ARCH

ARCH State-of-the-Art Report 2

Disaster risk management, emergency protocols, and post-disaster response

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List of Abbreviations

Abbreviation	Meaning
CH	Cultural Heritage
CPM	Civil Protection Mechanism
DMP	Data Management Plan
DoA	Description of Action
DRM	Disaster risk management
DRR	Disaster risk reduction
EC	European Commission
EC	European Commission
EEA	European Environment Agency
EISAC	European Infrastructure Simulation and Analysis Centre
ERCC	Emergency Response Coordination Center
EU	European Union
FAIR	Findable, Accessible, Interoperable, Re-usable
FP7	Seventh framework programme
H2020	Horizon 2020
HW	Hardware
ICOMOS	International Council on Monuments and Sites
IES	Institute for Environment and Sustainability
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
LiDAR	Light Detection and Ranging
MIBACT	Italian Ministry of the Cultural Heritage and Activities and the Tourism
NAS	Network-Attached Storage
NFC	National Fire Corps
RUSN	Real-time Urban Seismic Network
SEED	Standard for the Exchange of Earthquake Data
SotA	State of the Art Report
SW	Software
UAV	Unmanned Aerial Vehicle

UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations International Strategy for Disaster Reduction
WP	Work Package

Executive Summary

Disaster risk reduction and climate change adaptation for historic areas need advanced methods and tools due to the increasing vulnerability of historic areas to hazards.

The present report focuses on strategies for disaster risk management and disaster risk reduction, with special emphases on climate change and natural hazards' effects on Heritage. In addition, examples of case studies that can represent good practices are also included and an overview of current debates and knowledge gaps which will aid the technical development work of the ARCH project.

The aim of this report is to support the development of ARCH WP4 (Hazard and Object Information management system), WP5 (Impact and Risk Assessment) and WP6 (Resilience options and Pathway) mainly.

Disaster risk management is the key topic covered in this report but with the focus on Heritage and considering the climate change, as this will impact on World Heritage conservation directly and indirectly. Therefore, there exists an overlap between disaster risk management and climate change, which we will address by integrating a climate change perspective into disaster risk reduction strategies and by including DRM related actions into climate change adaptation plans as a way to increase the climatic resilience of urban historic areas.

The present report describes briefly the three stages of the disaster risk management actions: before (pre-disaster), during (emergency response), and after (recovery) based on the time of disaster occurrence.

1. Introduction

While negative impacts of climate-related and other hazards on urban areas are widely discussed, their impacts on historic areas have not been studied extensively enough. Disaster risk reduction (DRR) and climate change adaptation (CCA) for historic areas, with their unique structure, composition, and set of regulations, call for advanced methods, and tools, either re-used from other domains or custom-developed, as well as the promotion of relevant public policies and participatory governance processes, including residents from local communities and the general public [1]. In addition, according to the United Nations Educational, Scientific, and Cultural Organisation (UNESCO) DRR does not register as a priority area for management of World Heritage property, despite the increasing vulnerability of historic areas to hazards. Furthermore, historic areas are deeply embedded in larger urban and rural environments, providing important cultural, social, environmental, and economic functions, while relying on infrastructure services from these environments to keep functioning [2]. Therefore, there is a need to increase knowledge of climate change impacts and disaster risk management (DRM) on historic areas.

This State-of-the-Art (SotA) report focuses on strategies on DRM and DRR, with special emphases on climate change and natural hazards effects on Heritage. Apart from presenting the framework, the methods and strategies followed for pre-disaster and post-disaster are also presented, together with examples of case studies that can represent good practices (included in Annexes and referenced in the report). In addition, an overview of current debates and knowledge gaps are also presented in the report which will help the development of the ARCH project.

1.1. Background information and aim of this report

The present report aims to provide the ARCH consortium with details on relevant developments related of DRM and climate adaptation in heritage. It has the objective of supporting the technical development of ARCH WP4 (Hazard and Object Information management system), WP5 (Impact and Risk Assessment) and WP6 (Resilience options and Pathway) mainly. In addition, the aim of the report is to serve as a basis and ensure a clear and consistent application of concepts and terms related to DRM and climate adaptation in heritage.

1.2. Relation to other SotA reports and deliverables

This report is close to the other SotA 1 “Historic areas, conservation practices, and relevant regulations / policies” which refers to more DRR measures than those considered in this report and in addition it includes the regulation and policies; to SotA 3 “Building back better”, which goes in deep on post-disaster measures and highlighting the need of resilience; and to SotA 4 “Decision support frameworks and technologies” which inspires the future works on decision support systems.

1.3. Structure of this report

This document includes a section 2 with definitions of the key concepts and specialist terms. Section 3 covers the key topics and issues related to DRM and climate adaptation in Heritage which is based on the literature review. Building on the findings of the state-of-the-art review, the section 4 identifies the most important issues for consideration within the ARCH project. Section 5 includes the main conclusions of the report.

In addition, the annex of this report contains examples of case studies that can represent good practices.

2. Definitions

This section provides definitions of the key concepts and specialist terms covered in the report, focusing only on the most significant ones. The most appropriate definitions related to this SotA for use within the ARCH project are proposed in the following table.

	Term	Definition	Source
1	**Adaptation**	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects	[3]
2	**Build back better**	The use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies and the environment.	[4]
3	**Emergency preparedness**	The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters.	[4]
4	**Emergency response**	Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.	[4]
5	**Mitigation**	The lessening or minimizing of the adverse impacts of a hazardous event.	[4]
6	**Recovery**	The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and “build back better”, to avoid or reduce future disaster risk.	[4]
7	**Rehabilitation**	The restoration of basic services and facilities for the functioning of a community or a society affected by a disaster.	[4]

Table 1: Definitions of the key concepts.

3. Key topics and issues

Based on a literature review, the state of the art on strategies and methods used in DRM and climate adaptation in Heritage are presented in this section. The key themes emerging from the literature on this topic, an overview of important debates and an identification of gaps in the knowledge base is presented in the following lines.

Literature review methodology

Principally, the literature review focused on issues linked to the following themes:

- Policies and Strategies on DRM and DRR
- Climate change and its effect on World Heritage
- Intersection between DRM and climate change
- Pre-disaster strategies
- Post-disaster strategies

A keyword search was performed in the search engines Google Scholar and Science Direct tools using the English key topic terms. Science Direct was selected as it is a powerful, current, comprehensive and widely used search engine available for analysis of interdisciplinary, peer-reviewed literature. Google Scholar was selected as it includes most peer-reviewed online journals of Europe and America's largest scholarly publishers, plus scholarly books and other non-peer reviewed journals and documents.

The final review consisted of academic and scientific papers, reports and books and represented a total of 38 documents that assess DRM and climate adaptation in Heritage.

3.1. Disaster risk management

According to United Nations "Disaster Risk Management (DRM) is the application of disaster risk reduction policies and strategies, to prevent new disaster risks, reduce existing disaster risks, and manage residual risks, contributing to the strengthening of resilience and reduction of losses". Disaster risk management actions can be grouped into three stages (before, during and after) based on the time of disaster occurrence as shown in Figure 1.

The main activities before a disaster include risk assessment, conservation or prevention, and mitigation methods and warning systems for specific hazards. Emergency response actions are designed to manage, control, or mitigate the immediate effects of an incident. These are normally reflected in an Emergency Action Plan. Actions initiated after the disaster cover damage assessment, treatment of damaged components through interventions to repair, restore and retrofit and recovery or rehabilitation activities. This stage can also serve as an effectiveness assessment of the previous stages to identified potential future improvements within the DRM steps. However, DRM cycle also needs the inputs from knowledge building of the social, environmental and economical context and stakeholder engagement to build an adequate DRM framework.

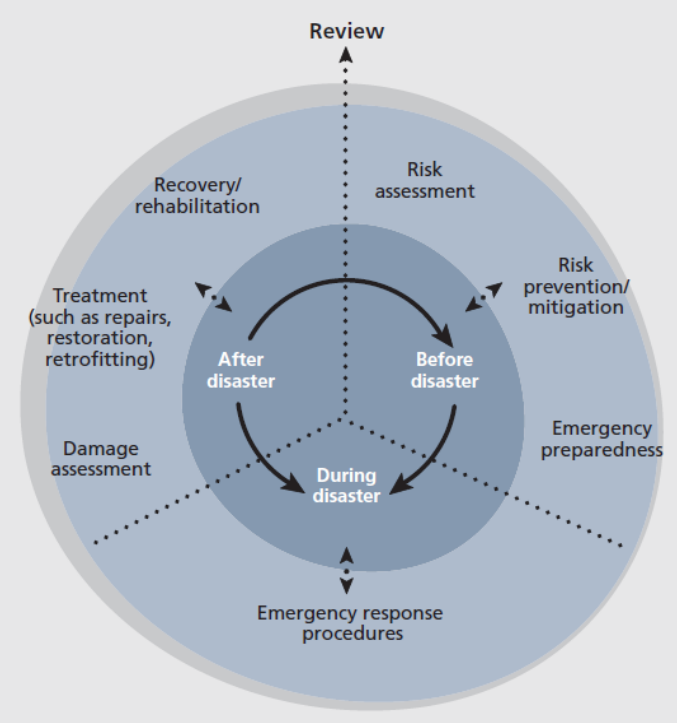

Figure 1: Disaster Risk Management cycle scheme

In the literature examples of good practices in DRM can be found. Albania elaborated a risk assessment of natural hazards and guidelines for the risk reduction of Cultural Heritage. Thailand promoted several risk prevention/mitigation projects at regional level to prevent flood risks. Italy conducted a training of stakeholders through simulation exercises to elaborate, test and improve the operational, procedural and methodological aspects of territorial and sector planning to reduce volcanoes activities consequences in cultural heritage. In the Danube, a network of existing and new protected areas are being developed to help the restoration and protection of the floodplain. More information regarding these examples is included in Annexes in the report.

3.1.1. Policies and Strategies on DRM and DRR

In 1994, a UN World Conference on Disaster Risk Reduction (DRR) was convened to discuss how to tackle the growing frequency and severity of natural disasters. The focus was on developing effective measures around preparation, response and mitigation of disasters.

In 2000, the United Nations International Strategy for Disaster Reduction (UNISDR) was launched and five years later the **Hyogo Framework for Action** [5], the main UN-wide policy on the subject of Disaster Reduction existing at the time of its conception (2005-2015), was presented. The Strategy for Risk Reduction at World Heritage Properties was presented and approved by the World Heritage Committee in 2007. Its priority actions, listed below, were structured around the five main objectives defined by the Hyogo Framework for Action. Hyogo´s five priority actions are summarized hereafter.

- Ensure that disaster risk reduction (DRR) is a national and a local priority with a strong institutional basis for implementation.
- Identify, assess and monitor disaster risks and enhance early warning.

- Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Reduce the underlying risk factors.
- Strengthen disaster preparedness for effective response at all levels.

Later on, in 2015, the **Sendai Framework** [6] for action 2015-2030 was adopted which is based on 4 priorities:

- **Understanding disaster risk:** "Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment."
- **Strengthening disaster risk governance to manage disaster risk: "**Disaster risk governance at the national, regional and global levels is vital to the management of disaster risk reduction in all sectors and ensuring the coherence of national and local frameworks of laws, regulations and public policies that, by defining roles and responsibilities, guide, encourage and incentivize the public and private sectors to take action and address disaster risk."
- **Investing in disaster risk reduction for resilience: "**Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental to save lives, prevent and reduce losses and ensure effective recovery and rehabilitation."
- **Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and construction: "**Experience indicates that disaster preparedness needs to be strengthened for more effective response and ensure capacities are in place for effective recovery. Disasters have also demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of the disaster, is an opportunity to «Build Back Better» through integrating disaster risk reduction measures. Women and persons with disabilities should publicly lead and promote gender-equitable and universally accessible approaches during the response and reconstruction phases."

At EU level, a framework for EU cooperation on disaster prevention across all types of natural and man-made hazards was agreed on in 2009. Risk assessment together with risk analysis are the pillars of this prevention framework which are fundamental for a successful disaster management strategy. Two years later the EU undertook a work to identify the risks the EU may face in the future based on national risk assessments [7]. This overview focuses primarily on risks that may have cross-border impacts and/or those larger scale impacts that may be experienced by more than one Member State.

3.1.2. Climate change and its effect on World Heritage

In the last century the increase of greenhouse gases in the atmosphere is leading to a change in our climate and, thus, in our environment. The primary consequence of this climate change

is the increase of the global average atmospheric surface and sea temperature, which implies an impact on the current climatic equilibrium of the planet. This will result in modifications of e.g. precipitation patterns, droughts, sea-level rise, ocean acidification, storminess etc. Such changes will impact on World Heritage conservation directly [8] and indirectly [9]. While cultural heritage sites may be more threatened by occasional disaster events, natural heritage sites will be jeopardised by the gradual climate change and the extreme natural events.

World Natural Heritage sites such as tropical coral reefs are threatened by an increased ocean temperature and acidification, which may lead to their massive extinction. On the other hand, the increase of atmospheric temperature poses a threat to glaciers worldwide (in both mountainous and polar regions), which are melting. Another example of foreseen impact is the affection of terrestrial biodiversity from diverse factors as migration of pets and invasive species, changes in the timing of biological cycles or the frequency and intensity of wildfires.

World Heritage cultural sites are also exposed to this threat. Rising sea levels threaten many coastal sites and thus, costal cultural heritage sites. Furthermore, the conditions for conservation of archaeological monuments evidence increase degradation in the context of soil properties variations, desertification, flooding etc. But aside from these physical threats, climate change will likely impact on social and cultural aspects. Communities may change their ability to earn a living due to socio-economic transformations of the areas as well as the way they live and socialize in buildings, sites and landscapes, which can ultimately result in the heritage abandonment due to heritage loss or migration.

Conservation of heritage sites, which can be seen as adaptation measures to prevent the impacts of climate change, is likewise a fundamental action from DRR view (risk prevention/mitigation). However, a perspective to climate change should be included in the management plans of heritage sites to ensure their sustainable conservation. In this context it is important the vulnerability assessments to determine the climate change impacts on cultural and natural heritage. This will allow a better understanding on the risks link to each site and consequently better decision-making and planning. Another relevant value in conservation of heritage is the knowledge and effective lessons learnt (e.g. improving anti-flooding systems like in Venice) exchange, that will improve climatic resilience.

3.1.3. Intersection between DRM and climate change

Natural disasters have been part of human life since ancient history, however the relative recent evidence of climate change and their probable impacts have naturally interwoven disaster risk reduction and adaptation to climate change communities and work (Figure 2). This has led to the integration of climate change perspective into DRR strategies. At the same time DRM related actions are often considered in climate change adaptation plans as a way to increase climate resilience.

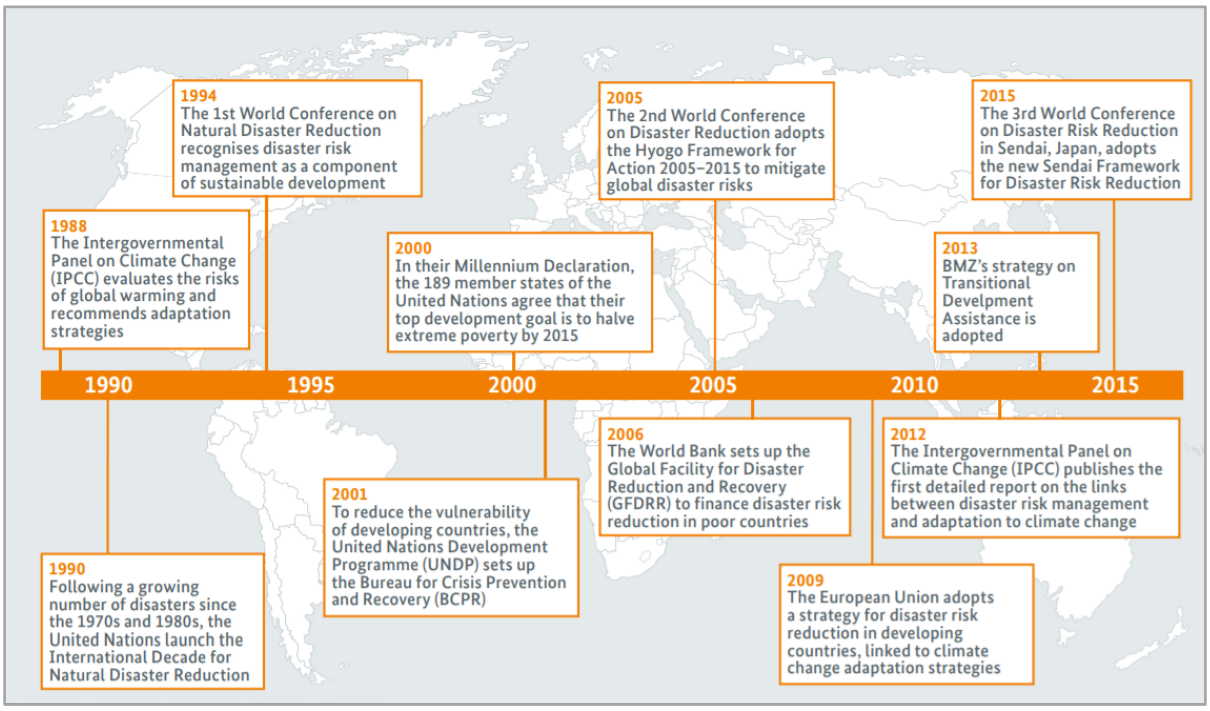

Figure 2. Milestones of investigations and policies in the domains of CCA and DRM. Source:[10]

The technical disciplines of climate change adaptation and disaster risk management overlap and complement each other as seen in Figure 3. The climate change adaptation cycle is strongly aligned with pre-disaster DRM steps. Furthermore, while climate change is linked to slow-onset and sudden weather extreme impacts where adaptation measures are put in place to diminish impacts associated to natural hazards, DRM addresses the risks associated with sudden weather and geophysical extreme events and their emergency response and posterior damage recovery.

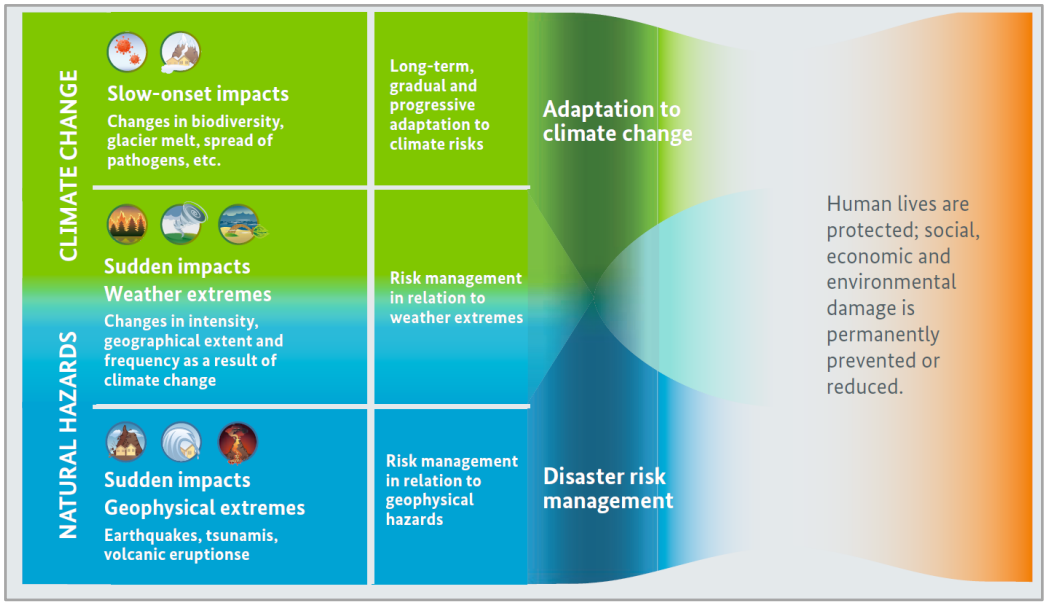

Figure 3. Intersection between DRM and adaptation to climate change. Source: [10]

3.2. Pre-disaster phase: mitigation and preparedness for heritage

The pre-disaster phase normally encompasses three steps as seen in Figure 4. However, despite having a common and comparable methodology the preparedness phase (also the DRM) should be site-specific. The pre-disaster phase focuses on actions to reduce hazard related risks in heritage, such as the use of early warning systems and all phases planning which includes emergency-response plans [11].

The aim of the pre-disaster phase is to:

(1) Reduce risk at source. The efforts are centred to reduce exposure and vulnerability to specific hazard or if possible, to eliminate the hazard. This may be achieved by improving the ambient conditions within which the cultural heritage sites.
(2) Reinforce the ability of property to resist or contain the consequences of a disaster. This include measures to strengthen and reinforce the structure or properties of heritage.
(3) Provide adequate warning. Technological systems like sensors to record, predict or announce a disaster in a timely manner are the basis of effective disaster warning.
(4) Develop an emergency plan. A participatory approach for the definition of the emergency plan is desired. Apart from an evaluation and a heritage salvage plan, efforts here involve awareness courses, on-site disaster simulations and instrumental and material provision.

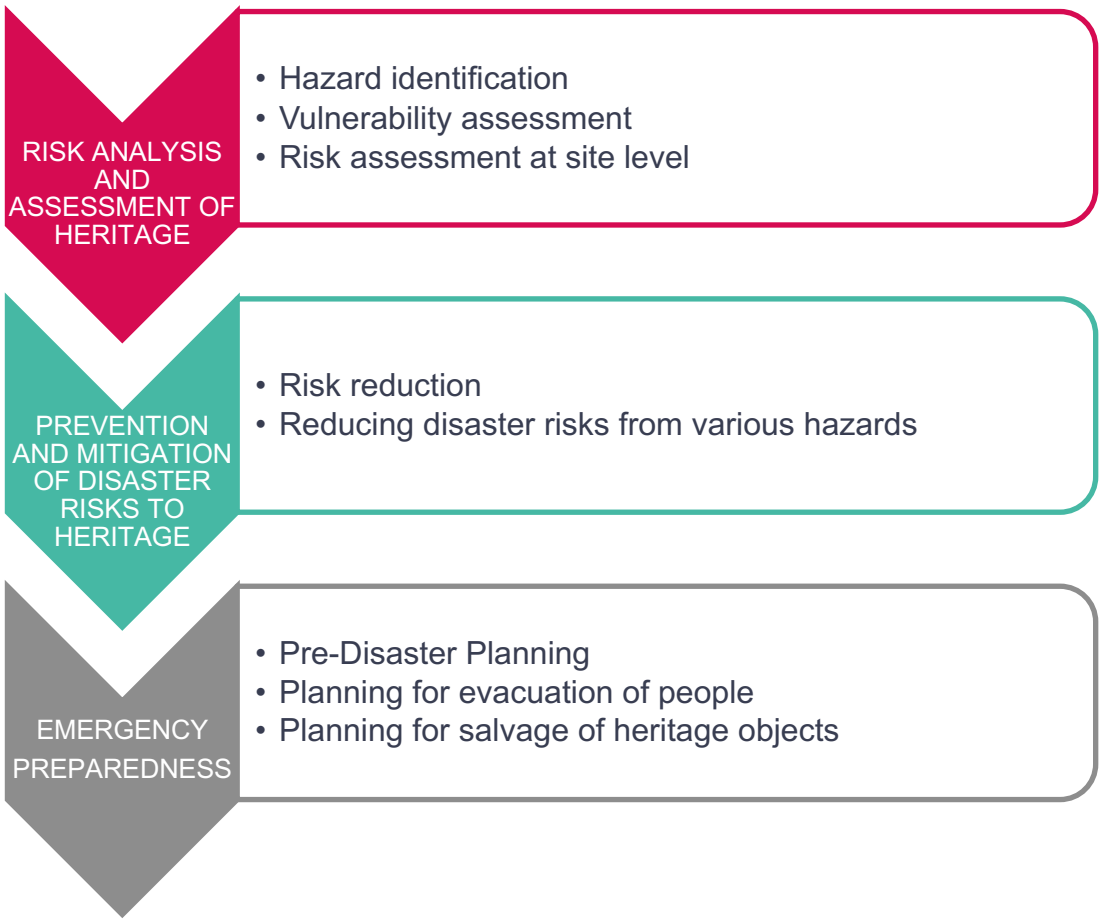

Figure 4. Pre-disaster phases´ steps

3.2.1. Risk analysis and assessment

This step requires the acquisition of information and its analysis to determine the level of risk, which is often done by a risk matrix, by considering the severity of the consequences and the probability of occurrence. The risk analysis may be undertaken at different spatial scales such as the urban level, the heritage site level or an individual heritage building/unit.

Risk assessment typically encompass two steps [12], [13]:

- Identification, analysis and evaluation of disaster risks through hazard identification and data collection linked to vulnerability, exposure and the hazard´s potential negative impacts
- Developing alternative disaster scenarios considering primary and/or secondary hazards for the heritage site. Then a ranking of risks is sought through a risk matrix. This allows the prioritisation of options in the risk prevention step.

The Intergovernmental Panel on Climate Change's (IPCC) AR5 risk approach focuses on the interaction between hazard, exposure and vulnerability. The risk calculation is done by following a formula where the components are the probability of the hazard, exposure and vulnerability (the combination of exposure and vulnerability represents the consequences or impacts if the events occurs)[14]:

$$\text{Risk (R)} = f\,(\text{Probability of a Hazard (p)} \times \text{Exposure (E)} \times \text{Vulnerability (V)})$$

In the literature we can find different methods for risk assessments. Some of them are quantitative approaches (probabilistic, deterministic risk assessment, indicator-based approach) and others qualitative (risk matrix) [15], [16]. Although there are many methods to cover the risk assessment, expert judgement is necessary to validate the scientific results but also to establish acceptable thresholds and communicate uncertainty or confidence levels [17].

Last, prioritising risk mitigation/prevention options may be performed considering different criteria or prioritisation tools:

- Cost / benefit analysis considering both implementation and maintenance stages. This is important as human and financial resources are often scarce.
- Multicriteria analysis taking into account those monetary and non-monetary factors that may be relevant for the site-specific context.
- Effect of a proposed strategy on risks from each and every hazard or on risks to each heritage component.

3.2.2. Prevention and Mitigation

This step of DRM consists of addressing the identified risks and minimise them through a series of strategic actions. This generally includes one or more of the following elements:

- Prevention of hazards: Eliminating the source of risk, e.g. preventing graffities by ensuring security and monitoring of the site. This in many instances is not feasible for climate hazards.

- Mitigation of impact of hazards: In cases of unavoidable hazards, for instance, meteorological hazards that include heavy rainfall leading to floods or landslides, tornadoes etc., proactive measures to reduce exposure may be undertaken to reduce the impact of the risk.
- Reducing vulnerability of cultural heritage: Cultural heritage can be supplemented with robust planning and interventions to reduce its vulnerability to certain kinds of hazards.
- Capacity building: At each stage of the disaster risk management process by developing the ability and knowledge of stakeholders and organization to effectively take actions and decision on DRM [17].

Planning is key to build a robust mitigation strategy, for urban and regional planning measures in and around the cultural heritage site, to consider technical measures for protecting sites from the impact of specific hazard, to integrate DRM with other existing planning frameworks etc.

Furthermore, conservation and maintenance programmes for historic properties should include the cultural heritage-at-risk perspective. Similarly, conservation principles should be integrated when appropriate in all phases of disaster planning, response and recovery.

Other approaches [18] of conservation preparedness organize mitigation or control of risks in five type of actions depending on the most suitable:

1. Avoid the cause of the risk. This is the desirable action as it is the most effective one (if possible)
2. Block the agent of deterioration. This encompasses protective barriers or measures between the heritage and the hazard.
3. Detect the agent or hazard that leads to deterioration and their effects on the heritage assets.
4. Respond to the damages from the deterioration agents (or hazard). This action is linked to the detection of the agent of deterioration. This action focuses in the planning and preparation to allow a quick and effective response. This action would correspond to the preparedness step of the pre-disaster phase.
5. Recover from the damages and loses caused to the heritage assets by a specific hazard. This action would lie within post-disaster stage when the other mitigation actions have failed.

3.2.3. Emergency preparedness

This step deals with the planning process needed in emergency situations and it consists of planning, organizing, training, equipping, exercising, evaluating and taking corrective actions. It results in protocols and the procedures which need to be in place in the event of a disaster. These protocols should include the evacuation routes and procedures which may include maps of the property indicating exits and emergency equipment, establishment of alarm systems and emergency equipment, assembling and training an emergency team and proposing the salvage of heritage objects. Protocols should also cover post-disaster planning such as heritage damage inspection and protection actions and strategies. It should be highlighted that preparedness requirements associated to heritage buildings should have least impact on

heritage value as possible. Coordination between heritage staff and external agencies and population awareness rising activities are key for a good performance.

Pre-Disaster Planning

After the risk assessment and selecting the most appropriate mitigation measures, an implementation plan should take place to achieve conservation objectives and to define emergency and post disaster rehabilitation protocols. This covers all levels of planning. Furthermore, in emergency preparedness, communication, collaboration and engagement among authorities, departments, professionals and community is essential for team building, awareness raising and, thus, a successful disaster risks planning. An emergency team is required to coordinate action with local police, health authorities and hospitals, firefighting force etc. Training of emergency teams is fundamental to test coordination and learn to prioritise activities during and immediately after a disaster. This will allow to adjust actions and prepare the teams for a prompt effective response.

Planning for evacuation of people

The evacuation plan requires all sort of information and actions to evacuate people safely in the case of an emergency. The plan should include: the evacuation protocol, the definition of evacuation routes, safe refuge places, clear roles and responsibilities by all authorities involved in the evacuation, the implementation of measures and provision of supplies and emergency equipment.

Planning for salvage of heritage objects

Likewise, there is a need for a plan to save cultural heritage collections if necessary and possible. Apart from a basic protocol with recovery operations where the same principles applied as for human beings (team definition, material supply etc.) heritage requires few extra actions. For small heritage elements inventories are essential to identify what can be recovered and where to find those elements promptly. The training and developing of skills to handle heritage and damage materials are also key to avoid further harm.

3.3. During and post disaster phase: emergency procedures and recovery process

When an emergency or a disaster affect a city or a region, efforts are spent:

- **during the emergency**, which is usually considered to last for the first 72 hours after the disaster event (but it may be even longer), **to implement various response procedures for saving people as well as heritage**, also following the training practised beforehand (Figure 5);

- **in the post-disaster phase, to restore basic services and lifelines**, including the road network and other essential facilities, to establish dwellings for the evacuated people **and afterwards to implement the recovery process**, including damage assessment, treatment of damaged components of the heritage property through interventions such as repairs, restoration and retrofitting and long-term recovery, rehabilitation and reconstruction (Figure 5).

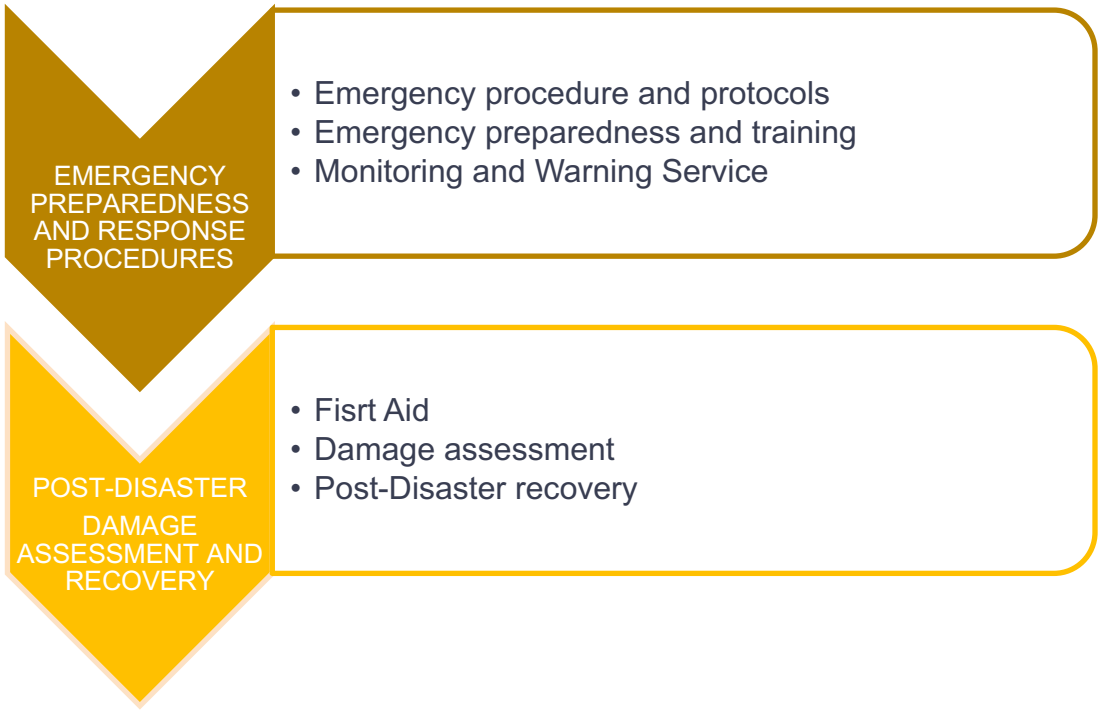

Figure 5: During and post-disaster phases´ steps

3.3.1. Emergency Procedures and Protocols

The emergency response planning with procedures and protocols can be defined as the tool to prepare systematically for possible contingencies, including major incidents and disasters.

The emergency plans articulate and integrate the procedures, which specify what must be done in certain circumstances, and protocols, which assign responsibilities to be followed from involved actors in complex operative activities, in order to understand their own roles and those of the other participants. By modifying an effective comparison with an orchestra, proposed by Alexander [19], that seeks harmony: the individual instrumentalists are the protocols, the scores are the procedures and the director is the plan. Therefore, a response plan should clearly delineate roles and responsibilities of disaster response organizations, explaining coordination both horizontally with each other and vertically with local, national authorities. Often national response plans include also how to request international resources, while local plans include evacuation and shelter plans. Typically, response plans consist of operational and logistical components, including procedures for damage and needs assessment in the aftermath of a disaster.

In summary, emergency response involves a mixture of plans, procedures, protocols and improvisation. In fact, despite preparedness, a share of improvisation cannot be avoided, it due to a degree of uniqueness presents in each new disaster [19]. Nevertheless, procedures and protocols can constrain improvisation to a necessary minimum. Emergencies are always learning fields, as such they a wealth of knowledge baggage for updating protocols able to reduce mistakes, inefficiencies and improvisations.

Although there are no consistently reliable way of defining the size of an event (e.g., major events, disasters, and catastrophes), its definition can involve the activation of different

emergency protocols. Generally, the civil protection system is based on the principle of subsidiarity, according to which social and political issues should be dealt with at the most immediate (or local) level that is consistent with their resolution. Therefore, decisions should be taken at the lowest appropriate level, with co-ordination at the highest necessary level. Local agencies are the building blocks of the response to and recovery from an emergency of any scale.

The national civil protection systems are underpinned by European solidarity. In fact, although the organization and the procedures are different in the European countries[1], the civil protection authorities stand ready and prepared to help each other when national resources for disaster response are overwhelmed or need to be reinforced. Whenever the scale of an emergency overwhelms the response capabilities of a single country, the EU Civil Protection Mechanism (CPM) enables coordinated assistance from its participating states (according to the Decision of the European Parliament and of the Council No 1313/2013/EU and the respective Implementing Decision[2]).

An additional complexity in the emergency response is due to the need to integrate several dimensions: 1) hierarchical that is referred to the tiers of government; 2) geographical that indicates spatial jurisdictions, considering also the mutual assistance; 3) organizational that refer to the different agencies participating in emergencies activities; 4) functional that is correlated to the different field of the society involved (cf. Figure 6). The emergency procedures and protocols contribute to govern the system of response to civil contingencies, in which an optimum balance is searched for both integrating these forces and allowing them a degree of autonomy and freedom of action [19].

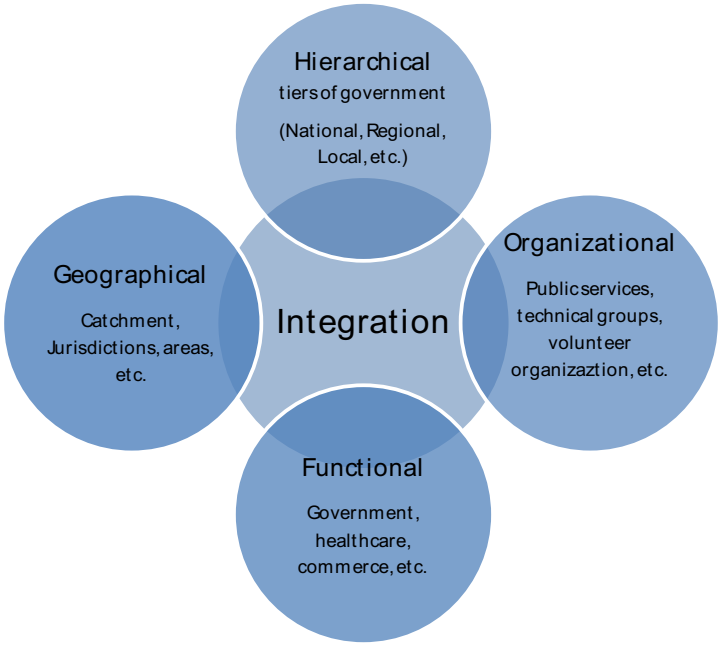

Figure 6: Dimensions to be integrated for the emergency response (modified after [19]).

[1] https://ec.europa.eu/echo/what/disaster-management_en
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02013D1313-20190321&from=EN

For example, procedures could aim to identify potential evacuation routes and refuge spaces, design emergency signage and maps, install equipment for monitoring an effective and timely response, also increasing the number of sensors and instruments already deployed on the area affected by the disaster event. Moreover, specific procedure and protocols should organize various kinds of emergency supplies and equipment, beside ensure the evacuation of people.

With reference to the cultural heritage, given the particularity and, often, fragility of the heritage objects, the procedures for saving them need:

- to collect pre-disaster documentation and preparing inventories for inspection;
- to identify the sources of risk, also those induced (e.g., the occurrence of fires following an earthquake);
- to understand the levels of control required to mitigate risks;
- to develop skills to handle damaged materials;
- to plan response and recovery operations for cultural heritage collections

In this context, in the last years, the Italian MIBACT have released and updated specific procedures to manage activities and to secure and safeguard cultural heritage in case of emergency due to a natural disaster (DIRECTIVE April 23rd, 2015). In particular, datasheets are provided for the damage assessment of the main heritage objects and the administrative and technical competences and responsibilities to be recall during an emergency are identified under the management of the Italian Department of Civil Protection operative unit.

3.3.2. Emergency preparedness and training

Emergency response protocols and procedures aim of guiding response teams to cope the crisis. A big assumption behind these protocols is that people could follow the right behaviours and react correctly under stress [20]. However, this assumption is not always valid as real histories often have demonstrated [21]. Some author, even, sustain that “the key to effective crisis management lies not so much with the writing of detailed manuals (that have a low likelihood of being used, and an even lower likelihood of being useful)”[22]. Also, humans would make mistakes during an emergency phase, which could produce more severe consequences via chain reactions. Common mistakes generally include inadequate situation assessment, erroneous judgements, blind allegiance to the procedures, adverse reaction under stress, unclear roles resulting in tasks falling through the cracks, and miscommunication [20], [21], [23]. A solution of this problem is represented by regular training, that allows a practical simulation to equip each member of the response teams with the capabilities, flexibility, and confidence to handle unexpected and sudden events [22]. Three main conventional methodologies are available for emergencies: classroom-based training, Tactical Decision Games (TDGs), and emergency drills in the real system [20], [24], [25].

In all European countries, the key personnel who ensure the fulfilling tasks of civil protection and crisis management are regularly trained and prepared accordingly to national plans and legislative. The organization of the activities and the involved bodies differ at national level (cf. https://ec.europa.eu/echo/what/disaster-management_en). Nevertheless, to cope cross-

border emergencies and to facilitate the synergy between national civil protections, a training programme has been set-up by the EU for civil protection and emergency management personnel to enhance prevention, preparedness and disaster response by ensuring compatibility and complementarity between the intervention teams and other intervention support as well as by improving the competence of the experts involved. The details can be obtained on the webpage https://ec.europa.eu/echo/index_en.

Recently, a training activity named "Exe Flegrei 2019"[3] has been deployed in Italy simulating the unrest of Phlegrean Fields volcano complex. The exercise project was conceived with a clear objective to update volcanic risk planning for the Phlegrean Fields area. The project which started some years ago, eventually led to the definition of the scientific scenario of reference and the consequent identification of interested areas, and involving Prefecture of Naples, the Campania Region and the centers of competence of the Italian DCP. Within the exercise activities, a special focus has been dedicated safeguard and management of the cultural heritage with a dedicated task. The scenario envisaged a simulation of activities for the securing of movable cultural assets with evaluation of site conditions and movement from the container to the storage. The exercise was an opportunity to elaborate, test and improve the operational, procedural and methodological aspects of territorial and sector planning. Moreover, the activities on the cultural heritage gave opportunity to MiBACT (Ministry for the cultural heritage and activities and for the tourism) to test:

- the emergency procedures for activating national and regional crisis units and integrating them with the civil protection system coordination centers;
- the employment of specialized figures for the formation of teams (Italian National Fire Corps and Carabinieri for the Protection of the Cultural Heritage and Anti-counterfeiting) to be used in the protection of cultural heritage
- the interoperability between specialized volunteers and MIBACT officials in competition with cultural heritage managers (movable and immovable assets).

3.3.3. Monitoring and Warning Service and Emergency Operation Centre

Hazards vary considerably in their predictability and the amount of lead time, if any, for preparations to take place. Nevertheless, warning and associated response are two vital elements of most emergency plans. The short-time warning must be distinguished from the forecast of hazards. For instance, earthquakes are predictable in terms of characteristic parameters with a probability of occurrence associated to the return time, but the impending shocks are not predictable in a short-time window. Nevertheless, a seismic monitoring system can provide information about potential effects and damages, immediately after that an earthquake occurred. Instead, the data sharing and functional linkages between the hydro-meteorological services and emergency response units can provide useful information about water bombs or tornados, based also on digital modeling, with lead times of some hours before the catastrophic event makes landfall. Hazard early warning systems issue warnings to help

[3] http://www.protezionecivile.gov.it/media-communication/dossier/detail/-/asset_publisher/default/content/exe-flegrei-2019

communities safely evacuate from hazardous areas. Warnings need to involve three essential components: scientific and technical, administrative and social [19] (cf. Figure 7).

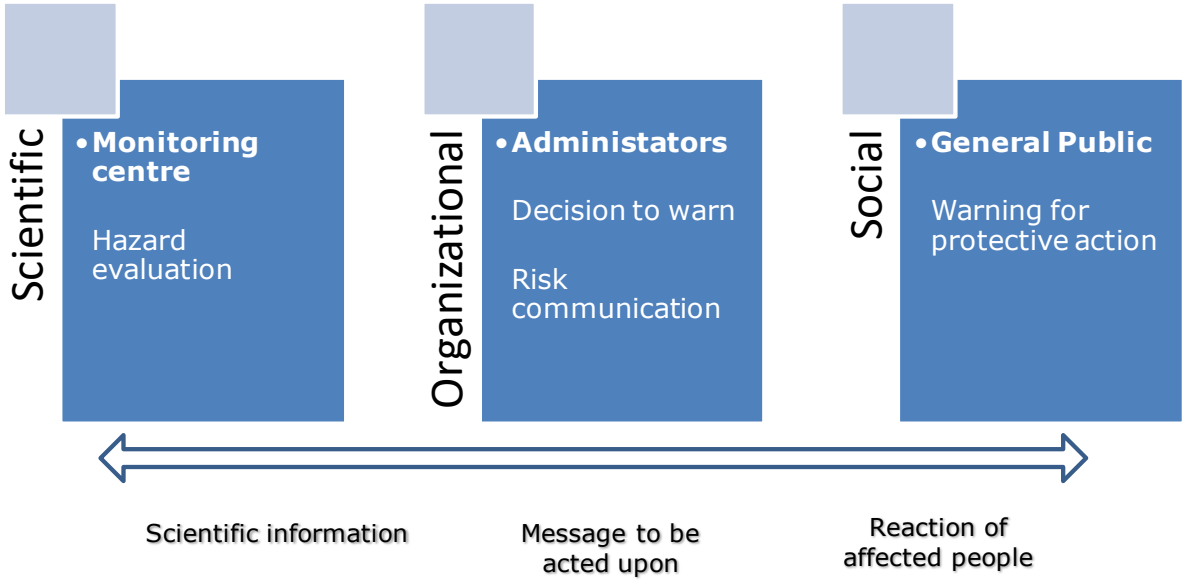

Figure 7: Warning process from technical-scientific monitoring to reaction of affected people (modified after [19])

Given the importance of monitoring and early warning system in crisis prevention, advances researches are oriented to introduce data-driven Artificial Intelligence (AI) methods, such as Deep Learning, which demonstrate promising skills to learn implicitly from data alone, but require significant computing capacities and a large amount of annotated, high-quality training data (e.g., [26]).

A key element of a robust emergency response system is the establishment of an operations centre, that coordinates the emergency services. Generally, the centre is responsible for activating staff to respond to emergencies; requesting resources, such as equipment and teams; coordinating response and recovery activities; tracking resources; and collecting information from the field like damage and needs assessments [27].

For instance, through the CPM, the EC plays a key role in coordinating the response to disasters in Europe and beyond and contributes to at least 75% of the transport and/or operational costs of deployments. In fact, after a request for assistance, the Emergency Response Coordination Center (ERCC) mobilises assistance or expertise. The ERCC monitors events around the globe 24/7 and can ensure rapid deployment of emergency support through a direct link with national civil protection authorities. The ERCC is the heart of the EU Civil Protection Mechanism and coordinates the delivery of assistance to disaster-stricken countries, such as relief items, expertise, civil protection teams and specialised equipment. The ERCC manages a reserve of pre-committed assistance from EU Member States and Participating States that can be immediately deployed. These countries may commit resources on standby in a pool, ready to be deployed as part of a faster and more coherent European response when the need arises.

The centre also provides emergency communications and monitoring tools through the Common Emergency Communication and Information System, a web-based alert and notification

application enabling real time exchange of information. Cooperation across the EC has facilitated the development of disaster forecasting and disaster management tools. The Institute for Environment and Sustainability of the EC has supported the development of

- the European Flood Alert System alerts the ERCC on the most severe flood events
- the European Forest Fire Information System provides daily meteorological fire danger maps and forecasts up to six days before, including maps of burnt areas and damage assessment
- The Global Disaster Alerts and Coordination System, developed by the Commission's Joint Research Centre and used jointly by the EU and UN, is a fully automatic 24/7 alert system which gathers data about natural events (earthquakes, tsunamis, tropical storms, floods and volcanoes).
- The Meteoalarm is an online alert platform established by the European meteorological services, which issues European weather warnings.
- An agreement with the European Mediterranean Seismological Centre has allowed earthquake detection in the Mediterranean area to be considerably quicker and accurate, by adding sensors in Tunisia.
- The EC also cooperates with the Intergovernmental Oceanographic Commission (IOC-UNESCO) on the establishment of a tsunami warning system for the North Atlantic and Mediterranean region.

3.3.4. First aid and Damage assessment

The immediate and interdependent actions taken to stabilise and reduce risks to endangered cultural heritage during and after an emergency are collectively defined as cultural heritage first aid.

Once the priority operations for saving lives and ensuring security are completed, cultural heritage first aid can be activated. In practice, the right time for initiating first aid varies and depends on the different factors [28]:

- the nature and scale of emergency;
- the access to affected areas;
- the scale of damage caused to cultural heritage and/or its significance for stakeholders;
- the significant cultural heritage (e.g., a World Heritage site may require specific skills for inspection).
- Local capacity and preparedness.

The assessment of damage is a key point towards post-disaster recovery of the cultural heritage; in fact, the analysing the degree of damage of the heritage object as a consequence of the disaster, as well as analysing new risks which may have been provoked by the disaster, can useful to make secure the asset in the immediacy and, afterwards, to rehabilitate it. The complete process involved in documenting, assessing and communicating post disaster damage to heritage needs to be explained to the operators and stakeholders. In addition, guidelines for carrying out preliminary and detailed assessment of damage to the assets are required in reporting phase; in fact, often it is not possible to undertake surveys and documentation immediately after the disaster because of difficulty in access, safety problems

and lack of resources. Nevertheless, compliance with timelines in the implementing damage assessment is essential to implement effective emergency protection measures and to start the recovery process. As example, the emergency protection measures undertaken immediately after the severe seismic events in Italy (from the 1976 Friuli earthquake to the 2016-2017 seismic sequence in Central Italy) managed to save buildings that might otherwise have been demolished and replaced, and permitted them to withstand the aftershocks [29].

Therefore, to guarantee homogeneity and the completeness of information, specific protocols should support the technical operators from the beginning of the observations up until detailed documentation and analysis of physical condition of affected sites or object. Compiling and recording of data and analysis correctly is important, not only for carrying out long term repairs and restoration, but also serves as a useful resource for the site managers to review and update the disaster risk management plan.

3.3.5. Recovery and Rehabilitation

Cultural heritage first aid is only successful if followed by conservation efforts to restore function and access. In practice, a delicate balance must be guaranteed between safety considerations and maintaining values, authenticity and integrity of cultural heritage. Repairs and conservation of heritage plays a key role in the disaster recovery, aiming anyway to minimize intervention and preventing demolition of heritage structures as far as possible.

Thus, once you have implemented first aid for the damaged cultural heritage, documented the entire process and set up a monitoring routine, the next step is to prepare a consensus-driven action plan for recovery and rehabilitation, which involves: detailed condition assessments; conservation treatments for tangible heritage; risk mitigation; restoration of livelihoods and services; improved use of cultural heritage following the principles of sustainable development, and ‘build back better' [28].

There are evidences which suggest that cultural heritage often suffers not just from disaster but also from inadequate and uncoordinated post-disaster recovery actions [30]. For example, the activities to quickly remove debris from damaged structures can worsen the damage of the assets inside them, or inadequate reconstruction efforts after an earthquake without right consideration of seismic protection techniques make structures again exposed to future events [31]. Therefore, the stakeholders need to be better prepared if they are to effectively respond to disaster impacts on heritage assets and support sensitive recovery, especially when local communities and livelihoods are closely connected to heritage sites. In fact, the recovery process can be strongly facilitated by collaboration with relevant authorities and stakeholders at different levels, in order to preserve culture and heritage, enhance safety and sustainability, and exploit cultural heritage as catalyst for social and economic recovery. For example, the National Committee of ICOMOS played a significant role during post-tsunami recovery of the cultural sites in Sri Lanka and successfully advocated the importance of including cultural heritage values in post-disaster recovery plans [32].

The key aspects influencing the recovery process are:

- long-term measures to ensure that the rehabilitation process is quickly started and the future disaster risks are reduced as much as possible;
- raising resources, both financial and human, through the larger institutional network at local, regional, national and even international levels as necessary.
- understanding the significance of the tangible and intangible values associated with cultural heritage and using it as an asset for recovery.
- preserving the heritage value of the sites, following a minimal intervention policy as far as possible and including local stakeholders in this process.
- reviewing site management as well as local and regional planning and management systems.
- technology for repair, retrofitting and restoration of cultural heritage;
- linking recovery with mitigation through development of human resources and planning measures;
- raising community awareness and participation in the recovery process.

3.4. Overview of current debates and knowledge gaps

Most risk analyses are focused on single hazards and do not consider multi-hazards in which several research communities need interact. The FP7 MATRIX project tried to fill the gap through event-tree and fault-tree strategies. Liu et al. [33] also proposed a systematic hazard

interaction classification that improves the MATRIX approach. But still, there are methodological gaps that need to be covered to develop a consistence multi-risk analysis that goes beyond indicator-based approach (e.g. Bayesian networks, agent-based models, system dynamic models, event and fault trees, hybrid models) [34], [35]. In addition, DRM should work to be a cross-cutting issue, promoting the involvement of different specialist fields [10].

After the IPCC introduced the risk components in the AR5 document, the proposed risk formula has been widely accepted in the research community. However, there is not yet a standardised methodology for the risk assessment (one can do a quantitative or qualitative assessment using the same components but with a different way of combining the concepts, different weighting or normalization methods for example) that will ensure comparability between studies. It this sense ARCH will follow closely the evolution of the ISO/TC 262 (for example the ISO/NP 31050). In addition, the end users of risk-assessment studies are demanding user-friendly tools which generates useful information for decision making [36].

Related to the risk analysis, the Impact Chains concept and methodology has emerged recently (first published in 2013 and used in some H2020 projects like RESIN in 2015 or SOCLIMPACT in 2018) in climate risk assessment [37], but it has not been used in DRM. The Impact Chains diagrams can be a useful tool for including in the cause-effect relation the climate change issues. Therefore, the inclusion of this concept in DRM should be analysed.

It is also known that the quantitative risk assessment has a high data demand and therefore there is an important challenge on increasing the data availability (largely at local level), not forgetting the data quality and the need for validation of the obtained risk assessment analysis [36].

The DRM community already worked strengthening the multi-level approach. BMZ highlighted the need to follow this work and reinforce the relation between levels (local, national, international) but also the cooperation between agents (administration, society, private sectors, research institute, …) [10]. In

addition, Gonzalez et al. mentioned the need to go in deep in the correct scales selection for the DRM [34].

Another gap in the risk assessment and climate change is the lack of knowledge in the future vulnerability. A lot of work is been doing in future climate projection, but less effort is been doing in vulnerability related indicators projections (e.g. changes on socio-economic indicators, land use or urbanisation) [36].

An important gap is the lack of clarity with regards to the terms and definitions connected with multi-risk and multi-hazard approaches, therefore is most important to provide a common vocabulary. In addition, also for input parameters, there is a need to harmonize existing methodologies on data collection and databases across the European countries. In this case, there are already on-going programs dealing with this, such as the INSPIRE (http://inspire.jrc.ec.europa.eu/) initiative of the European Union.

During previous funded project, stakeholders highlight—besides the necessity to implement a multi-risk and multi-hazard approaches with financial, political, conceptual, methodological and operational aspects—three particular barriers as being most problematic [38]:

1. The absence of common methodologies and data for different types of hazards and risks is considered the most problematic barrier. In particular data on cost estimations are also not fully comprehensive due to the role played by insurance companies, therefore their assessments are not fully comprehensive or independent.
2. Political priorities differ from multi-risk assessment improvement.
3. A significant limit is the absence of cooperation between the institutions, organizations and departments, reducing transparency in the decision processes. Results of assessments are not always let available to other stakeholders outside the institution which was responsible for the assessment.

Last but not least, over the last decade, DRM felt the need to use the resilience and sustainability concepts and this need forced the use of the concept “building resilience of nations and communities to disasters” present in Hyogo framework for action 2005–2015. Nevertheless, there is a lack of empirical research that introduces the resilience conceptualization systematically in the DRM [39].

4. ARCH project issues and connections

Building on the findings of the state-of-the-art review, this section identifies the most important issues for consideration within the ARCH project. This includes:

The DRM will have the focus on World Heritage and will consider the climate change in the context of ARCH project. The before, during and after stages of the DRM covered in the project will ensure the alignment of the concepts and approaches with the ones considered in World Heritage and Climate Change studies. Therefore, ARCH project will follow the concepts and approaches from the DRM (Sendai Framework for Disaster Risk Reduction 2015-2030) and aligned with the IPCC's Assessment Report 5 (AR5) and UNESCO World Heritage. In this regard, the risk analysis should follow the AR5 risk approach, where the components are the probability of the hazard, exposure and vulnerability.

In the literature we find different methods for risk assessment. ARCH should select the one fits better the ARCH purpose: some are quantitative approaches (probabilistic, deterministic risk assessment) and others qualitative (risk matrix, indicator-based approach among others). Considering that the risk analysis will be done for the heritage (for which it is hard to have the hazard probability data at fine scale, or obtain the damage costs data among others), a priori it seems more feasible to use a qualitative approach like the indicator-based approach including expert judgement (interaction with agents). This will depend on the data availability (quality and quantity).

It is also identified interesting the use of the Impact Chains in the risk analysis and therefore ARCH will explore in this line.

The ARCH platform could support the emergency operations during and post disaster (e.g., providing tools to collect pre-event data useful for the recovery process or analysing the impacts to inform the training and management activities).

In addition, the platform will develop tools for monitoring effects of the disaster at the local scale that could affect the damage distribution (e.g. for seismic risk, the continuous recording of the ground accelerations will permit to elaborate shake maps at urban scale).

5. Conclusion

Climate-related and other hazards are impacting and will impact in the future on World Heritage. Studies are needed on this to find advanced methods and tools to building resilience. This means that the DRM should include concepts and methods from other domains (climate change, resilience, sustainability, world heritage) or need to custom-developed if necessary. ARCH project will ensure the alignment of the proposed concepts and methods with the other domains.

In this regard, ARCH will use the risk components described in the IPCC AR5 document and in addition will explore the way to co-create the risk assessment methodology (having a focus on methods that includes interaction with agents) and explore the applicability of the Impact Chains approach for Heritage risk assessment. The present report highlighted the need to have a standardised methodology for the risk assessment which will ensure comparability between studies. Therefore, ARCH will closely follow the evolution of the ISO/TC 207.

It is also known that the quantitative risk assessment needs to balance the high data demand with the data quality and the need for validation of the obtained risk assessment analysis. Another key challenge detected in this report is the need of the future vulnerability analysis. In this regard, more effort needs to be done in future vulnerability projection (e.g. changes on socio-economic indicators, land use or urbanisation). ARCH will try to find future vulnerability studies to see what can be applicable in the present project.

This report highlights the need of multi-level and multi-hazard approach and the need of methodologies for future vulnerability analysis. The ARCH project will probably not be able to give an answer to these questions but will have them present for making some steps in this direction.

Regarding to the multi-risk and multi-hazard approaches, ARCH will follow on-going programs dealing with this, such as the INSPIRE (http://inspire.jrc.ec.europa.eu/) initiative of the European Union, to see how they approach the following barriers: the absence of common methodologies and data for different types of hazards and risks; political priorities differ from multi-risk assessment improvement; the absence of cooperation between the institutions, organizations and departments, reducing transparency in the decision processes.

Last but not least, ARCH will consider the resilience and sustainability concepts into the DRM.

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8. Annex

Key resources

The key resources – books, papers (open access only), webpages – on the topic are included in this section.

1. **Risk preparedness: A management Manual for World Cultural Heritage**

- Citation: H. Stovel, Risk preparedness: a management manual for world cultural heritage. Rome: ICCROM, 1998. ISBN 92-9077-152-6
- Accessible on: https://www.iccrom.org/sites/default/files/ICCROM_17_RiskPreparedness_en.pdf
- Short summary: it gives an overview of risk-preparedness for cultural heritage (principles, planning approaches and hazard-based strategies).

2. **Managing Disaster Risks for World Heritage**

- Citation: R. Jigyasu et al., Managing Disaster Risks for World Heritage. Paris: United Nations Educational, Scientific and Cultural Organization, 2010. ISBN 978-92-3-104165-5
- Accessible on: http://whc.unesco.org/en/managing-disaster-risks
- Short summary: the objectives of the document are: 1) to help heritage authorities reducing the risks from natural and humanmade disasters; 2) to present the DRM framework and methodologies; to support the a DRM plan preparation; 3) to help finding the arguments for the heritage conservation; 4) to help in the integration of the DRM plan in different levels (national, regional).

3. **Promoting disaster resilient cultural heritage**

- Citation: World Bank and GDFRR
- Accesible on: http://documents.worldbank.org/curated/en/696061511882383371/Promoting-disaster-resilient-cultural-heritage
- 2017
- Short summary: this key resource highlights a number of recommendations that can help policy makers and practitioners further develop DRM practices for more resilient cultural heritage. The document: 1) includes key definitions and lays out the context for protecting cultural heritage; 2) presents common challenges and a framework for managing disaster risk; 3) summarizes good practice and lessons learned; 4) presents select case studies; 5) summarizes key recommendations. The document is an easy to read document useful for analyzing different international experiences in creating and promoting the cultural heritage more resilient to disasters

4. **First aid to cultural heritage in times of crisis**

- Citation: ICCROM and Prince Claus Fund
- https://www.iccrom.org/it/publication/first-aid-cultural-heritage-times-crisis

- ISBN 978-92-9077-281-1
- 2018

Short summary: it is a Handbook for coordinated emergency preparedness and response to secure tangible and intangible heritage. The document gives guidelines: 1) to develop coordinated emergency plans; 2) to enhance disaster resilience in-risk prone regions of the world; 3) to define practical toolkit and checklists. It is specifically oriented on the first aid of heritage assets in times of crisis and describes pathways for preserving culture that start with development and end with resilience.

Case studies

DRM IN WORLD HERITAGE SITES IN ALBANIA

BERAT, BRUTINI, GJIROKASTRA

The UN launched a project called "Natural Risk Preparedness and Mitigation - Building capacity in the field of risk mitigation for Cultural Heritage properties in Albania" between 2011-2013. The project started with an intensive training on Disaster Risk Preparedness and Management for heritage professionals and civil emergency responders which led to a methodological framework for DRM planning. Special focus was devoted to risk preparedness for earthquakes and fires, but consider others.

Then a Risk Analysis of natural hazards and the guidelines for the risk reduction of Cultural Heritage in Albania were elaborate. The risk analysis was conducted considering several exposed attributes like architecture, coexistence (various religious and cultural traditions), artisan tradition, urban heritage and natural heritage.

A post "site by site" visit of UNESCO-ICCROM team secured a post-training coaching support to devise new management plans for the studied sites.

Finally, a science-based seismological and geo-vulnerability mapping was performed to provide useful information for: (1) Establishing guidelines and criteria of interventions in urban areas and cultural sites and (2) defining priorities for interventions. As a result, several measures on prevention and mitigation, emergency preparedness, response, recovery and rehabilitation (short and long term) were proposed.

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Source: R. Jigyasu et al., 2014. Disaster Risk Management of Cultural Heritage Sites in Albania, CNR IGAG, Rome

DRM IN WORLD HERITAGE SITE IN THAILAND

Integrating heritage in urban and regional planning: risk preparedness for the Historic city of Ayutthaya

Over ten ancient towns and several archaeological sites and monuments were flooded due to incessant heavy rainfall during several weeks in 1995. Many historic sites were damaged, and some buildings collapsed. The main cause of increasing flood intensity in historic areas of Ayutthaya was the lack of effective land-use control, causing many natural floodways and retention areas to be destroyed and developed as functional urban areas. In fact, traditional flood prevention systems using water gates and dykes had been effective in Ayutthaya for centuries until they suffered deterioration and destruction in recent years.

As a preventive measure for such devastating floods in the future, several projects were formulated at regional level. These included construction of dams and reservoirs, grass plantation along the banks of major rivers, floodwater retention projects, dredging of waterways and removal of water weeds. Revitalization of ancient city moats, walls and gateways was proposed to prevent future floods. Site plans were also prepared for monuments in lower areas outside the city to be protected by dams and drainage systems.

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Source: K. Ronarit, 1997, Risk Preparedness for Cultural Properties: a Case Study on the Old Cities of Bangkok and Ayutthaya, Kobe/Tokyo International Symposium on Risk Preparedness for Cultural Properties.

DRM IN WORLD HERITAGE SITE IN ITALY

Training through simulation exercises: salvaging cultural heritage in Phlegrean Fields (Italy)

Phlegrean Fields is a volcanic depression called "caldera" in the center of Pozzuoli. Compared to the central volcanoes, characterized by frequent eruptions occurring from a single crater and the deposits of volcanic materials the caldera shows eruptions that are unlikely to present regular patterns. In general, explosive eruptions of variable scale prevail, arising from scattered mouths, some or many of which may be very intense and violent. The last eruption of the Phlegraean Fields occurred in 1538. Since then, the volcano has been dormant although it shows signals of activity such as seismicity, gas emissions and soil deformation. From 2012 to the present, the variations of some monitoring parameters measured in the caldera area required an increase in the alert level from green to yellow and the activation of the operational attention phase.

In order to protect cultural heritage, the scenario envisages a simulation of activities for the securing of movable assets with evaluation of site conditions and movement from the container to the storage (Baia Castle, Bacoli). The procedures for the employment of specialized figures for the formation of teams to be used in the protection of cultural heritage must also be tested. The exercise was an opportunity to elaborate, test and improve the operational, procedural and methodological aspects of territorial and sector planning. The players have been identified in terms of role and responsibilities as reported in the following table.

Activity	Responsible
Crisis and National Coordinator Unit (UCCN) delegates Regional Crisis Unit (UCCR)	Coordinator of damage level survey unit
Organize teams to assess the damage to immovable asset	Coordinator of the technical unit and safety interventions
Organize teams for the recovery and security of movable asset	Coordinator of damage level survey unit
Assessment of damage to immovable assets by filling dedicated forms to be delivered to Command and Control Centre (DICOMAC)	Coordinator of the technical unit and safety interventions
Assessment of damage to movable assets by filling dedicated forms. The documentation collected is delivered to DICOMAC	Coordinator of the technical unit and safety interventions
Movement of the movable assets present inside the immovable assets (e.g., museum) towards the safe packing and filling area	Coordinator of temporary warehouses and first intervention laboratory
Transport of movable assets toward safe storage	Carabinieri Cultural Heritage Protection Unit

DRM IN WORLD HERITAGE SITE IN DANUBE

Flood mitigation through ecosystem restoration: the Danube in south-eastern Europe

In Europe, floods are the most common type of natural disaster, threatening lives and livelihoods and incurring great cost. As an example, in summer 2002, one hundred people lost their lives through flooding of the Danube. The calculated cost of the flooding was €10 billion in Germany, €3 billion in Austria and €2 billion in the Czech Republic.

Studies of satellite pictures and geographical data systems determined that the direct cause of flooding was rapid snow melt and heavy rains. However, the restriction of the floods to former floodplains demonstrated that the underlying causes of the disaster were poor planning and investment, allowing industry, agriculture and property to be located on the high-risk Danube floodplain. More than 80 per cent of the previous natural floodplain in the Danube Basin has been lost in the last 150 years due to such measures. The Danube Delta World Heritage site is one of the few remaining areas along the lower and middle Danube which still contains large natural floodplain ecosystem complexes capable of mitigating the flood risk. Flood analysis and models suggest that if natural processes were restored in the most affected areas, the water level would be 40 cm lower during flooding events.

Recent studies based on climate models predict that intensity and frequency of flooding will increase in the future. While climate change is difficult to address directly, mitigation through ecological restoration of floodplains, including reconnecting side channels and widening of the riverbed upstream of settlements, would reduce flood risks by restoring ecological functions. These measures would provide additional ecosystem services including provision of wood, reed, fish, drinking water, nutrient reduction and storage.

A network of existing and new protected areas including Srebarna Nature Reserve World Heritage site (Bulgaria), Ramsar Sites, Biosphere Reserves and National and Nature Parks is being developed to help the restoration and protection of the Danube floodplain.

Sources: European Environment Agency, 2005, EEA Briefing – Climate Change and River Flooding in Europe