural modeling, materials characterization and new solutions).
- Collect and integrate environmental parameters (temperature, humidity,..) and pollution indicators in order to have an always updated status of the anthropogenic pressure. This information will be enhanced by modeling of climate weather change and of extreme events at very high resolution, allowing the evaluation of the exposure to the hazards induced by climate events.
- Digitalize and organise information at very different spatial scales, from territory to the site, till to the single monument in the site and to the single element of the monument.
- Support the decision in risk management by activating early warning/pre-alarm/alarm indications, on the basis of the information already present in the platform and of the updated measurements from the sensors network present in the area.
- Support the decision for predictive and cost-effective maintenance actions by exploiting the information present on the platform about the status of the site/monument, by identifying the priorities and the typology of the interventions. This information base is very important in prioritizing and planning the interventions by accounting also the economic sustainability.
- Activate a continuous and always updated information flow with the local community in order to receive information, suggestions about the preservation issues and opportunities related to the possible “use” of the CH assets and to make the community aware about the actions/strategies for conservation and improved fruition of the CH assets providing social and economic benefits. For example, HERACLES platform could make aware the community about the status of the restoration interventions, by means of periodic updating and/or to announce cultural



events expected at the CH site. From the point of view of the citizens, they could feed the HERACLES platform with information about the status and threats affecting the CH assets by acting as unconventional guardians (“human sensors”) and by suggesting ideas to improve the touristic attractiveness of the CH assets in the area.

8.3 HERACLES experience as guidelines for other useful scenarios for different areas and risks

The always underline flexibility of HERACLES platform approach permits to face with different risk scenarios and with different contexts at more general European level. In fact, the flexibility of the platform allows to deal with different sensors, information and models, which can be adapted to the specific case under study. In particular, the involvement of the end-users and stakeholders is very important for the definition of the requirements, of the observation/measurement chain specifically thought for the sites, as well as for the indications of the materials and interventions necessary for both the long-term maintenance and risk management.

8.4 HERACLES added value (not only data repository, but a real supporting decision system)

At European level, there is not a similar system for CH heritage management and protection. Most part of ICT platforms are devoted to the digitization with the following main goals: storage of CH data information; preservation of the original media carrying CH information; management of the CH information; exploitation of CH information. In this frame, CH data acquisition and storage in digital domain are well assessed processes. A relevant challenge still concerns the exploitation of these data, enabling and improving their fruition opportunities also by resorting to web and mobile devices.

The HERACLES platform exhibits several revolutionary aspects such as:

- HERACLES platform is able not only to handle common information sources as photos and images but even outcomes/measurements from state of art and novel sensors based on different observational systems for non-invasive and remote monitoring/diagnostics of the CH site and its territory. The integration of the different sensing technologies will permit a multi-scale monitoring, where the global vision of the site is combined with the diagnostics to the single elements of the site, by focusing on the surfaces and on the bulk of the structures and of the underground. In particular, HERACLES platform is able to provide different modeling of the site in order to correlate the status of the site/monuments with the different risks scenario.
- In this way, HERACLES platform is able to achieve an always updated situational awareness about the status of the site and of the surrounding territory, which represents a crucial information for the end-users/stakeholders providing useful info for an early warning and disaster prevention capabilities.
- HERACLES platform is able to provide decision-making support to the end-users/stakeholders for prioritizing and planning any interventions for maintenance. For this aim, the platform will handle and integrate information about new materials for long-term maintenance, remediation and restoration actions, as well as about the procedures and guidelines able to account specifically the CH site characteristics and the risks affecting it.
- HERACLES platform will operate as decision support system in ordinary conditions and after a crisis event, as well.



- HERACLES platform should be fed with the information about the “history” of the previous interventions made on a particular CH asset and with the info on what it is important to carry on, on the basis of the suggestion provided by the platform sensors network. It will be possible to include also the info regarding the realization of the suggested actions. Doing that, two important results will be achieved: first HERACLES platform is always well aligned with the status of the CH structure and can provide an updated situation; second, this information once stored in the platform will enrich the whole data source improving the indications for further successful interventions.
- The HERACLES platform should activate a continuous and always updated information flow with the local community in order to receive information, suggestions about the issues and opportunities related to the “use” of the CH assets and to make the community aware about the actions/strategies for conservation and improved fruition of the CH assets providing social and economic benefits. To this end, as already stated, the citizens will act as unconventional sensors (human sensors), able to suggest ideas to improve the CH assets fruition.
- This last aspect is strictly linked with the important role that information and education can play in CH preservation, together with the Identity value. In fact, also from the social analysis, resulted that more a Community is conscious of the importance of its own roots and history, more it will be responsible and actively involved in the conservation of its own cultural heritage and of the values of the community itself.
- If the platform will be use as a tool to inform and share knowledge on CH issues, this will represent a very important aspect, strictly related to the education, too. The educational value of the knowledge sharing will have a beneficial effect on the preservation and on passing on the own cultural heritage.
- **Indeed, it will be essential to develop the consciousness of the importance of the own CH and it will represent a guarantee for its protection and preservation.**

9 Selected sources and documents

Acosta C. E., Luis A. Guerrero. Supporting the collaborative collection of user's requirements. In Stefan Seifert and Christof Weinhart, editors, Group Decision and Negotiation (GDN) 2006, pages 27–30. Universitätsverlag Karlsruhe, 2006.

AllInterview.com <http://www.allinterview.com/showanswers/88635/what-is-the-difference-between-risk-threat-hazard.html>

Ashworth, G. J. & Howard, P., (1999). European heritage, planning and management. Intellect Books.

Bonazza A., Sabbioni C., Messina P., Guaraldi C., De Nuntiis P., Climate change impact: Mapping thermal stress on Carrara marble in Europe Science of the Total Environment 407 (2009) 4506

Borelli S., Lenzerini F., Cultural Heritage, Cultural Rights, Cultural Diversity: New Developments in International Law di Studies in Intercultural Human Rights, Ed. Martinus Nijhoff Publishers, 2012

Bugini R., Folli L., Lezioni di Petrografia Applicata 2008, http://www.icvbc.cnr.it/didattica/petrografia/lezioni_petrografia.htm.

California Technology Agency State of California http://www.cioarchives.ca.gov/itpolicy/pdf/PM1.4_Overview_Roles_and_Responsibilities.pdf



- Carta del Rischio <http://www.cartadelrischio.it/>
- CGE Risk Management Solutions <http://www.cgerisk.com/knowledge-base/risk-assessment/risk-matrices>
- Civil Protection Service Institution Legge n. 225 del 24 febbraio 1992. (Istituzione del Servizio nazionale della protezione civile)
- Civil Protection Ordinanza n. 393 del 13 settembre 2016: ulteriori interventi urgenti di protezione civile per l'eccezionale evento sismico che ha colpito le Regioni Lazio, Marche, Umbria e Abruzzo il 24 agosto 2016
- Codice dei beni culturali e del paesaggio, Code of Cultural Heritage and Landscape, Legislative Decree No 42 of 22 January 2004)
- European and Mediterranean Major Hazards Agreement EUR-OPA <http://www.coe.int/en/web/europarisks/home>
- European Strategy for climate change: EU Adaptation Strategy Package https://ec.europa.eu/clima/policies/adaptation/what_en#tab-0-1
- Federal Guidelines for Dam Safety Risk Management <https://www.ferc.gov/industries/hydropower/safety/guidelines/draft-guidelines.pdf>
- FEMA Unit V Risk Assessment/Risk Management https://www.fema.gov/pdf/plan/prevent/rms/155/e155_unit_v.pdf
- Gubbio Municipality Civil Protection Plan (2017): VOLUME GENERALE PIANO PROTEZIONE CIVILE available on <https://www.comune.gubbio.pg.it>
- HERACLES Grant Agreement Part B p. 29
- ICOMOS INTERNATIONAL CHARTER FOR THE CONSERVATION AND RESTORATION OF MONUMENTS AND SITES (1964, THE VENICE CHARTER)
- ICOMOS International Scientific Committee for Stone ISCS 2008 Illustrated glossary on stone deterioration patterns
- ICOMOS THE DECLARATION OF AMSTERDAM (1975, AMSTERDAM)
- International Charter http://www.icharter.org/articles/risk_equation.html
- Introduction to the island of Crete in Greece Interkriti http://www.interkriti.org/crete/introduction_to_crete.html
- ISO 31000:2900 http://www.iso.org/iso/catalogue_detail?csnumber=43170
- LA CARTA DI GUBBIO (1960) Dichiarazione finale approvata all'unanimità a conclusione del Convegno Nazionale per la Salvaguardia e il Risanamento dei Centri Storici (Gubbio 17-18-19 settembre 1960) (Final declaration by unanimity adopted at the conclusion of the National Convention for the Protection and Restoration of Historic Centres (Gubbio 17-18-19 September 1960).
- La Carta di Gubbio (1982) The Gubbio Document or the Gubbio Charter (1982)
- LA NUOVA (o SECONDA) CARTA DI GUBBIO (1990) Dichiarazione finale approvata all'unanimità a conclusione del Convegno Nazionale per la Salvaguardia e il Risanamento dei Centri Storici (Gubbio, 1990) (Final declaration by unanimity



- adopted at the conclusion of the National Convention for the Protection and Restoration of Historic Centres (Gubbio, 1990).
- Malczewski Jacek (2006) GIS-based multicriteria decision analysis: a survey of the literature, *International Journal of Geographical Information Science*, 20:7, 703-726.
- MIBACT Procedure per la gestione delle attività di messa in sicurezza e salvaguardia del patrimonio culturale in caso di emergenze derivanti da calamità naturali. (14A02464) (2013)
- MIBACT Aggiornamento della direttiva 12 dicembre 2013, relativa alle «Procedure per la gestione delle attività di messa in sicurezza e salvaguardia del patrimonio culturale in caso di emergenze derivanti da calamità naturali». (15A05594) (2015)
- MIBAC Decreto del ministro dei Beni e attività Culturali per il monitoraggio ed il coordinamento delle attività emergenziali (circolare 24/2012)
- MIBAC allegato 1, DECRETO UNITA' DI CRISI al Decreto del ministro dei Beni e attività Culturali per il monitoraggio ed il coordinamento delle attività emergenziali (circolare 24/2012)
- MIBAC Decreto Segretario Generale MIBAC n.7/25 maggio 2012 UNITÀ DI CRISI NAZIONALE PER LA GESTIONE DELLE EMERGENZE E DI UNITÀ DI CRISI REGIONALI
- Moses C., Robinson D., Barlow J., Methods for measuring rock surface weathering and erosion: A critical review, *Earth-Science Reviews* 135 (2014) 141
- National Adaptation Strategy to Climate Change, Ministry of the Environment (Strategia Nazionale di Adattamento ai Cambiamenti Climatici), Italy (2014)
- National Geographic <http://environment.nationalgeographic.com/environment/global-warming/gw-effects/>
- Organisation for Economic Co-operation and Development OECD Glossary of Statistical Terms <https://stats.oecd.org/glossary/index.htm>.
- Piano di Gestione del Rischio Alluvioni (PGRA) Regione Umbria (November 2015)
- Quora website: What is disaster management?: <https://www.quora.com/What-is-disaster-management-cycle>
- Regional Coordination Plan for Multirisk Prevention PIANO REGIONALE COORDINATO DI PREVENZIONE MULTIRISCHIO, REGIONE UMBRIA SERVIZIO PROTEZIONE CIVILE (March 2014)
- Saaty, T.L., 1980. "The Analytic Hierarchy Process." McGraw-Hill, New York.
- UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage (1972, Paris).
- L. G. Vasilescu, H. Khan, A. Khan, Disaster Management CYCLE-a theoretical approach, (2008), *Management & Marketing* 6(1), 43-50
- Winslade J., Monk G., Cotter A. A narrative approach to the practice of mediation. *Negotiation Journal*, 14(1), (1998), 21-41.
- Yuxian Du,^a Xi Lu,^{a,b} Xiaoyan Su,^{c,d} Yong Hue and Yong Denga: New Failure Mode and Effects Analysis: An Evidential Downscaling Method, *Qual. Reliab. Engng. Int.* (2016) 32, 737-746, Wiley