DELIVERABLE D.T1.3.1

Manual for cultural heritage managers containing mitigation and adaptation strategies to face up future climate change pressures

Version 1
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With contribution of all partners

CONTENTS

1. INTRODUCTION

The formulation and predisposal of the here presented manual, suitable for cultural heritage managers and curators and municipalities, has been developed for the protection of Cultural Heritage in a changing environment.

In accordance with the Sendai Framework for Disaster Risk Reduction 2015-2030[1], which has included the need to protect cultural heritage among its key priorities, this manual aims at enhancing the **knowledge of hazards and risks integrated with cultural heritage protection measures**.

Always considering the Sendai Framework, the **resilience issue deserves greater attention and prominence in each of the Seven Global Targets** (Fig. 1.1) and the **Four Priorities for Action** (Fig. 1.2).

FIGURE 1. 1. THE SENDAI FRAMEWORK INTRODUCES SEVEN GLOBAL TARGETS TO ASSESS GLOBAL PROGRESS TOWARD THE EXPECTED OUTCOME[2].

[1] http://www.unisdr.org/we/coordinate/sendai-framework

[2] https://www.preventionweb.net/drr-framework/sendai-framework-monitor/introduction

FIGURE 1. 2. THE SENDAI FRAMEWORK FOUR PRIORITIES FOR ACTION (COPYRIGHT DR. CHADIA WANNOUS SENIOR ADVISOR UN OFFICE FOR DISASTER RISK REDUCTION – UNISDR[3])

Based on these statements, it can be affirmed that conservation and resilience need to be equally matched and balanced. Either a "resilience friendly conservation policy" or "conservation friendly resilience policy" needs to be established and promoted.

As stated in the recent work published by the EU, entitled *Safeguarding Cultural Heritage from Natural and Man-Made Disasters* (Bonazza et al., 2018[4]) "*it is highly likely that the* ***majority of disasters affecting the built heritage will have immediate operational implications (****involving safety considerations for the attending rescue services, operational crews, and owners)*". *Therefore, "they should be operating on the basis of* ***pre-planned practical programmes, based on adequate risk assessments, training and familiarisation techniques previously carried out****. For this reason,* ***feedback from the operational bodies is essential*** *in order to improve and refine the process. Appropriate information, data and experience should be required to deal more effectively with future incidents. In the normal course of events this material should be passed up through the operational line of command to be synthesised at regional level before being passed on to central government and further inform political direction, policy, legislation, standards and guidance. Such an information loop requires the creation and reporting of appropriate data, following an incident, on the circumstances and the effectiveness of actions taken preferably in a standardised format.*

[3] https://www.cbd.int/health/doc/workshops/wshb-euro-01-presentations/health-and-DRR-UNISDR.pdf

[4] Bonazza A., Maxwell I., Drdácký M., Vintzileou E., Hanus C., Ciantelli C., De Nuntiis P., Oikonomopoulou E., Nikolopoulou V, Pospíšil S., Sabbioni C., Strasser P. (2018) Safeguarding Cultural Heritage from Natural and Man-Made Disasters - A comparative analysis of risk management in the EU. Corporate Author(s): Directorate-General for Education, Youth, Sport and Culture (European Commission), 207 pp. ISBN 978-92-79-73945-3, (catalogue) NC-05-17-059-EN-N. DOI:10.2766/224310

*With adequate forethought, **appropriate measures** (preparedness, emergency, recovery) should also have been pre-considered and agreed between governmental departments and policy makers. Central government might pass the responsibility for dealing with an incident down to regional and local authorities, depending on the repartition of competences in each Member State. Here adequate resources, both financial and human, need to be pre-determined and provided to deal with emerging circumstances.*

*At all levels, **European cooperation** is essential for strengthening response capacities to disasters of all actors involved and should be continuously boosted. The proposal for the creation of "rescEU"4, a reserve of civil protection resources managed by the European Commission, represents a promising action in this direction."*

2. GENERAL RECOMMENDATIONS FRAMED IN ACCORDANCE WITH THE SENDAI FOUR PRIORITIES FOR ACTION

Always according with Bonazza et al., 2018[5], recommendations for **Policy Makers** framed in accordance with the Sendai Four Priorities for Action have been extracted and schematized in the following images (Fig.2.1 – 2.4).

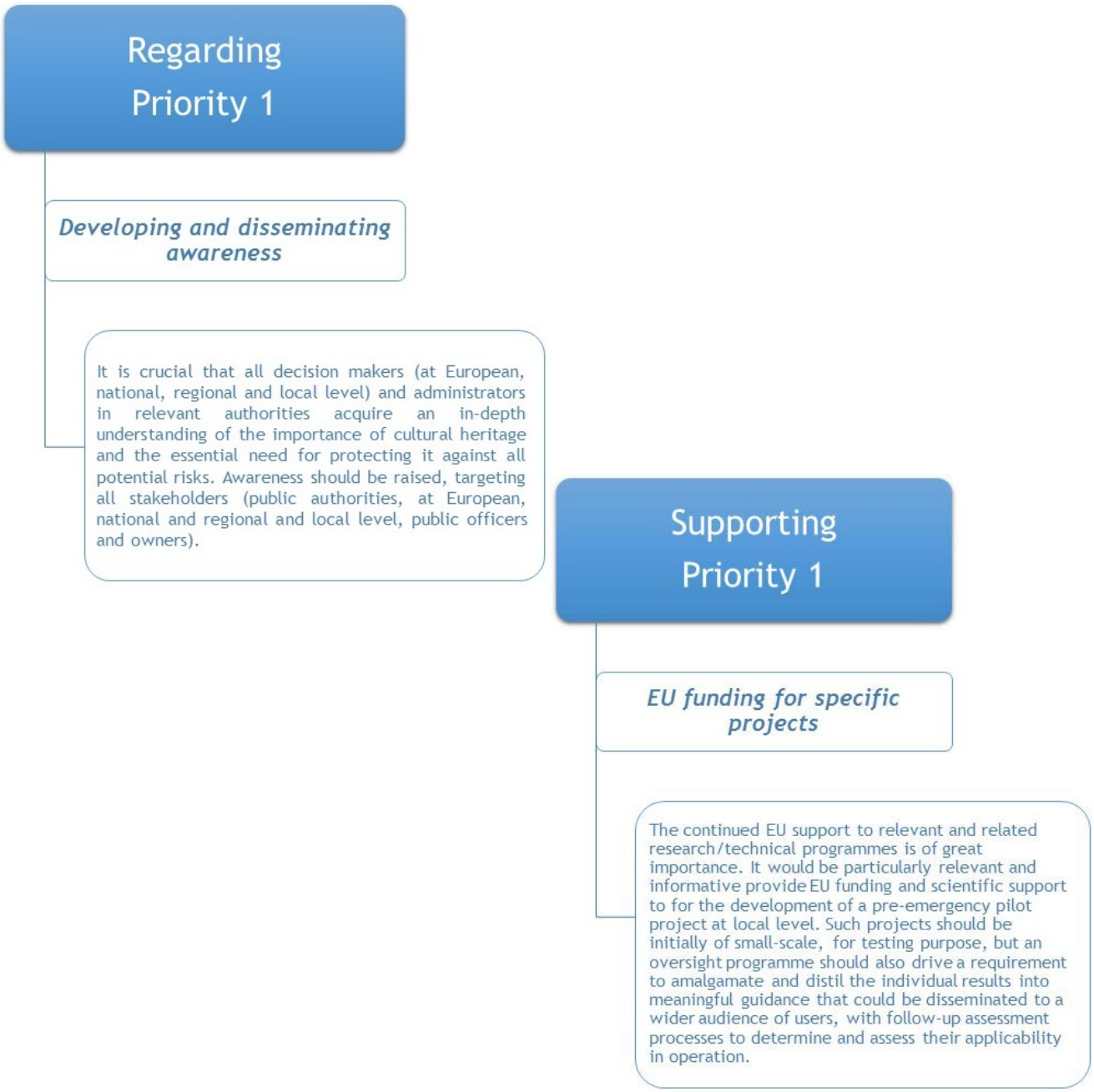


FIGURE 2. 1. REGARDING AND SUPPORTING PRIORITY 1- UNDERSTANDING DISASTER RISK.

[5] Bonazza A., Maxwell I., Drdácký M., Vintzileou E., Hanus C., Ciantelli C., De Nuntiis P., Oikonomopoulou E., Nikolopoulou V, Pospíšil S., Sabbioni C., Strasser P. (2018) Safeguarding Cultural Heritage from Natural and Man-Made Disasters - A comparative analysis of risk management in the EU. Corporate Author(s): Directorate-General for Education, Youth, Sport and Culture (European Commission), 207 pp. ISBN 978-92-79-73945-3, (catalogue) NC-05-17-059-EN-N. DOI:10.2766/224310

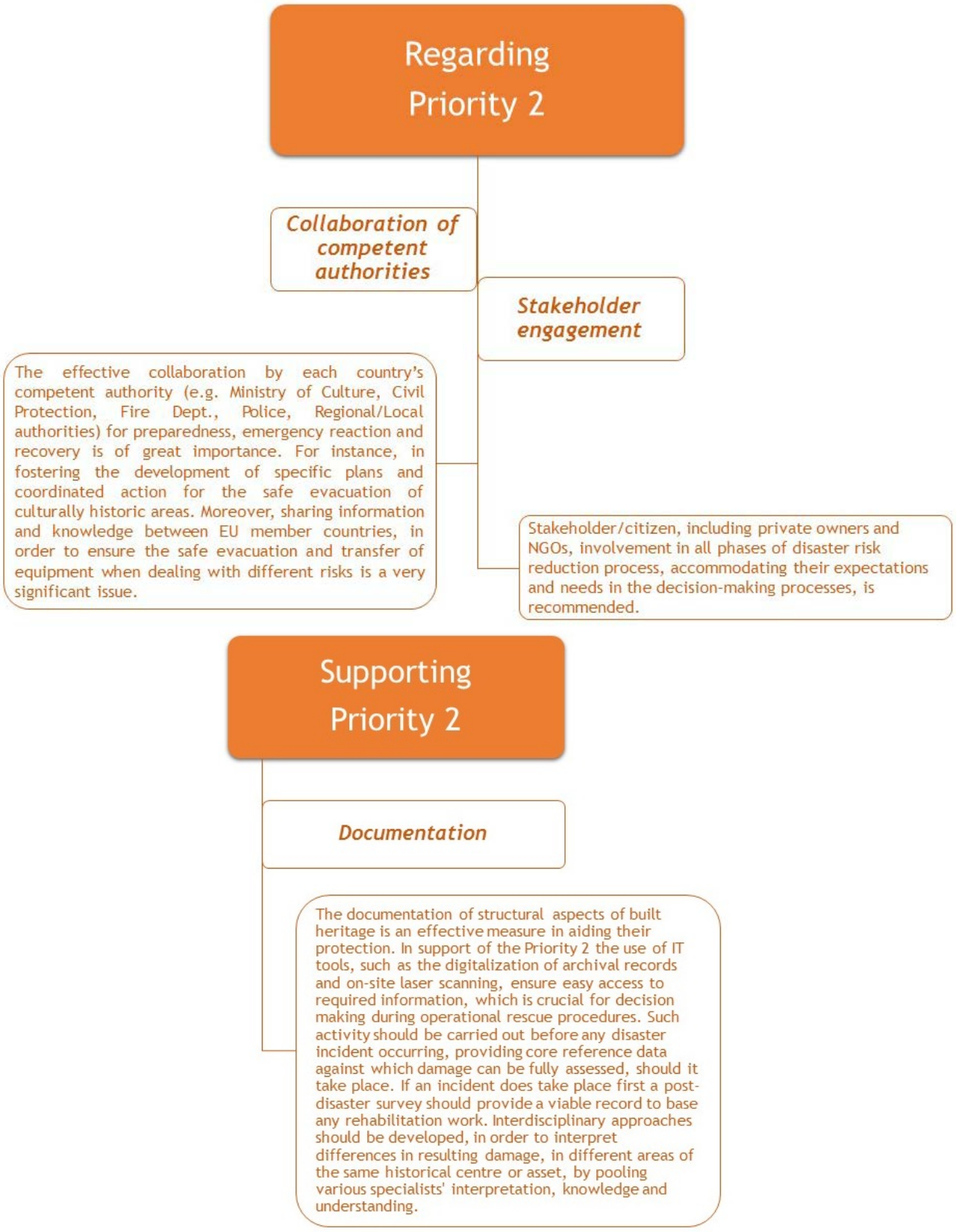


FIGURE 2. 2. REGARDING AND SUPPORTING PRIORITY 2 - STRENGTHENING DISASTER RISK GOVERNANCE TO MANAGE DISASTER RISK.

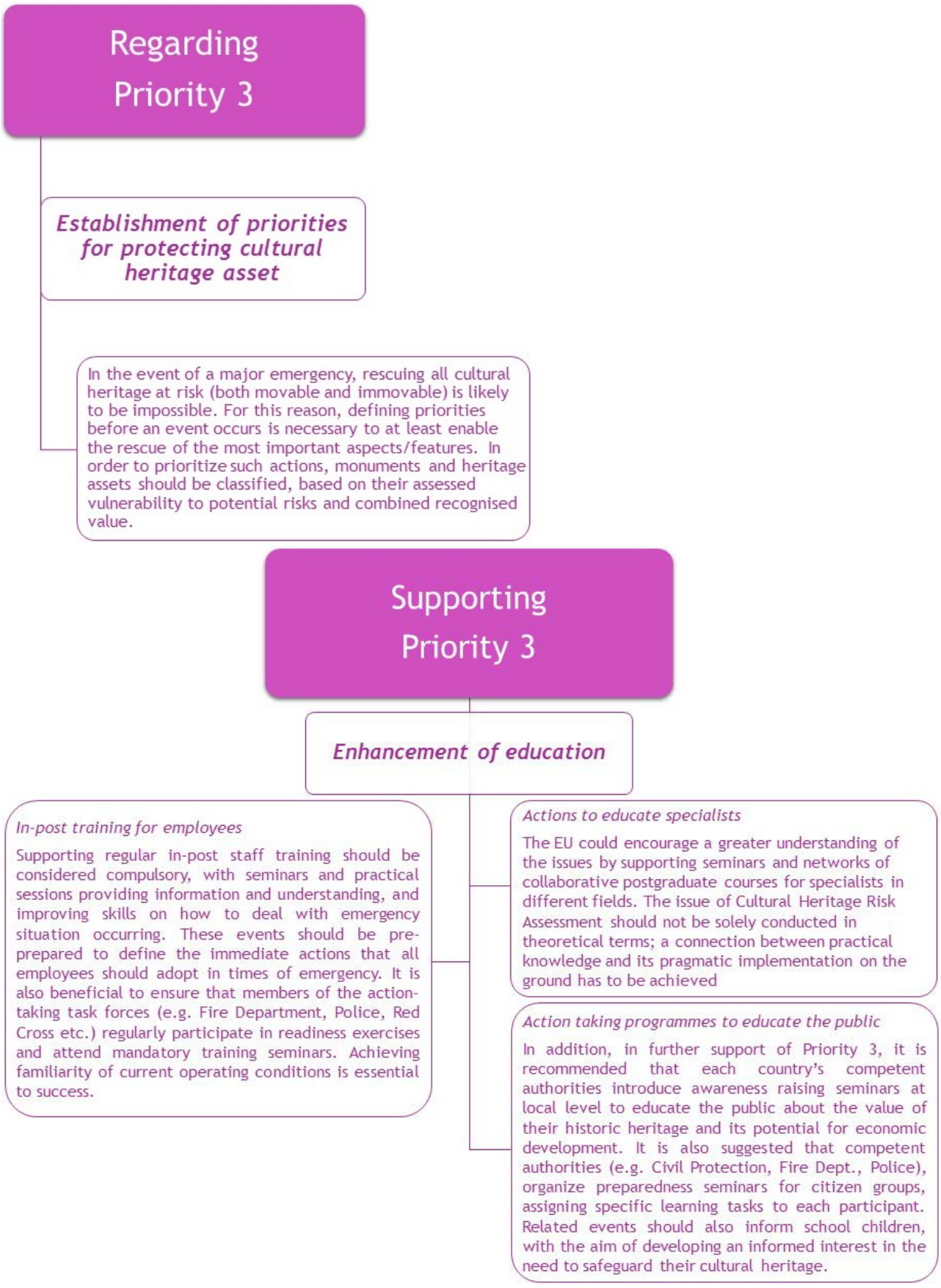


FIGURE 2. 3. REGARDING AND SUPPORTING PRIORITY 3 - INVESTING IN DISASTER RISK REDUCTION FOR RESILIENCE.

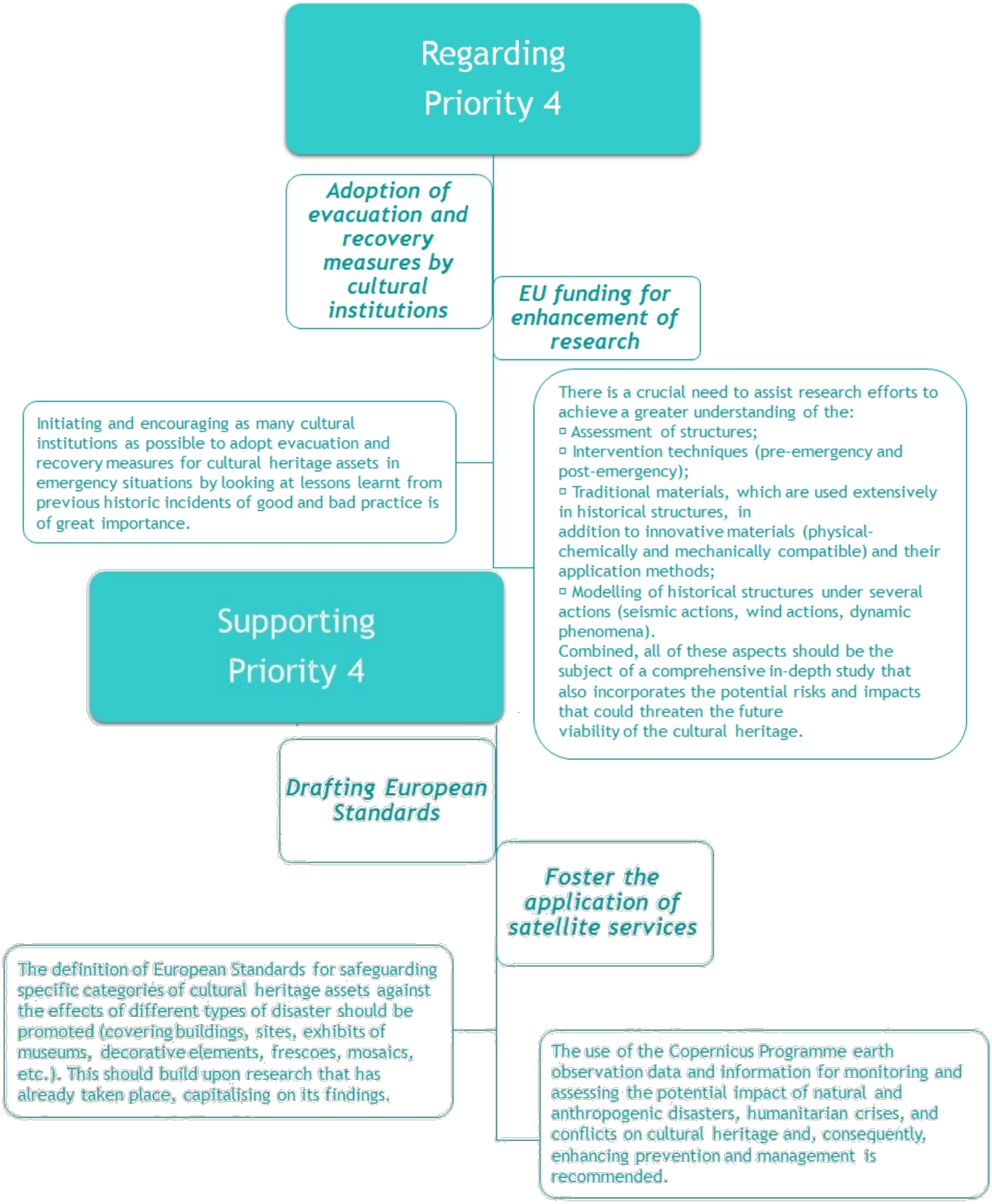


FIGURE 2. 4. REGARDING AND SUPPORTING PRIORITY 4- ENHANCING DISASTER PREPAREDNESS FOR EFFECTIVE RESPONSE AND TO "BUILD BACK BETTER" IN RECOVERY, REHABILITATION AND RECONSTRUCTION.

Key Lessons Learnt:

The integration of cultural heritage into national disaster and risk reduction strategies developed by EU Member States still suffers from:

- The lack of coordination between and across the different (European, National and Regional) strategies of risk management policies in most countries.
- The lack of alignment in the responsibility chain from policy making to practical application.
- The low current priority of cultural heritage in risk management planning.
- The lack of integration of cultural heritage protection measures into risk management strategies.

To maximise synergies between the political, governmental and operational levels in the field of disaster awareness an integrated approach is required, as illustrated in the diagram below (Fig. 2.6):

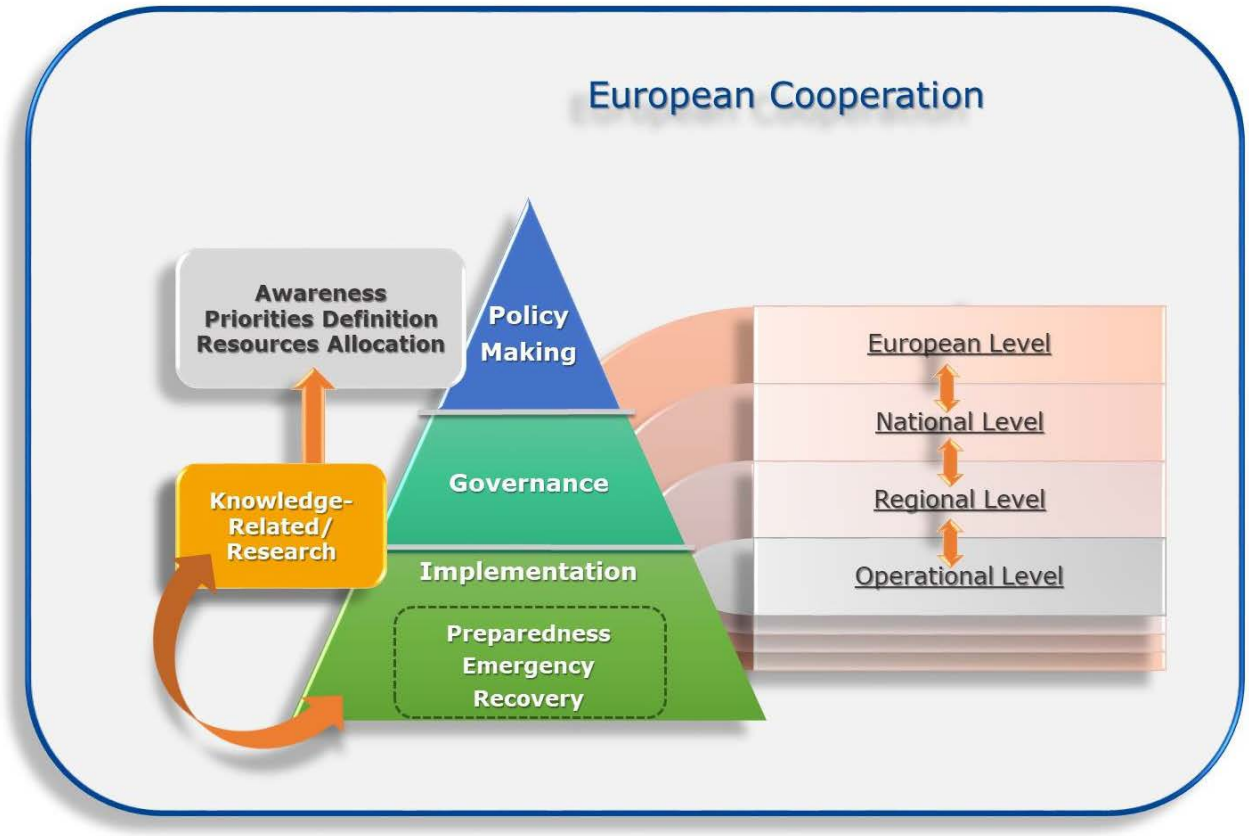


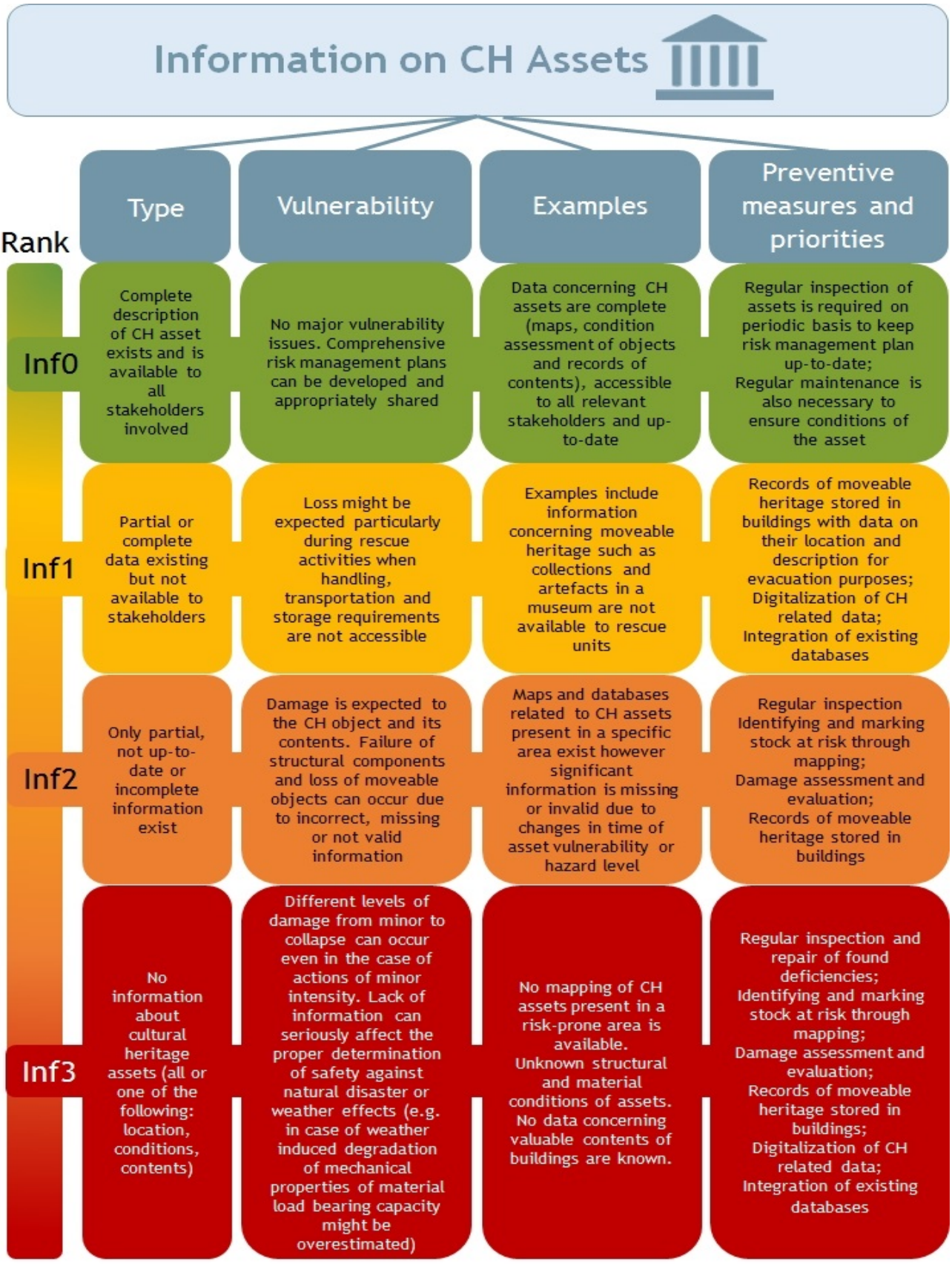
FIGURE 2. 5. DIAGRAM ILLUSTRATING HOW SYNERGIES AMONG THE POLITICAL, GOVERNMENTAL AND OPERATIONAL LEVELS CAN PROVIDE AN INTEGRATED APPROACH IN THE FIELD OF DISASTER AWARENESS (BONAZZA ET AL., 2018).

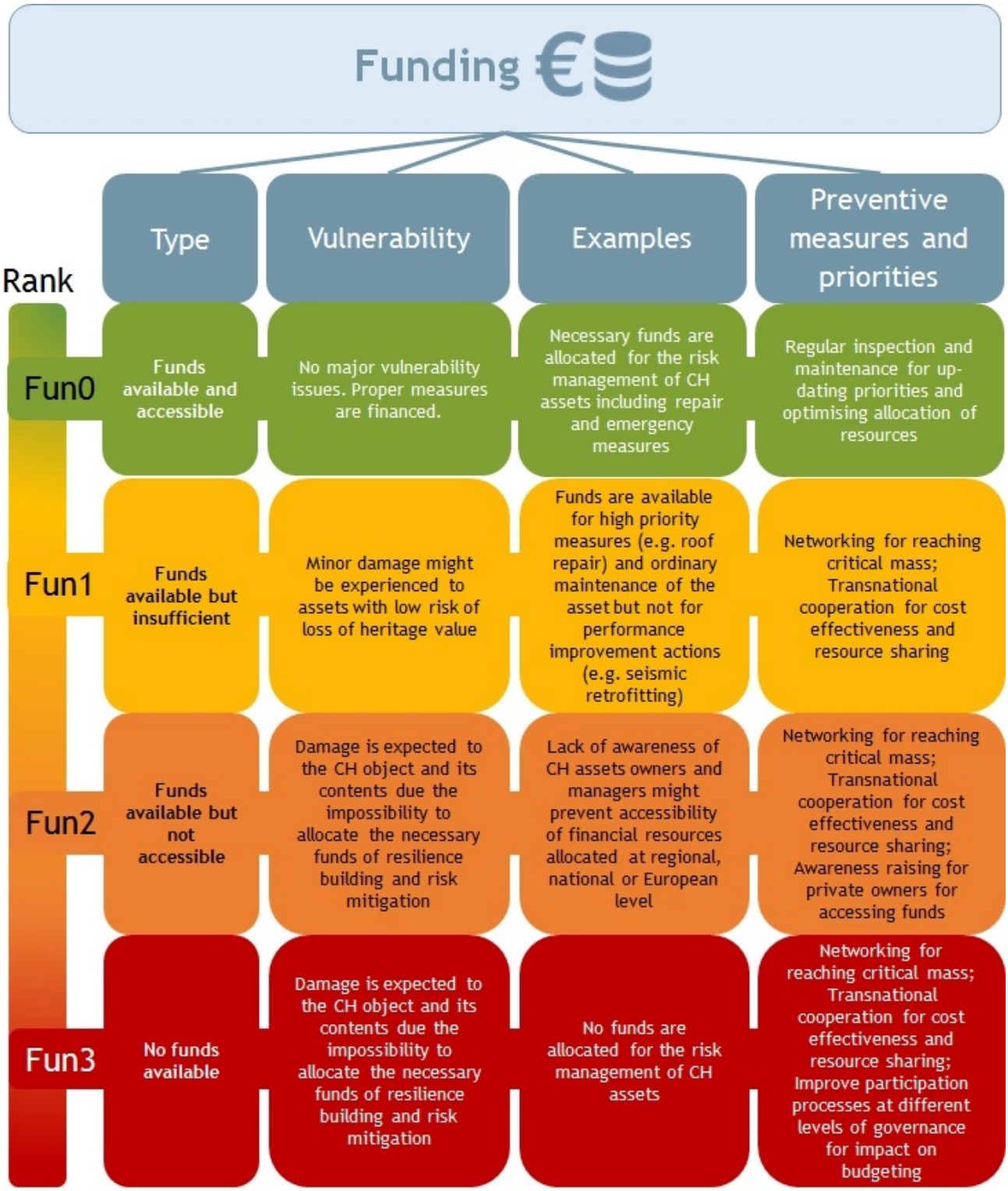
3. SPECIFIC RECOMMENDATIONS & GUIDELINES

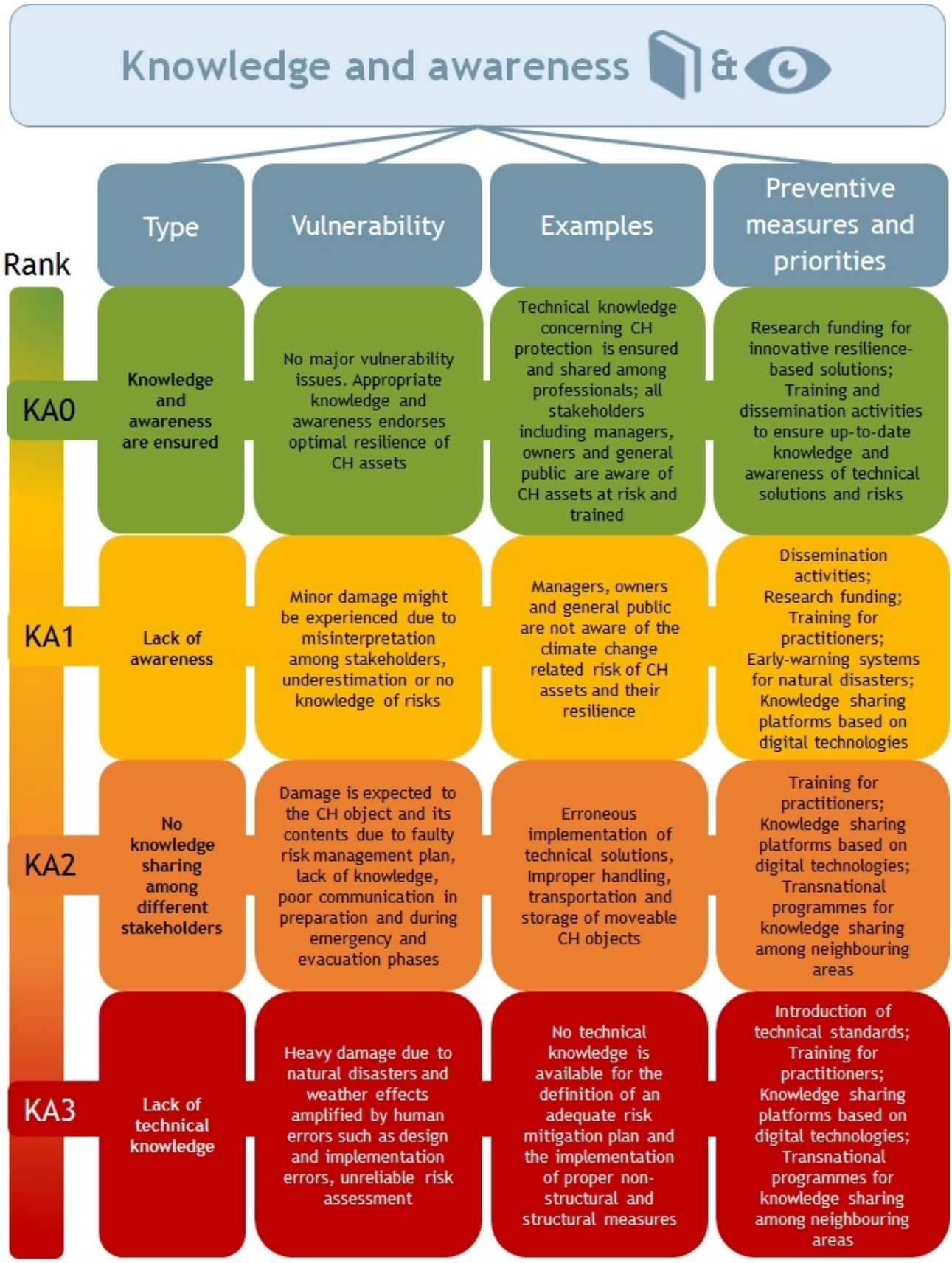
The following subchapters collect specific recommendations and guidelines divided by managerial critical elements and evaluation of extreme events effects, utilizing the works developed within the "*Deliverable D.T2.1.3 Decision support tool*"by ITAM, the *Deliverable D.T1.2.1 1. Risk Assessment of Cultural Heritage in Central Europe in Facing Extreme Events*" and the EU publication "*Safeguarding Cultural Heritage from Natural and Man-Made Disasters*[6]*".*

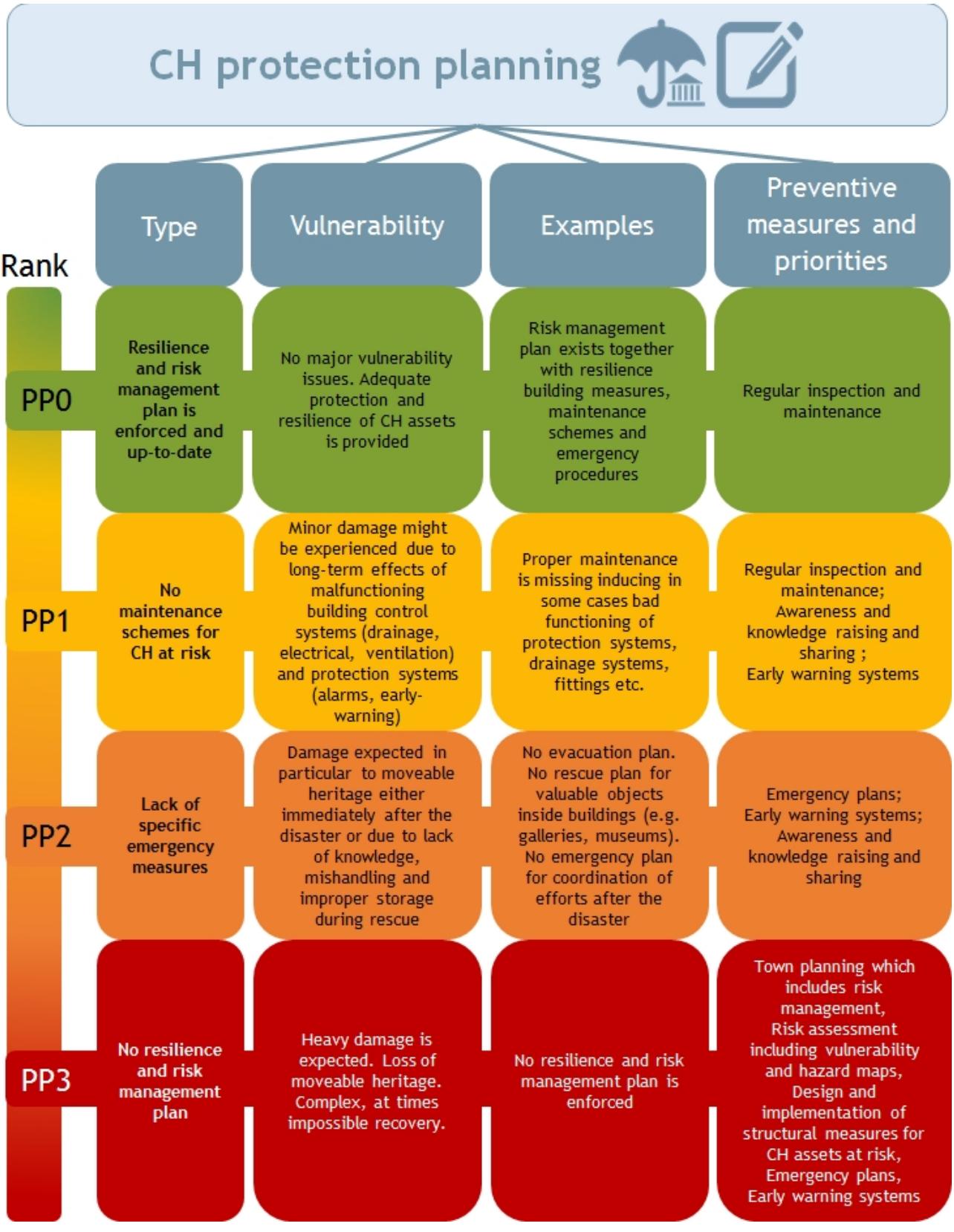
[6] Bonazza A., Maxwell I., Drdácký M., Vintzileou E., Hanus C., Ciantelli C., De Nuntiis P., Oikonomopoulou E., Nikolopoulou V, Pospíšil S., Sabbioni C., Strasser P. (2018) Safeguarding Cultural Heritage from Natural and Man-Made Disasters - A comparative analysis of risk management in the EU. Corporate Author(s): Directorate-General for Education, Youth, Sport and Culture (European Commission), 207 pp. ISBN 978-92-79-73945-3, (catalogue) NC-05-17-059-EN-N. DOI:10.2766/224310

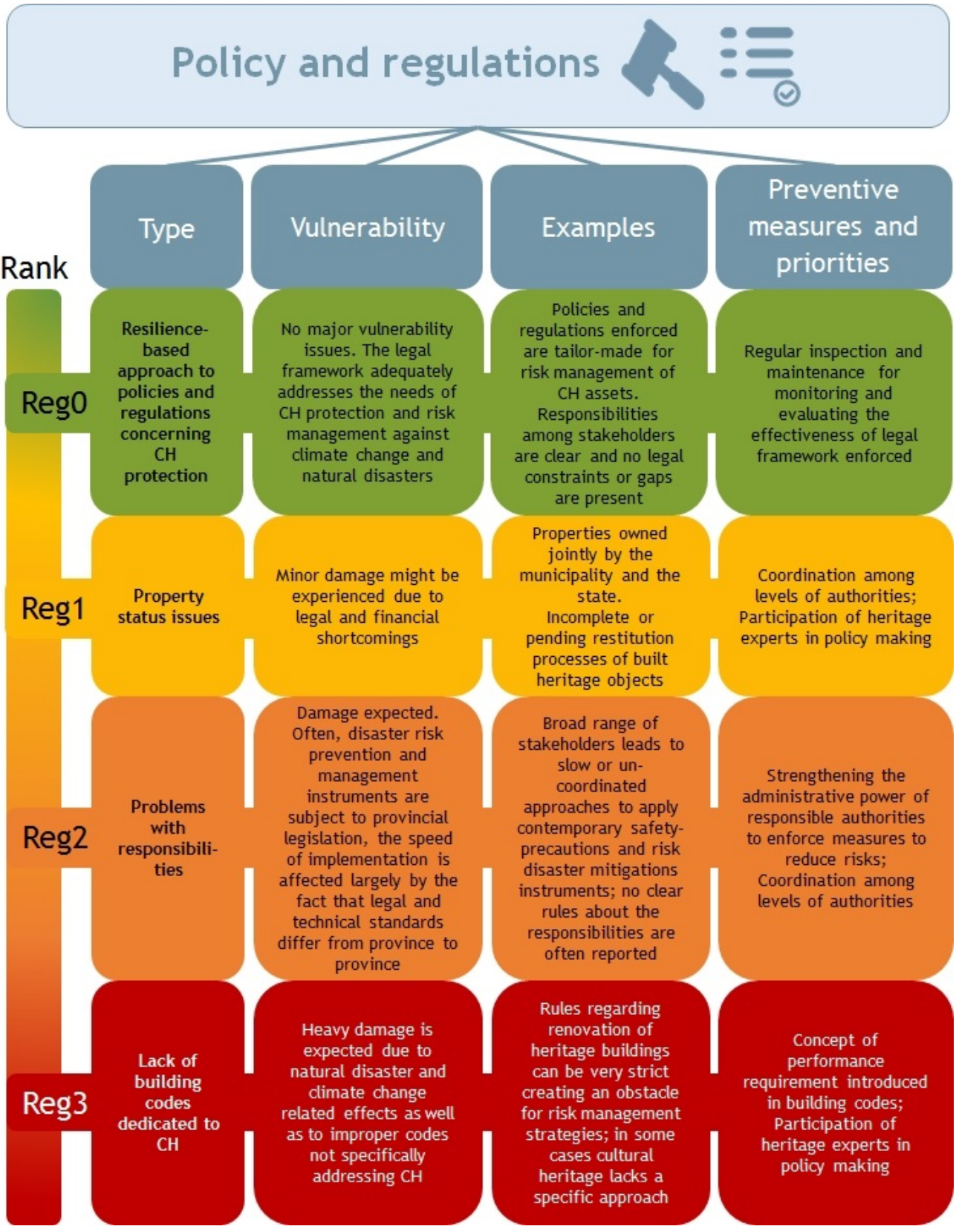
3.1. GENERAL MANAGERIAL CRITICAL ELEMENTS




Funding €
Rank
Type
Vulnerability
Examples
Preventive measures and priorities
Fun0
Funds available and accessible
No major vulnerability issues. Proper measures are financed.
Necessary funds are allocated for the risk management of CH assets including repair and emergency measures
Regular inspection and maintenance for up-dating priorities and optimising allocation of resources
Fun1
Funds available but insufficient
Minor damage might be experienced to assets with low risk of loss of heritage value
Funds are available for high priority measures (e.g. roof repair) and ordinary maintenance of the asset but not for performance improvement actions (e.g. seismic retrofitting)
Networking for reaching critical mass; Transnational cooperation for cost effectiveness and resource sharing
Fun2
Funds available but not accessible
Damage is expected to the CH object and its contents due the impossibility to allocate the necessary funds of resilience building and risk mitigation
Lack of awareness of CH assets owners and managers might prevent accessibility of financial resources allocated at regional, national or European level
Networking for reaching critical mass; Transnational cooperation for cost effectiveness and resource sharing; Awareness raising for private owners for accessing funds
Fun3
No funds available
Damage is expected to the CH object and its contents due the impossibility to allocate the necessary funds of resilience building and risk mitigation
No funds are allocated for the risk management of CH assets
Networking for reaching critical mass; Transnational cooperation for cost effectiveness and resource sharing; Improve participation processes at different levels of governance for impact on budgeting


Knowledge and awareness &
Rank
Type
Vulnerability
Examples
Preventive measures and priorities
KA0
Knowledge and awareness are ensured
No major vulnerability issues. Appropriate knowledge and awareness endorses optimal resilience of CH assets
Technical knowledge concerning CH protection is ensured and shared among professionals; all stakeholders including managers, owners and general public are aware of CH assets at risk and trained
Research funding for innovative resilience-based solutions; Training and dissemination activities to ensure up-to-date knowledge and awareness of technical solutions and risks
KA1
Lack of awareness
Minor damage might be experienced due to misinterpretation among stakeholders, underestimation or no knowledge of risks
Managers, owners and general public are not aware of the climate change related risk of CH assets and their resilience
Dissemination activities; Research funding; Training for practitioners; Early-warning systems for natural disasters; Knowledge sharing platforms based on digital technologies
KA2
No knowledge sharing among different stakeholders
Damage is expected to the CH object and its contents due to faulty risk management plan, lack of knowledge, poor communication in preparation and during emergency and evacuation phases
Erroneous implementation of technical solutions, Improper handling, transportation and storage of moveable CH objects
Training for practitioners; Knowledge sharing platforms based on digital technologies; Transnational programmes for knowledge sharing among neighbouring areas
KA3
Lack of technical knowledge
Heavy damage due to natural disasters and weather effects amplified by human errors such as design and implementation errors, unreliable risk assessment
No technical knowledge is available for the definition of an adequate risk mitigation plan and the implementation of proper non-structural and structural measures
Introduction of technical standards; Training for practitioners; Knowledge sharing platforms based on digital technologies; Transnational programmes for knowledge sharing among neighbouring areas


CH protection planning
Rank
Type
Vulnerability
Examples
Preventive measures and priorities
PP0
Resilience and risk management plan is enforced and up-to-date
No major vulnerability issues. Adequate protection and resilience of CH assets is provided
Risk management plan exists together with resilience building measures, maintenance schemes and emergency procedures
Regular inspection and maintenance
PP1
No maintenance schemes for CH at risk
Minor damage might be experienced due to long-term effects of malfunctioning building control systems (drainage, electrical, ventilation) and protection systems (alarms, early-warning)
Proper maintenance is missing inducing in some cases bad functioning of protection systems, drainage systems, fittings etc.
Regular inspection and maintenance; Awareness and knowledge raising and sharing ; Early warning systems
PP2
Lack of specific emergency measures
Damage expected in particular to moveable heritage either immediately after the disaster or due to lack of knowledge, mishandling and improper storage during rescue
No evacuation plan. No rescue plan for valuable objects inside buildings (e.g. galleries, museums). No emergency plan for coordination of efforts after the disaster
Emergency plans; Early warning systems; Awareness and knowledge raising and sharing
PP3
No resilience and risk management plan
Heavy damage is expected. Loss of moveable heritage. Complex, at times impossible recovery.
No resilience and risk management plan is enforced
Town planning which includes risk management, Risk assessment including vulnerability and hazard maps, Design and implementation of structural measures for CH assets at risk, Emergency plans, Early warning systems


Policy and regulations
Rank
Type
Vulnerability
Examples
Preventive measures and priorities
Reg0
Resilience-based approach to policies and regulations concerning CH protection
No major vulnerability issues. The legal framework adequately addresses the needs of CH protection and risk management against climate change and natural disasters
Policies and regulations enforced are tailor-made for risk management of CH assets. Responsibilities among stakeholders are clear and no legal constraints or gaps are present
Regular inspection and maintenance for monitoring and evaluating the effectiveness of legal framework enforced
Reg1
Property status issues
Minor damage might be experienced due to legal and financial shortcomings
Properties owned jointly by the municipality and the state. Incomplete or pending restitution processes of built heritage objects
Coordination among levels of authorities; Participation of heritage experts in policy making
Reg2
Problems with responsibili-ties
Damage expected. Often, disaster risk prevention and management instruments are subject to provincial legislation, the speed of implementation is affected largely by the fact that legal and technical standards differ from province to province
Broad range of stakeholders leads to slow or un-coordinated approaches to apply contemporary safety-precautions and risk disaster mitigations instruments; no clear rules about the responsibilities are often reported
Strengthening the administrative power of responsible authorities to enforce measures to reduce risks; Coordination among levels of authorities
Reg3
Lack of building codes dedicated to CH
Heavy damage is expected due to natural disaster and climate change related effects as well as to improper codes not specifically addressing CH
Rules regarding renovation of heritage buildings can be very strict creating an obstacle for risk management strategies; in some cases cultural heritage lacks a specific approach
Concept of performance requirement introduced in building codes; Participation of heritage experts in policy making

3.2. EVALUATION AND MANAGEMENT OF EXTREME EVENTS EFFECTS

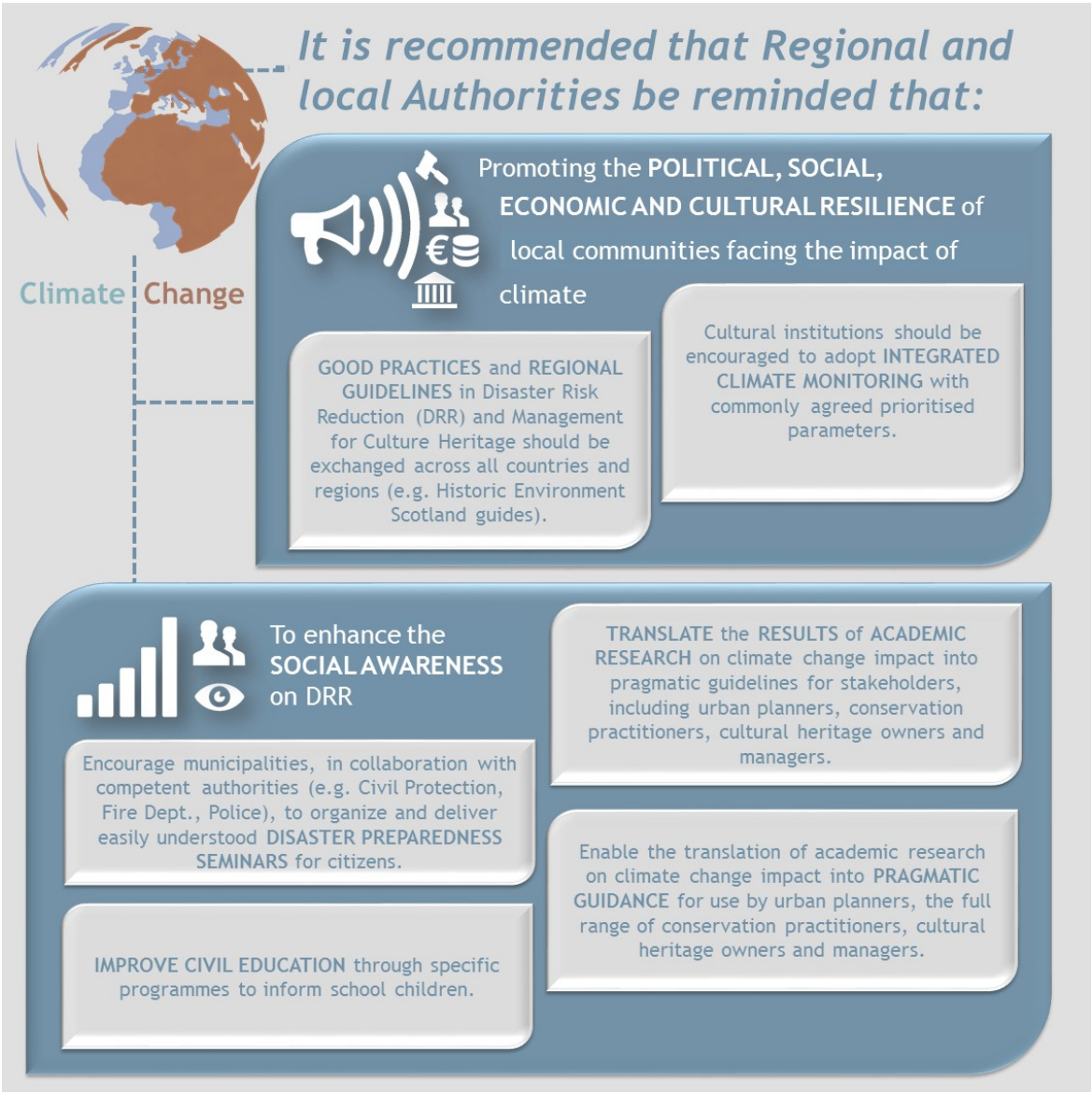
In order to easily consider and manage the effects due to the action of extreme events on Cultural Heritage assets, the following paragraphs list both managerial and technical recommendations subdivided by the equivalent extreme event.

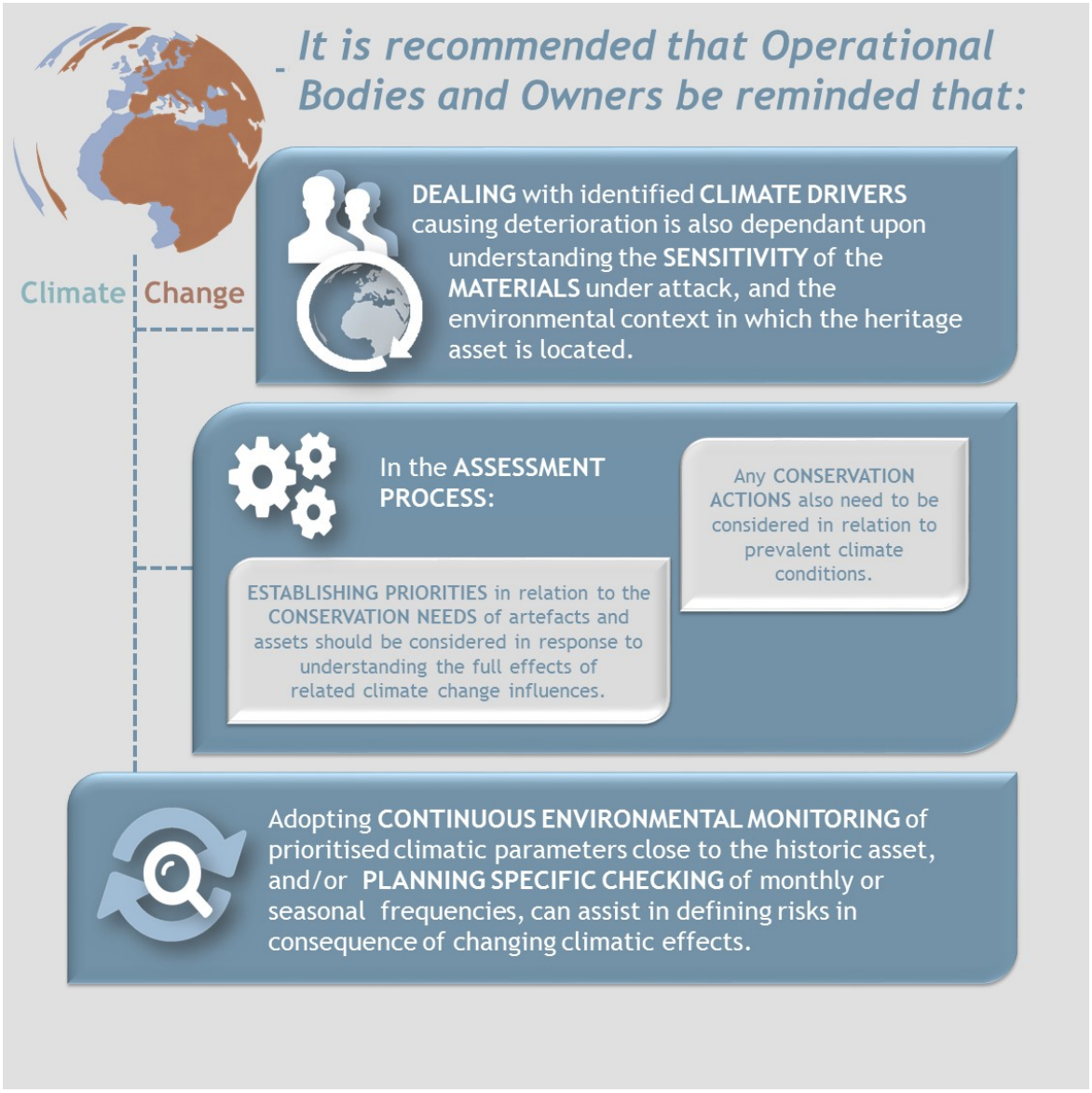
3.2.1. Climate Change

Managerial recommendations

In order to give a preliminary and more general view regarding the impacts of climate change on monuments, archaeological sites and historic buildings, the pertaining recommendations are hereafter reported. In particular, they derive from the work performed within the EU publication: "Safeguarding Cultural Heritage from Natural and Man-Made Disasters[7]".

[7] Bonazza A., Maxwell I., Drdácký M., Vintzileou E., Hanus C., Ciantelli C., De Nuntiis P., Oikonomopoulou E., Nikolopoulou V, Pospíšil S., Sabbioni C., Strasser P. (2018) Safeguarding Cultural Heritage from Natural and Man-Made Disasters - A comparative analysis of risk management in the EU. Corporate Author(s): Directorate-General for Education, Youth, Sport and Culture (European Commission), 207 pp. ISBN 978-92-79-73945-3, (catalogue) NC-05-17-059-EN-N. DOI:10.2766/224310


It is recommended that Regional and local Authorities be reminded that:
Climate Change
Promoting the POLITICAL, SOCIAL, ECONOMIC AND CULTURAL RESILIENCE of local communities facing the impact of climate
GOOD PRACTICES and REGIONAL GUIDELINES in Disaster Risk Reduction (DRR) and Management for Culture Heritage should be exchanged across all countries and regions (e.g. Historic Environment Scotland guides).
Cultural institutions should be encouraged to adopt INTEGRATED CLIMATE MONITORING with commonly agreed prioritised parameters.
To enhance the SOCIAL AWARENESS on DRR
Encourage municipalities, in collaboration with competent authorities (e.g. Civil Protection, Fire Dept., Police), to organize and deliver easily understood DISASTER PREPAREDNESS SEMINARS for citizens.
IMPROVE CIVIL EDUCATION through specific programmes to inform school children.
TRANSLATE the RESULTS of ACADEMIC RESEARCH on climate change impact into pragmatic guidelines for stakeholders, including urban planners, conservation practitioners, cultural heritage owners and managers.
Enable the translation of academic research on climate change impact into PRAGMATIC GUIDANCE for use by urban planners, the full range of conservation practitioners, cultural heritage owners and managers.

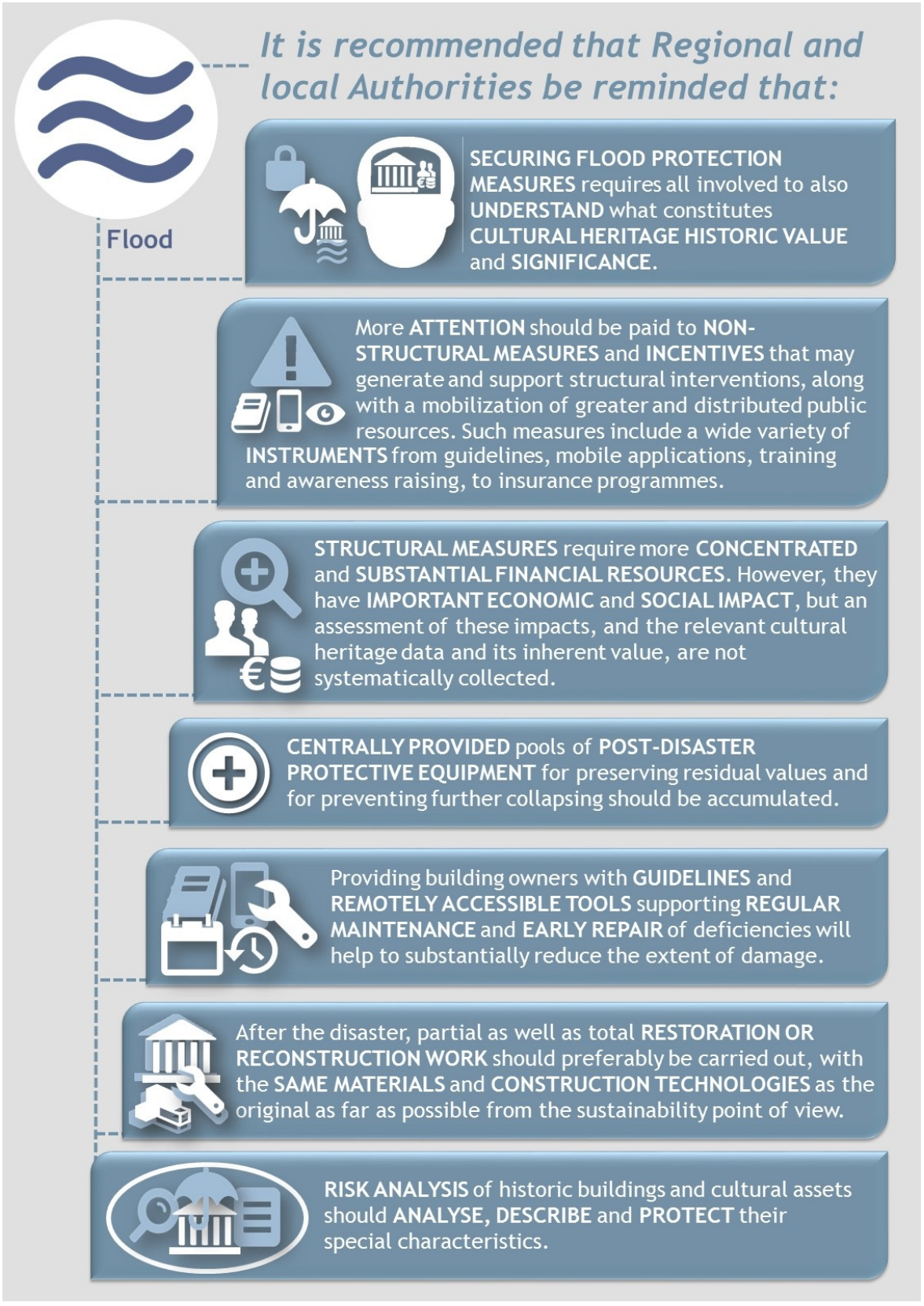

It is recommended that Operational Bodies and Owners be reminded that:
Climate Change
DEALING with identified CLIMATE DRIVERS causing deterioration is also dependant upon understanding the SENSITIVITY of the MATERIALS under attack, and the environmental context in which the heritage asset is located.
In the ASSESSMENT PROCESS:
Any CONSERVATION ACTIONS also need to be considered in relation to prevalent climate conditions.
ESTABLISHING PRIORITIES in relation to the CONSERVATION NEEDS of artefacts and assets should be considered in response to understanding the full effects of related climate change influences.
Adopting CONTINUOUS ENVIRONMENTAL MONITORING of prioritised climatic parameters close to the historic asset, and/or PLANNING SPECIFIC CHECKING of monthly or seasonal frequencies, can assist in defining risks in consequence of changing climatic effects.

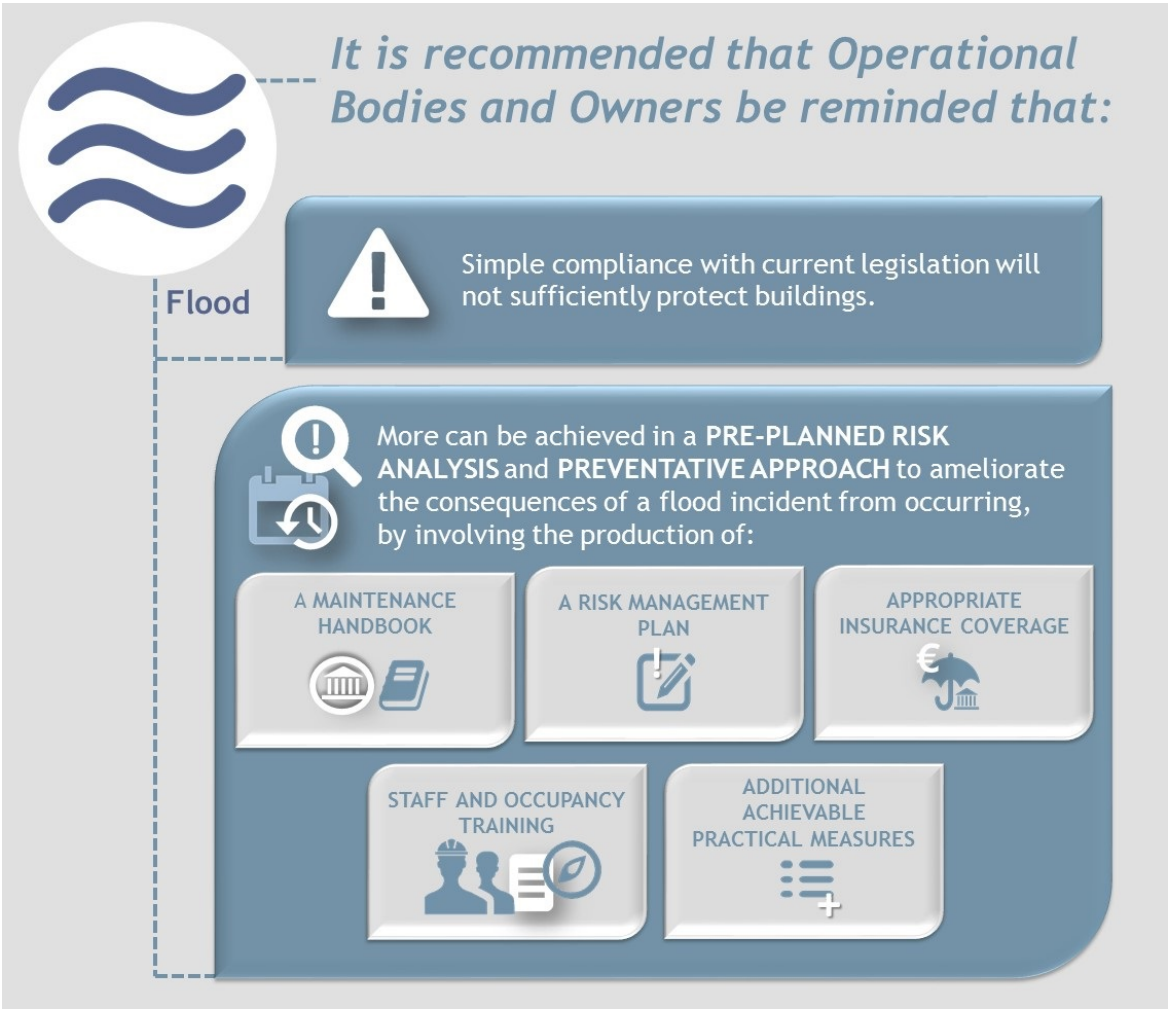
3.2.2. Flood

The action of floods on materials belonging to historical heritage, such as masonries, wooden and metal structures, can cause both physical and chemical deterioration processes (due to the water penetration producing the variation of moisture content).

The main effects on historical materials, caused by flood, are shown below.

MASONRIES, NATURAL AND ARTIFICIAL STONE MONUMENTS AND WORKS-OF-ART	
EFFECTS	***DESCRIPTION***
Erosion	Due to the mechanical action of water and eventual debris carried by flood (e.g. in case of river and coastal/sea flood, e.g. mud-flood);
Damage due to horizontal static pressure of raised water	It typically destroys light shutters of building openings, e.g. doors and windows, especially glazing, and it can destroy freestanding walls and fences, in many cases together with dynamic action of streams and flows.
Saturation of materials with water	It causes a wide variety of actions and damage related to volumetric changes, chemical action, loss of strength, etc.
Wet-dry cycles/Salts weathering	Cyclical absorption and desorption of moisture in a building material, responsible of salt crystallisation problems: efflorescence (on surfaces) and/or subflorescence (beneath surfaces). They can cause cracks, fractures, detachments and loss of materials (Grossi et al., 2011; Arnold and Zehnder, 1989).
Structural problems	Hydrostatic pressure can uplift floors or whole objects, decreases their stability against overturning and facilitates their damage by horizontal forces;
	Dynamic low velocity stream action is typically observed inside closed buildings where floated objects move and are displaced;
	Collapse of historic retaining walls: long lasted action can even wash out subsoil or clay mortar from masonry;
	Dynamic high velocity stream action represents one of the most dangerous actions on structures and it is responsible for the majority of severe damage on bridges, on earth structures, (e.g. dams), destruction of masonry by washing out joint mortars (the effect can be worsened by the effect of also water pollution)
WOODEN STRUCTURES	
EFFECTS	***DESCRIPTION***
Swelling and shrinkage	The variations of relative humidity, especially relevant for wooden objects inside buildings, cause a dimensional change within the structures, which can lead to irreversible deformation or mechanical damages.
Biodeterioration	The attack by wood-degrading fungi, mainly relevant for wooden structure exposed to outdoor weather, where wood is wet for sufficiently long periods and mould can grow. Thus, it depends jointly by precipitation amount, temperature and exposure (Sabbioni et al. 2012)
	The increasing rainfall and humid conditions raising the spectre of damage to fabrics or furniture, while enhancing insect growth (Brimblecombe, 2014).
METALS STRUCTURES AND ARTEFACTS	
EFFECTS	***DESCRIPTION***
Atmospheric Corrosion	This is influenced by the following main environmental degradation factors: • Climatic parameters • Gaseous air pollutants • Particulate air pollutants • Acid rain According to Sabbioni et al. (2012) the atmospheric corrosion of metals in inland areas is expected to increase in Northern Europe and decrease in Southern Europe. In coastal areas, where corrosion is higher due to the effect of chloride deposition, it is expected to be intensified all over Europe due to the increased temperature (T). For instance: - The combined effect of T and SO_2 pollution, is responsible of carbon steel and bronze corrosion (e.g. on bronze, according to the different exposure to rainfall, the alteration patterns could be formed by cuprum and calcium sulphates and cuprum oxalates, Morigi, 2000); - The combined effect of T and chloride deposition, including windborne sea salt aerosol, is responsible of zinc, lead and steady state copper corrosion.


It is recommended that Regional and local Authorities be reminded that:
Flood
SECURING FLOOD PROTECTION MEASURES requires all involved to also UNDERSTAND what constitutes CULTURAL HERITAGE HISTORIC VALUE and SIGNIFICANCE.
More ATTENTION should be paid to NON-STRUCTURAL MEASURES and INCENTIVES that may generate and support structural interventions, along with a mobilization of greater and distributed public resources. Such measures include a wide variety of INSTRUMENTS from guidelines, mobile applications, training and awareness raising, to insurance programmes.
STRUCTURAL MEASURES require more CONCENTRATED and SUBSTANTIAL FINANCIAL RESOURCES. However, they have IMPORTANT ECONOMIC and SOCIAL IMPACT, but an assessment of these impacts, and the relevant cultural heritage data and its inherent value, are not systematically collected.
CENTRALLY PROVIDED pools of POST-DISASTER PROTECTIVE EQUIPMENT for preserving residual values and for preventing further collapsing should be accumulated.
Providing building owners with GUIDELINES and REMOTELY ACCESSIBLE TOOLS supporting REGULAR MAINTENANCE and EARLY REPAIR of deficiencies will help to substantially reduce the extent of damage.
After the disaster, partial as well as total RESTORATION OR RECONSTRUCTION WORK should preferably be carried out, with the SAME MATERIALS and CONSTRUCTION TECHNOLOGIES as the original as far as possible from the sustainability point of view.
RISK ANALYSIS of historic buildings and cultural assets should ANALYSE, DESCRIBE and PROTECT their special characteristics.


It is recommended that Operational Bodies and Owners be reminded that:
Flood
Simple compliance with current legislation will not sufficiently protect buildings.
More can be achieved in a PRE-PLANNED RISK ANALYSIS and PREVENTATIVE APPROACH to ameliorate the consequences of a flood incident from occurring, by involving the production of:
A MAINTENANCE HANDBOOK
A RISK MANAGEMENT PLAN
APPROPRIATE INSURANCE COVERAGE
STAFF AND OCCUPANCY TRAINING
ADDITIONAL ACHIEVABLE PRACTICAL MEASURES

Technical recommendations related to physical critical elements in facing Flood

3.2.3. Fire due to drought

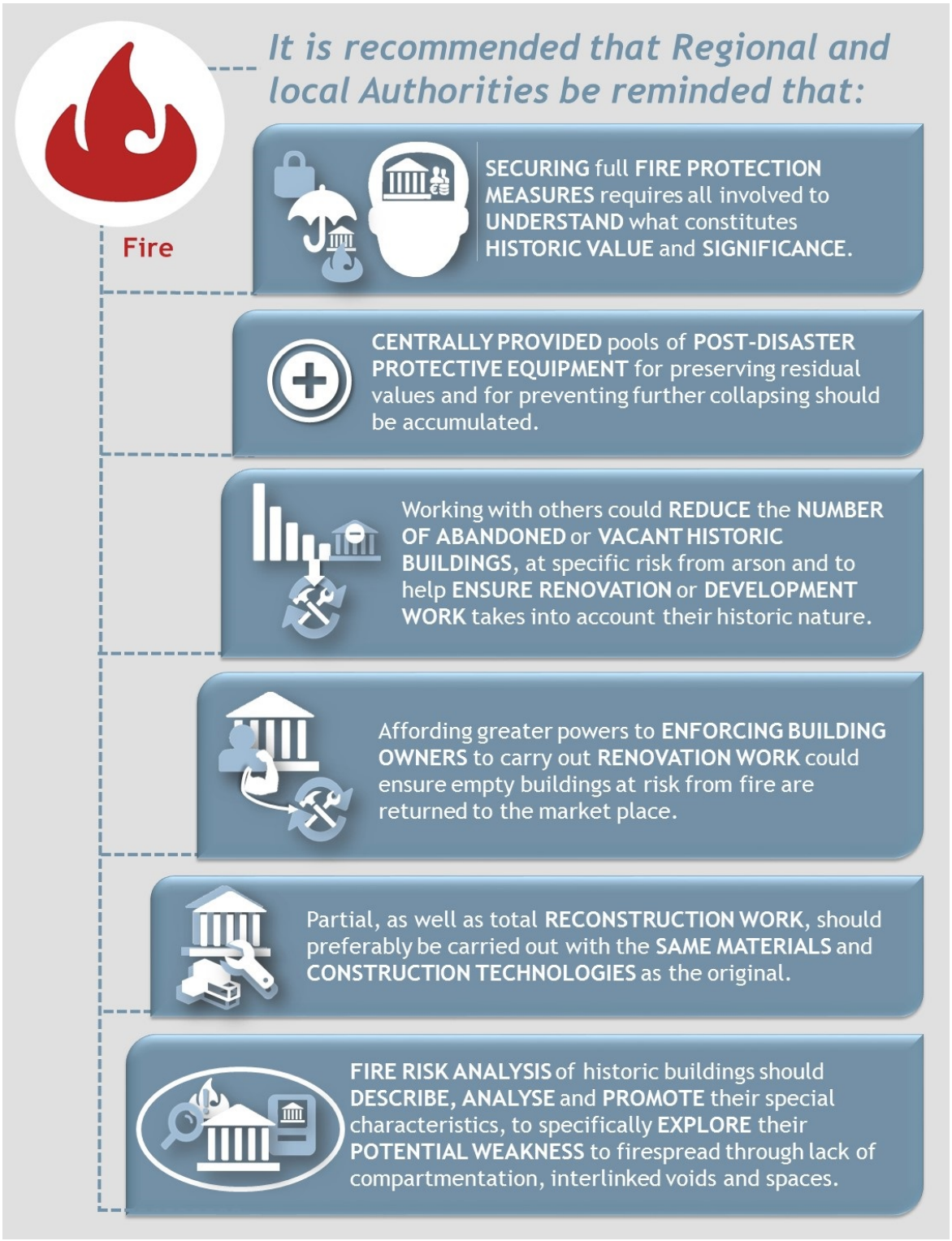
Fire propagation can be enhanced by prolonged period of warm spells and drought, which in turn can cause other previous alterations in the materials making them more prone to fire risk, such as the variation of moisture content in the structures, drying the materials, etc.. Furthermore, warm spells and drought can weak the materials also leading to:

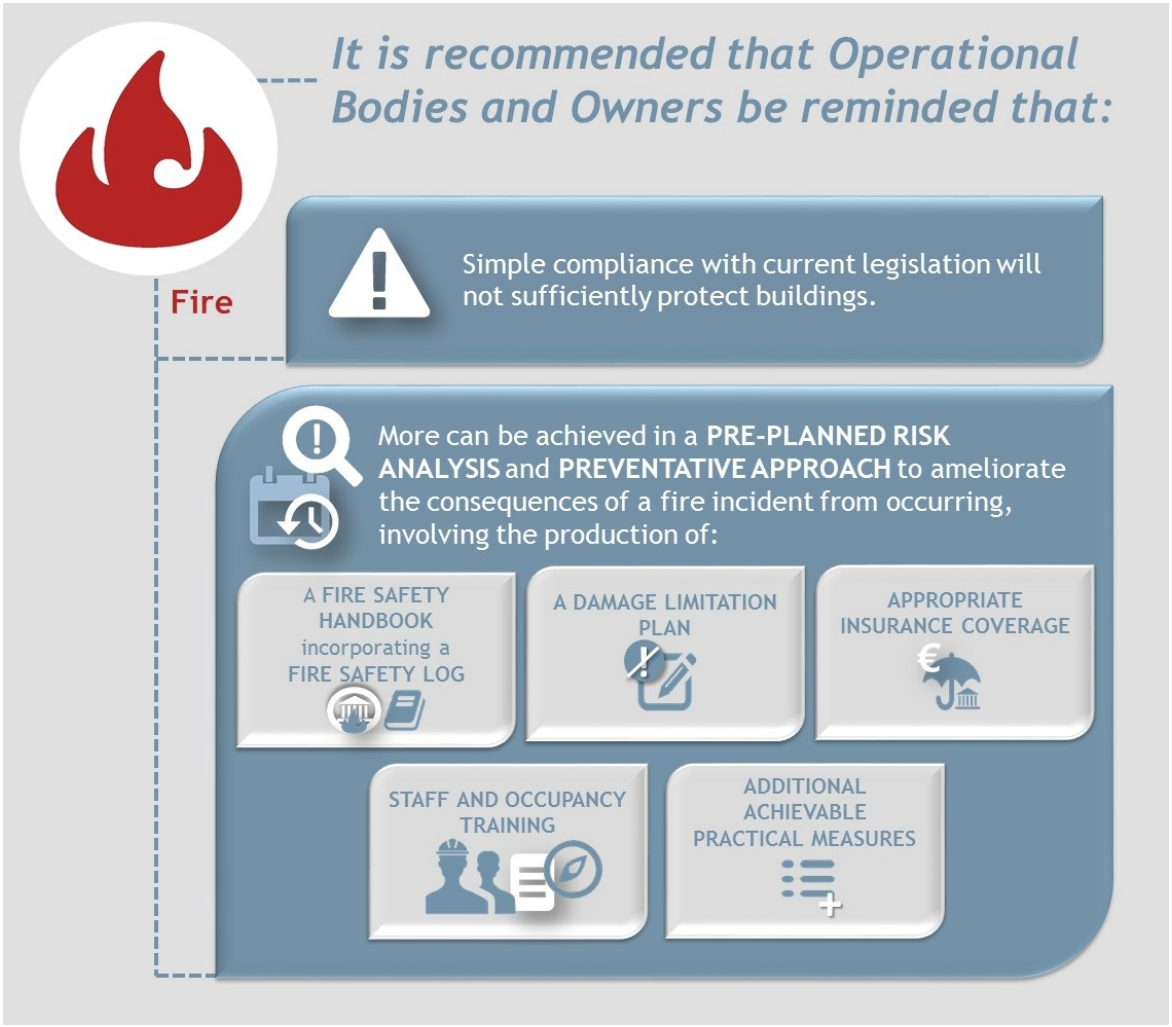
- *Thermoclastism*: Process caused by differential thermal expansion and contraction of surface mineral grains and interstitial salt deposits in response to long- and short-term temperature fluctuations at the material surface, due to solar radiation effect (Bonazza et al., 2009b).

- *Wet-dry cycles/Salts weathering*: Cyclical absorption and desorption of moisture in a building material, responsible of salt crystallisation problems: efflorescence (on surfaces) and/or subflorescence (beneath surfaces). They can cause cracks, fractures, detachments and loss of materials (Grossi et al., 2011; Arnold and Zehnder, 1989).

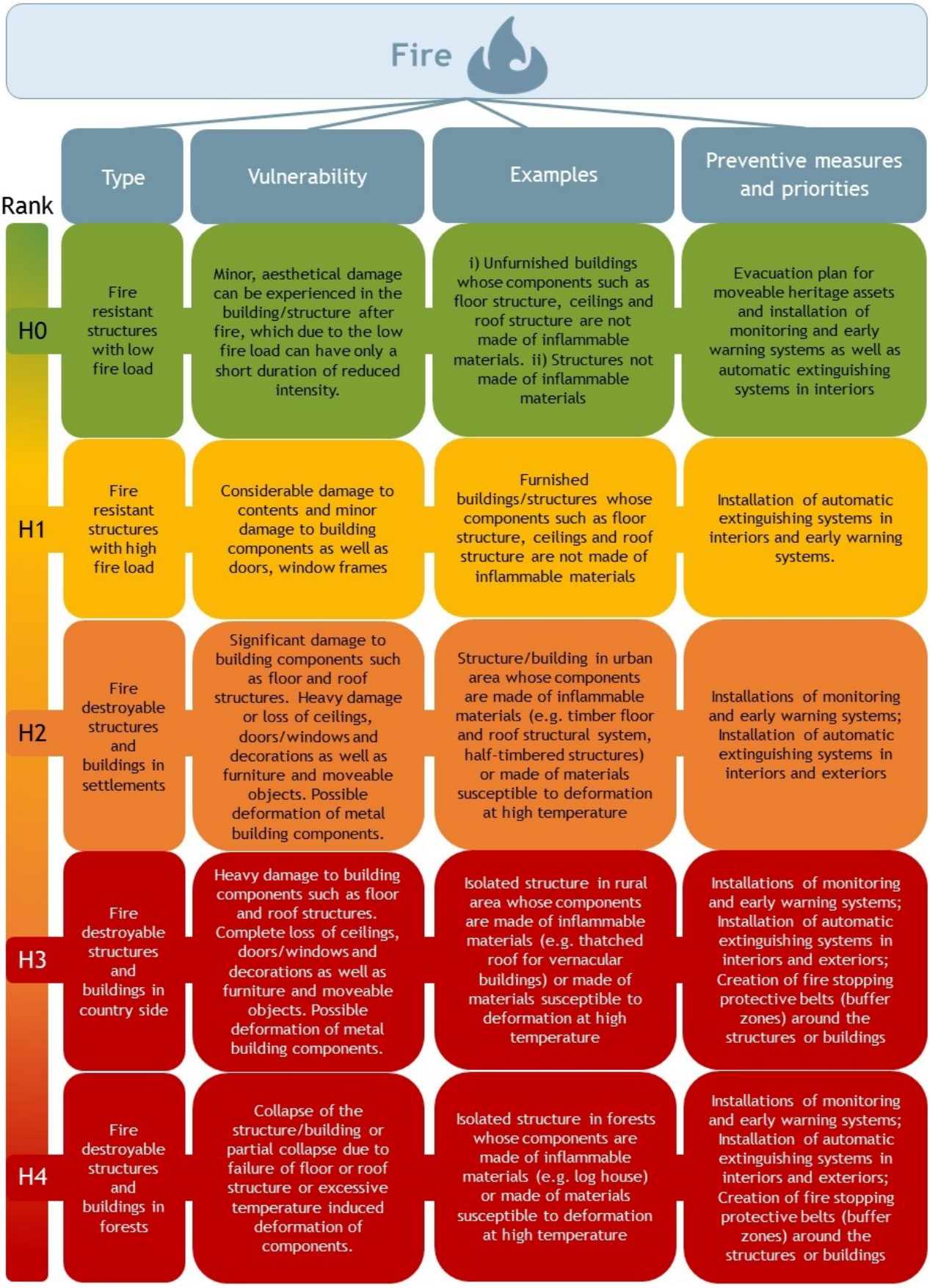
The main effects on historical materials, caused by fire, are shown below.

MASONRIES, NATURAL AND ARTIFICIAL STONE MONUMENTS AND WORKS-OF-ART	
EFFECTS	***DESCRIPTION***
Macro-decay	*Cracking* of stone at high temperatures;
	Coating by soot;
	Colour change in stones containing iron;
Micro-decay	Mineralogical and textural changes, which can lead to subsequent processes that act at a greater scale, as changes in porosity, mineralogy and micro-cracking.
Structural instability of the stone	Main effects that fire has in porous materials with an intergranular matrix (mainly sandstones) are related to chemical changes within the matrix (clay minerals are especially sensitive to temperature increase).
	In dense materials (low porous materials) the breakdown of stone due to fire is evident.
Material deformation	Spalling and loss of material.
Longer-term effects	Patterns of decay may be influenced by a combination of weaknesses inherited from the fire with background environmental factors like salt-weathering/temperature cycling (Gomez-Heras et al., 2009)
WOODEN STRUCTURES	
EFFECTS	***DESCRIPTION***
Material loss	It can be referred to a part or to the entire structure depending on the fire extent and the structure features.
METALS STRUCTURES AND ARTEFACTS	
EFFECTS	***DESCRIPTION***
Material loss	It can be referred to a part or to the entire structure depending on the fire extent and the structure features.


It is recommended that Regional and local Authorities be reminded that:
Fire
SECURING full FIRE PROTECTION MEASURES requires all involved to UNDERSTAND what constitutes HISTORIC VALUE and SIGNIFICANCE.
CENTRALLY PROVIDED pools of POST-DISASTER PROTECTIVE EQUIPMENT for preserving residual values and for preventing further collapsing should be accumulated.
Working with others could REDUCE the NUMBER OF ABANDONED or VACANT HISTORIC BUILDINGS, at specific risk from arson and to help ENSURE RENOVATION or DEVELOPMENT WORK takes into account their historic nature.
Affording greater powers to ENFORCING BUILDING OWNERS to carry out RENOVATION WORK could ensure empty buildings at risk from fire are returned to the market place.
Partial, as well as total RECONSTRUCTION WORK, should preferably be carried out with the SAME MATERIALS and CONSTRUCTION TECHNOLOGIES as the original.
FIRE RISK ANALYSIS of historic buildings should DESCRIBE, ANALYSE and PROMOTE their special characteristics, to specifically EXPLORE their POTENTIAL WEAKNESS to firespread through lack of compartmentation, interlinked voids and spaces.


It is recommended that Operational Bodies and Owners be reminded that:
Fire
Simple compliance with current legislation will not sufficiently protect buildings.
More can be achieved in a PRE-PLANNED RISK ANALYSIS and PREVENTATIVE APPROACH to ameliorate the consequences of a fire incident from occurring, involving the production of:
A FIRE SAFETY HANDBOOK incorporating a FIRE SAFETY LOG
A DAMAGE LIMITATION PLAN
APPROPRIATE INSURANCE COVERAGE
STAFF AND OCCUPANCY TRAINING
ADDITIONAL ACHIEVABLE PRACTICAL MEASURES

Technical recommendations related to physical critical elements in facing Fire



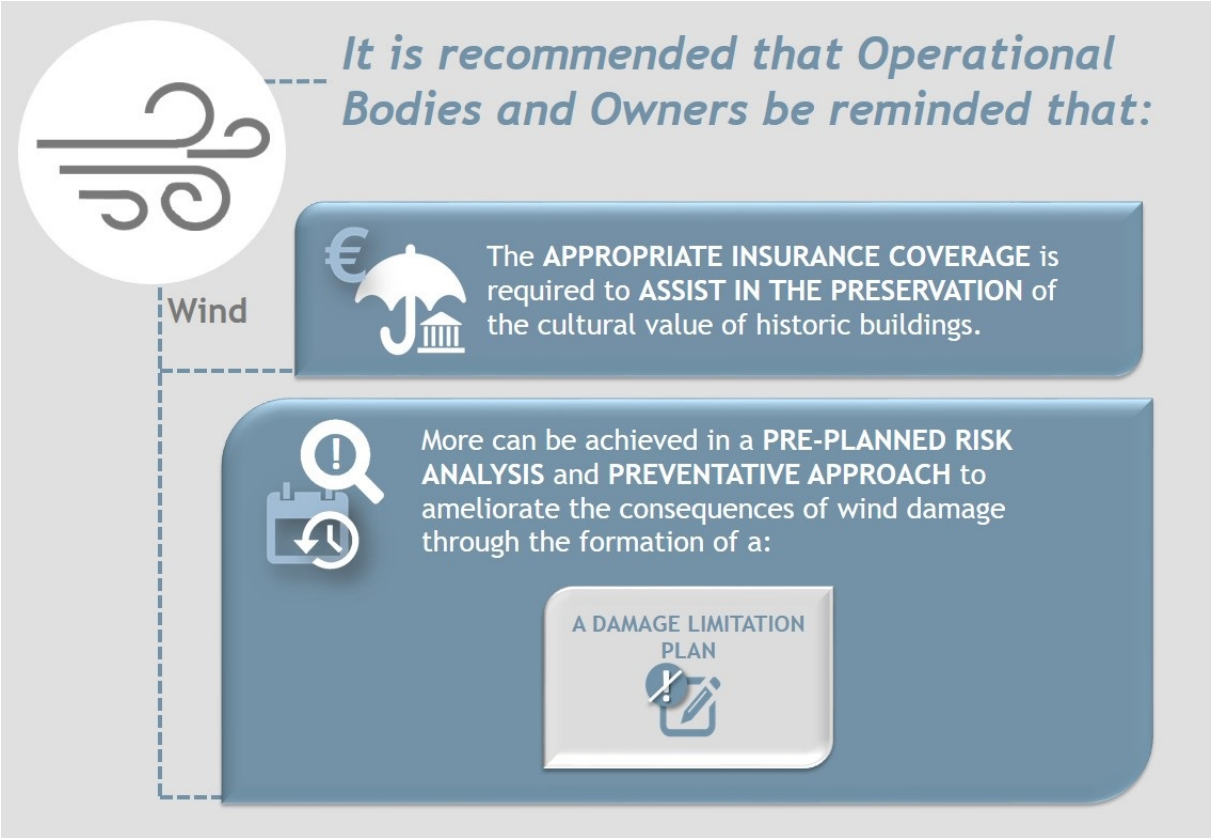
3.2.4. Wind

The wind action can be responsible of structural problems of heritage, but can enhance other phenomena in conjunction with other deterioration factors (e.g. concurrence of rain, pollutants, etc.).

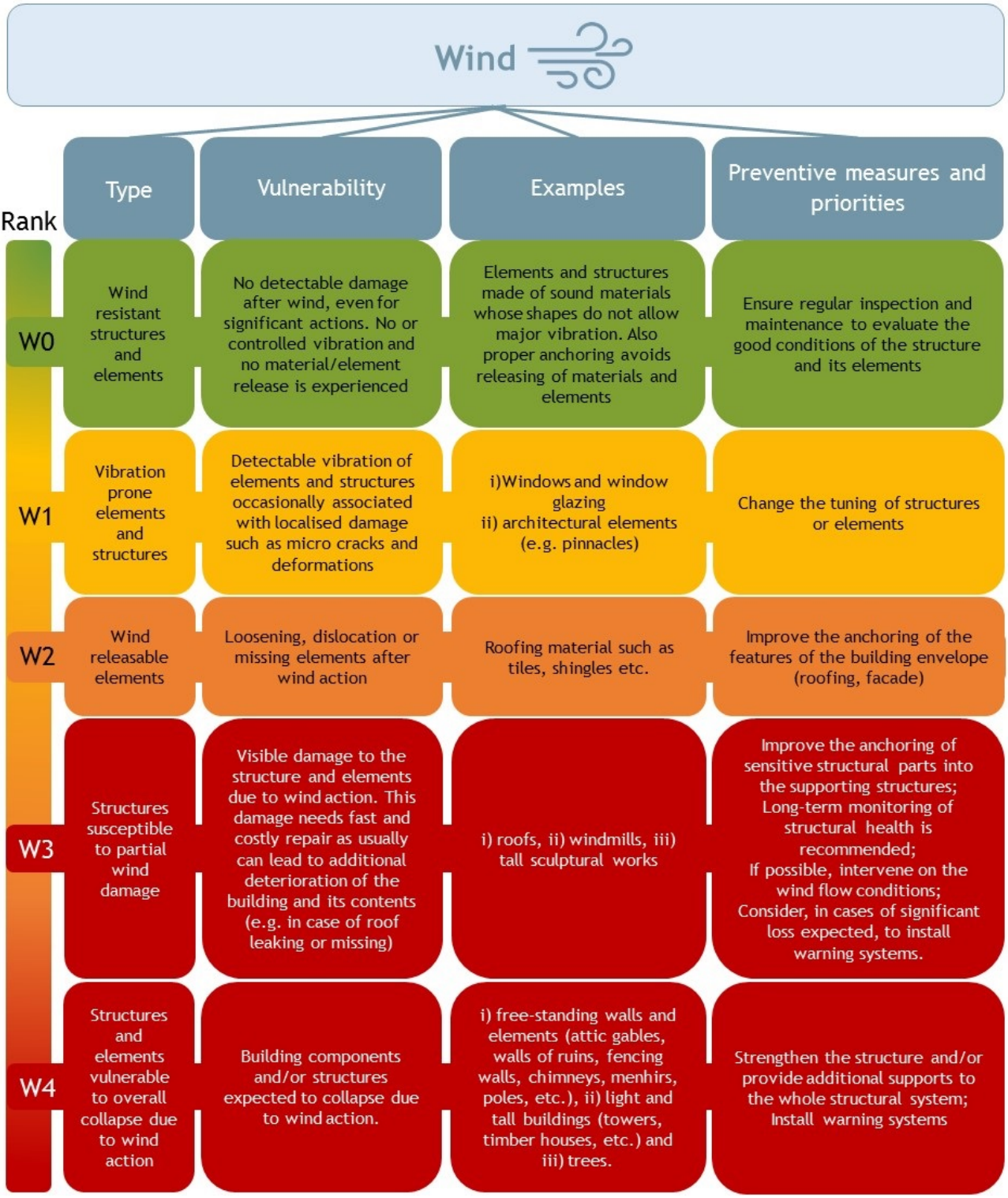
The main effects on historical materials, caused by wind, are shown below.

MASONRIES, NATURAL AND ARTIFICIAL STONE MONUMENTS AND WORKS-OF-ART & WOODEN STRUCTURES	
EFFECTS	***DESCRIPTION***
Erosion	Due to the mechanical action of wind and eventual rain (wind-driven-rain action) or soil dust, which can worsen the effect of the erosion.
Damage due to pressure and vibrations	The effect of wind load can cause cracks, fractures, loss of material; leading also to elements failure until collapse of parts or of entire monuments.
METALS STRUCTURES AND ARTEFACTS	
EFFECTS	***DESCRIPTION***
Atmospheric Corrosion	The wind can carry the following main environmental degradation factors: ● Climatic parameters ● Gaseous air pollutants ● Particulate air pollutants ● Acid rain According to Sabbioni et al. (2012) the atmospheric corrosion of metals in inland areas is expected to increase in Northern Europe and decrease in Southern Europe. In coastal areas, where corrosion is higher due to the effect of chloride deposition, it is expected to be intensified all over Europe due to the increased temperature (T). For instance: - The combined effect of T and SO_2 pollution, is responsible of carbon steel and bronze corrosion (e.g. on bronze, according to the different exposure to rainfall, the alteration patterns could be formed by cuprum and calcium sulphates and cuprum oxalates, Morigi, 2000); - The combined effect of T and chloride deposition, including windborne sea salt aerosol, is responsible of zinc, lead and steady state copper corrosion.

Managerial recommendations


It is recommended that Operational Bodies and Owners be reminded that:
Wind
The APPROPRIATE INSURANCE COVERAGE is required to ASSIST IN THE PRESERVATION of the cultural value of historic buildings.
More can be achieved in a PRE-PLANNED RISK ANALYSIS and PREVENTATIVE APPROACH to ameliorate the consequences of wind damage through the formation of a:
A DAMAGE LIMITATION PLAN

Technical recommendations related to physical critical elements in facing Wind



3.2.5. Heavy rain

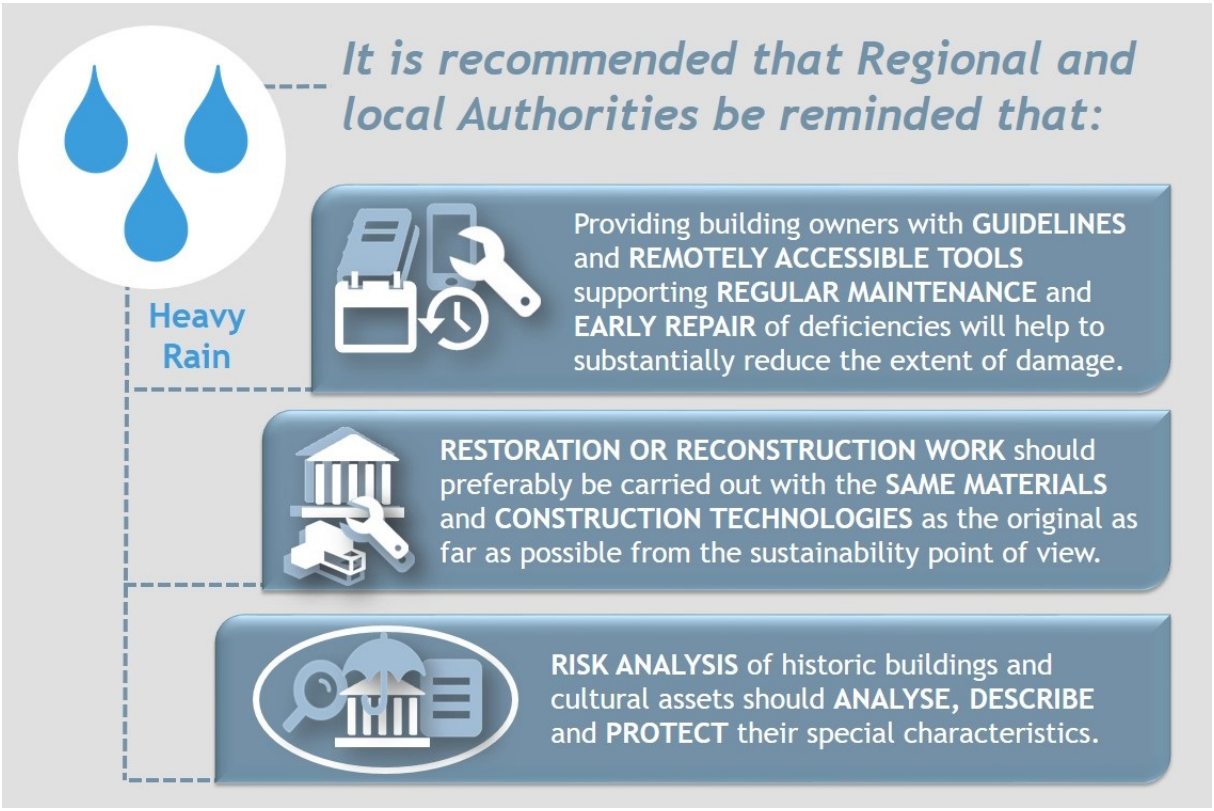
Heavy rain can cause to the materials belonging to cultural heritage both physical and chemical deterioration processes (due to the prolonged exposure to rain that increases the presence of moisture in the structures).

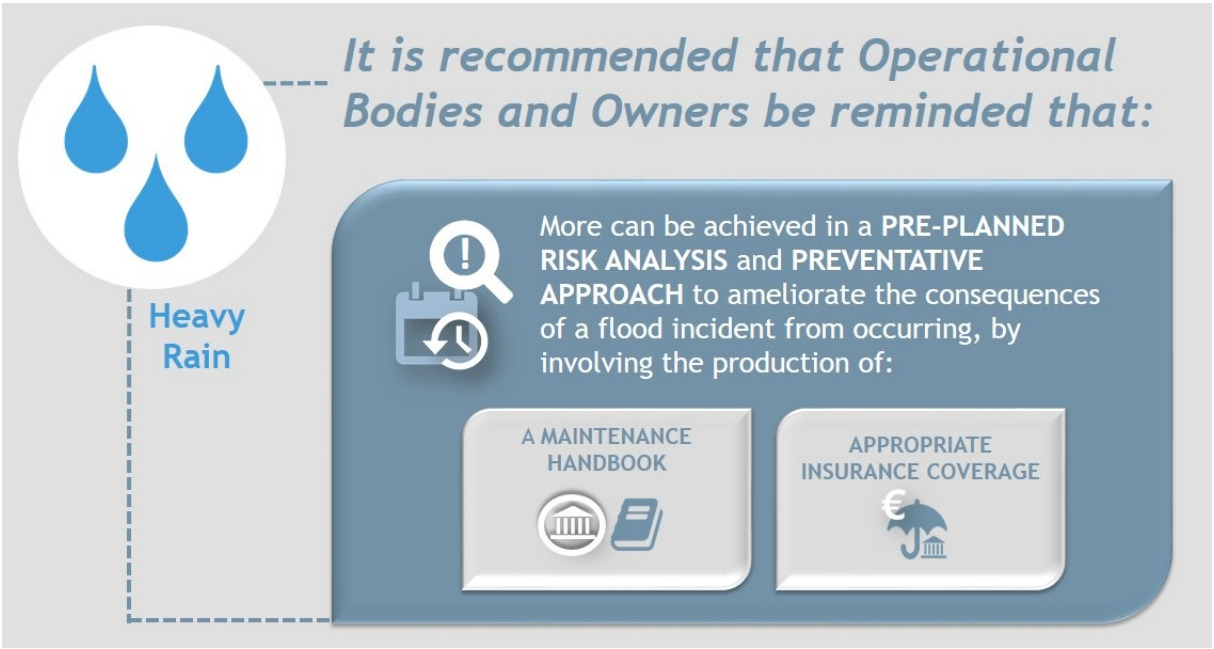
The main effects on historical materials, caused by heavy rain, are shown below.

MASONRIES, NATURAL AND ARTIFICIAL STONE MONUMENTS AND WORKS-OF-ART	
EFFECTS	***DESCRIPTION***
Erosion	The mechanical action of wind driven rain can cause loss of material.
Wet-dry cycles/Salts weathering	Cyclical absorption and desorption of moisture in a building material, responsible of salt crystallisation problems: efflorescence (on surfaces) and/or subflorescence (beneath surfaces). They can cause cracks, fractures, detachments and loss of materials (Grossi et al., 2011; Arnold and Zehnder, 1989).
Freeze-thaw cycles	Cyclical formation of ice crystals when temperature fluctuates above and below 0 °C, which can cause cracks, fractures, detachments and loss of materials (Sabbioni et al., 2012).
Biological growth	The persistent presence of humidity, in conjunction with favourable temperature and substrate conditions, can foster the biological colonization (mold, moss, lichens, algae, fungi and even vascular plants) (Gomez-Bolea, 2012; Caneva et al., 2009).
Surface recession	On areas exposed to rain wash out, loss of material, in terms of recession of the surface, can occur. It is due to chemical attack induced by the effect of clean rain (karst effect), acid rain (due to presence of sulphuric and nitric acid) and dry deposition of gaseous pollutants (especially SO_2 and NO_X). It occurs between precipitation events, mainly affecting carbonate stones of low porosity (marbles and compact limestones) (Bonazza et al., 2009a).
Soiling	Deposit of soot that can change the colour of architectonical surfaces, depending on its nature (e.g. diesel soot in proximity of a busy road can blacken the surfaces of buildings). This has an aesthetic impact, depending on the direction and the magnitude of colour change, indeed the rain-washing can lead to disfiguring patterns on cultural surfaces. It can have also economic implications due to changes in the approach to cleaning and maintaining buildings (Sabbioni et al., 2012; Brimblecombe and Grossi, 2005).
Black-crusts formation	The deposit of soot can originate, on areas partially protected against direct rainfall or water runoff in urban environment, black crusts. They are formed by gypsum (that is calcium sulphate, through the sulphation process of the calcium carbonate substrate), which traps particles from the atmosphere. (Ruffolo, 2015; La Russa et al., 2013; Török, 2003).
Eventual structural problems	In conjunction with the surroundings, heavy rainfall can also lead to landslides and ground instability, thus consequently structural instability for the whole heritage complex.
WOODEN STRUCTURES	
EFFECTS	***DESCRIPTION***
Swelling and shrinkage	The variations of relative humidity, especially relevant for wooden objects inside buildings, cause a dimensional change within the structures, which can lead to irreversible deformation or mechanical damages.
Biodeterioration	The attack by wood-degrading fungi, mainly relevant for wooden structure exposed to outdoor weather, where wood is wet for sufficiently long periods and mould can grow. Thus, it depends jointly by precipitation amount, temperature and exposure (Sabbioni et al. 2012)
	The increasing rainfall and humid conditions raising the spectre of damage to fabrics or furniture, while enhancing insect growth (Brimblecombe, 2014).
METALS STRUCTURES AND ARTEFACTS	
EFFECTS	***DESCRIPTION***
Atmospheric Corrosion	This is influenced by the following main environmental degradation factors: • Climatic parameters • Gaseous air pollutants • Particulate air pollutants • Acid rain According to Sabbioni et al. (2012) the atmospheric corrosion of metals in inland areas is expected to increase in Northern Europe and decrease in Southern Europe. In coastal areas,

	where corrosion is higher due to the effect of chloride deposition, it is expected to be intensified all over Europe due to the increased temperature (T). For instance: - The combined effect of T and SO_2 pollution, is responsible of carbon steel and bronze corrosion (e.g. on bronze, according to the different exposure to rainfall, the alteration patterns could be formed by cuprum and calcium sulphates and cuprum oxalates, Morigi, 2000); - The combined effect of T and chloride deposition, including windborne sea salt aerosol, is responsible of zinc, lead and steady state copper corrosion.

Managerial recommendations





Technical recommendations related to physical critical elements in facing Heavy Rain

3.3. GOOD PRACTICES

In the last few years, some projects, initiatives, strategies and tools have been carried out in the field of mitigation and adaptation to face up future climate change pressures. In the following paragraphs, examples are reported.

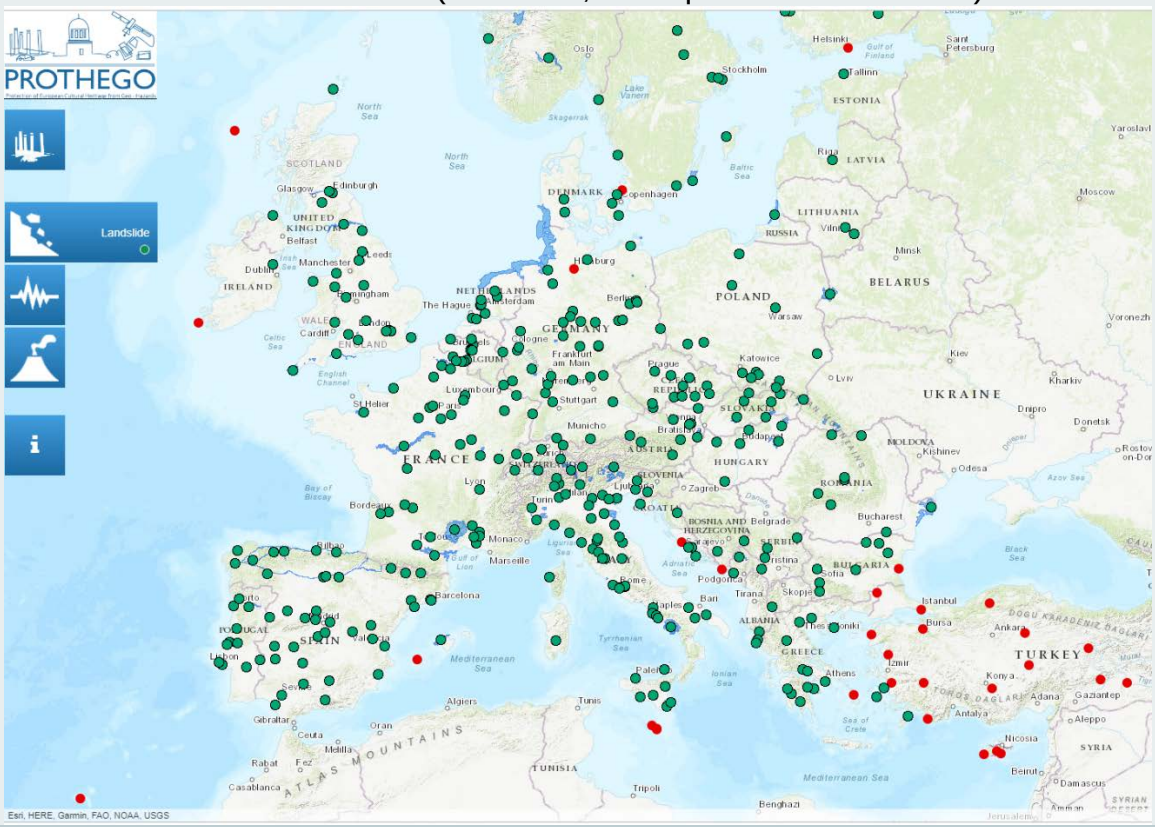
PROJECTS

Considering projects, in terms of European Founded Projects, examples are given as follows:

Mapping the exposure risk of CH

The PROTHEGO Project[8] (PROTection of European Cultural HEritage from GeO-hazards) funded in the framework of the Joint Programming Initiative on Cultural Heritage and Global Change (JPICH), within the HERITAGE PLUS, an ERA-NET plus action (www.prothego.eu). Within this project tangible cultural heritage was considered, impacted and weathered by several internal and external factors, with both rapid and slow onset, including natural hazards, such as landslides, sinkholes, settlement, subsidence or earthquakes or extreme meteorological events, all of which could be worsened by climate change and human interaction.

In addition to the deliverables produced during the Project (downloadable at http://www.prothego.eu/downloads.html), PROTHEGO developed an interesting map viewer, which allows end-users to visualize all the UNESCO sites located in Europe and their exposure to three differnt hazards (volcanoes, earthquakes and landslides).



[8] http://www.prothego.eu/

Platforms for a more resilient heritage

The aim of **H2020 HERACLES**[9] (HEritage Resilience Against CLimate Events on Site) is to design, validate and promote responsive systems/solutions for effective resilience of CH against climate change effects. For pursuing these objectives, a system exploiting an **ICT** (Information and Communications Technology) **platform** able to collect and integrate multisource information will be developed, in order to effectively provide complete and updated situational awareness and support decision for innovative measurements improving CH resilience, including new solutions for maintenance and conservation. Furthermore, the HERACLES effectiveness will be ensured by the design and validation of manageable methodologies also for the definition of operational procedures and guidelines for risk mitigation and management.

The **H2020 STORM** [10] Project (Safeguarding Cultural Heritage through Technical and Organisational Resources Management) is building new technologies and processes to better protect and preserve Europe's cultural heritage against the threats of climate change and natural hazards. In particular, one of the aims of this research work is to realize an **integrated framework and a platform** providing tools and services both at macro (global) and specific level for a more resilient European cultural patrimony (http://www.storm-project.eu/achievements/platform/).

PreventionWeb is a collaborative knowledge sharing platform on disaster risk reduction (DRR), managed by the UN Office for Disaster Risk Reduction (UNISDR). The site offers a range of knowledge products and services to facilitate the work of DRR professionals. In particular, within the section "Themes", there is the part dedicated to Cultural Heritage[11], where the latest additions on the thematic of DDR and Cultural Heritage are promoted.

Supporting decision tool for the safeguarding of CH

The main objective of **ResCult**[12] (Increasing Resilience of Cultural heritage) is to enhance the capability of Civil Protection (CP) to prevent and mitigate impacts of disasters on sites of Cultural Heritage (CH). This will be carried out through the realization of an **integrated European Interoperable Database** (EID) for CH, designed to provide a unique framework for CP, national Ministries of CH, the European Union (EU), local authorities. Moreover, ResCult will provide a **disaster risk reduction strategy identifying tailored actions and investments** to improve both prevention and resilience capacities.

Learning from the past for a more resilient future

COORDINATINGforLIFE[13] is an ERC funded project, which illustrates the success and failure of Western European societies in coping with rural hazards and disasters, (1300-1800). It aims to explain why some societies do well in preventing or remedying disasters through

[9] http://www.heracles-project.eu/

[10] http://www.storm-project.eu

[11] https://www.preventionweb.net/themes/view/729#hits=20&sortby=default&view=pw&filter=themes%3A%5E%22Cultural+Heritage%22%24

[12] https://www.rescult-project.eu/

[13] https://cordis.europa.eu/project/rcn/111456_it.html; https://erc.europa.eu/projects-figures/stories/eu-research-and-innovation-for-more-resilient-cultural-heritage

institutional arrangements and others not, thus evaluating **organizational capacities of a society, both in mitigation and recovery**.

HANDBOOKS and TOOLKITS

First Aid to Cultural Heritage

ICCROM and the Prince Claus Fund have published an innovative handbook[14] and toolkit[15] on First Aid to Cultural Heritage in Times of Crisis, created for the various actors involved in an emergency.
Dissemination resource handbook and toolkit from response to resilience
https://www.iccrom.org/news/pioneering-resource-first-aid-cultural-heritage-now-available

[14] https://www.iccrom.org/sites/default/files/2018-10/fac_handbook_print_oct-2018_final.pdf

[15] https://www.iccrom.org/sites/default/files/2018-10/fac_toolkit_print_oct-2018_final.pdf

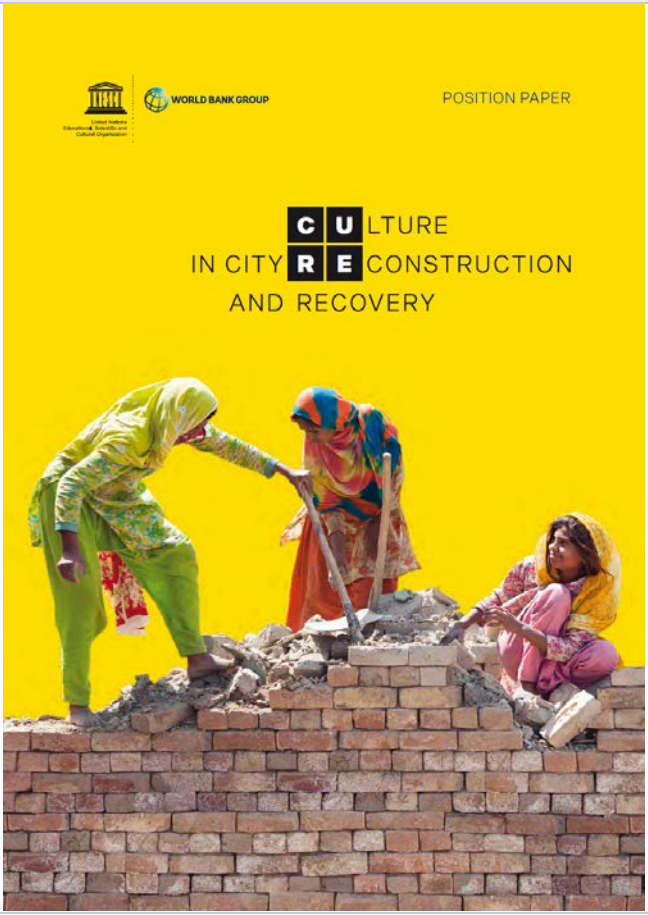
Emergency Evacuation of Heritage Collections

The publication entitled "Endangered Heritage -Emergency Evacuation of Heritage Collections" [16], realized by UNESCO and ICCROM, provides a step-by-step guidance for evacuating cultural collections under extreme conditions (mainly addressed for CH exposed to an armed conflict, but applicable also to other situations). It is meant to assist those communities and institutions, which are trying to prevent the destruction and looting of cultural objects during a crisis situation.

[16] http://unesdoc.unesco.org/images/0024/002466/246684E.pdf

Reconstruction and Recovery

UNESCO and World Bank recently presented a publication entitled "Culture in City Reconstruction and Recovery (CURE)"[17], which offers an enhanced culture-based framework for city reconstruction and recovery that integrates both people-centered and place-based approaches.



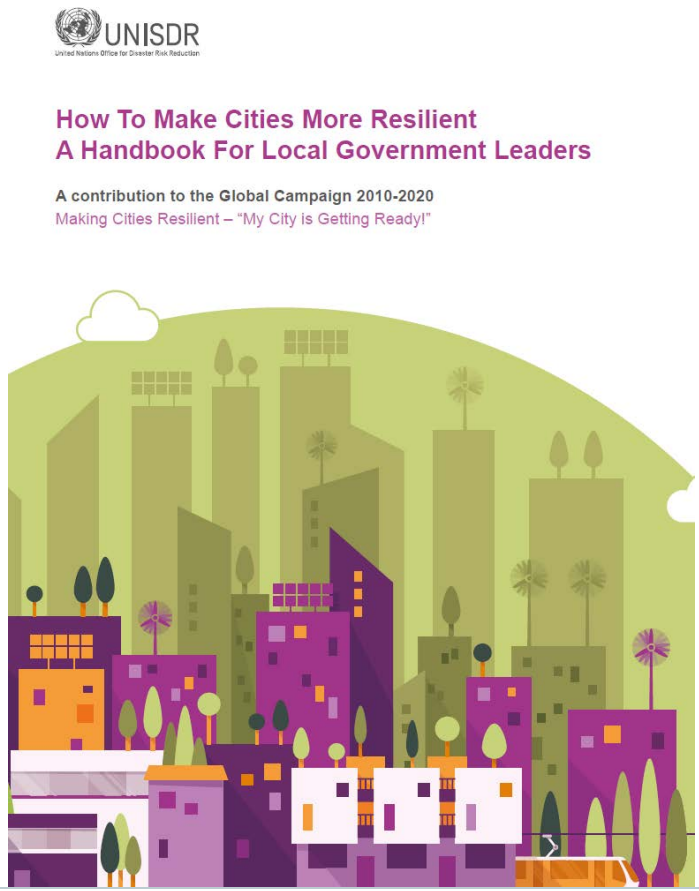
[17] http://unesdoc.unesco.org/images/0026/002659/265981e.pdf

Making Cities Resilient

The **Making Cities Resilient: "My city is getting ready!"** is a campaign, which addresses local risk governance, urban risk and resilience. Launched in May 2010, it will continue beyond 2020. The Campaign is led by the UNISDR but it is self-motivating, partnership and city-driven with an aim to raise the profile of resilience and disaster risk reduction among local governments and urban communities worldwide.

The choice of making cities resilient was driven the fact that "they serve as a nations' economic engine, being centres of technology and innovation, and are **living evidence of our cultural heritage**."

The campaign produced also a handbook for Local Government Leaders [2017 latest edition[18]], which seeks to support public policy and decision making in implementing activities to reduce disaster risk and build resilience.



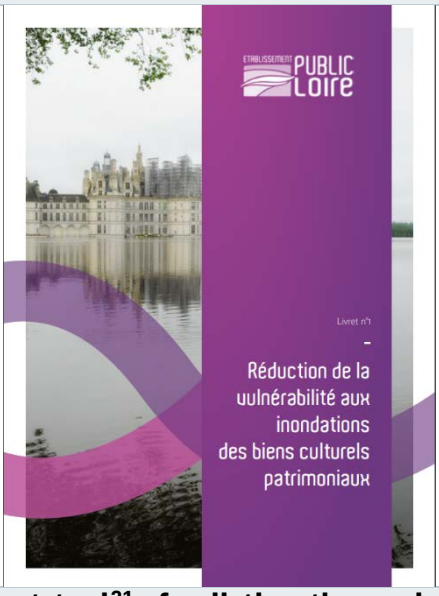
[18] https://www.unisdr.org/campaign/resilientcities/assets/documents/guidelines/Handbook%20for%20local%20government%20leaders%20%5B2017%20Edition%5D.pdf

Dissemination and tools against flood hazard

The Loire River Basin Authority has developed three tools for helping to safeguard the heritage at risk of flooding:

1. **An exhibition "Heritage at risk of flooding: protected sites, safeguarded heritage"[19].**

2. **A booklet entitlied "Réduction de la vulnérabilité des biens culturels patrimoniaux sur le bassin de la Loire et ses affluents"[20].**



3. **A vulnerability self-assessment tool[21], for listing the various issues and developing tools aimed at limiting the damage wrought by floods as far as possible.**

[19] http://www.eptb-loire.fr/expo-patrimoineinondable/

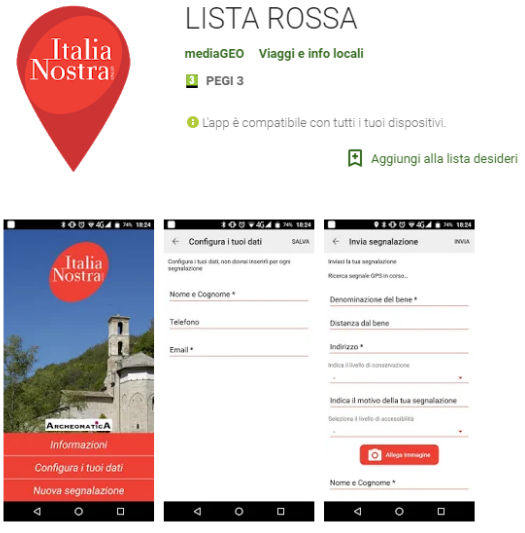
[20] http://www.eptb-loire.fr/wp-content/uploads/2017/07/Livret_n1_Biens-patrimoniaux.pdf

[21] http://autodiagnostic-patrimoine.eptb-loire.fr/

Dissemination and tools against flood hazard

CH preservation - Citizens involvement

The Italian association “Italia Nostra”, aimed at preserving the historical, artistic and natural heritage of Italy, has develop a free app for smartphone, called “Lista Rossa” (Red List), which enable citizens to point out heritage in danger, through pictures, authomatic georeferentiation and description of the state of conservation. Thanks to this tool, the association can verify the indicated heritage and eventually intervene.



Mitigation and Adaptation strategies

Italy has produced the National Strategy for the Adaptation to the Climate Changes (Strategia Nazionale per l'Adattamento ai Cambiamenti Climatici[22]), which has also Regional developments, as in Emilia-Romagna Region[23]. Both the strategies contains the reference to the cultural sector exposed to climate changes impact.

[22] http://www.pdc.minambiente.it/sites/default/files/allegati/strategia_nazionale_adattamenti_climatici.pdf

[23] http://ambiente.regione.emilia-romagna.it/sviluppo-sostenibile/temi/strategia-regionale-per-i-cambiamenti-climatici

REFERENCES

Arnold A., Zehnder K. 1989. Salt weathering on monuments, proceedings, I Simposio Internazionale Bari 7-10 giugno La conservazione dei monumenti nel bacino del Mediterraneo, pp.31-58.

Bonazza A., Maxwell I., Drdácký M., Vintzileou E., Hanus C., Ciantelli C., De Nuntiis P., Oikonomopoulou E., Nikolopoulou V, Pospíšil S., Sabbioni C., Strasser P. (2018) Safeguarding Cultural Heritage from Natural and Man-Made Disasters - A comparative analysis of risk management in the EU. Corporate Author(s): Directorate-General for Education, Youth, Sport and Culture (European Commission), 207 pp. ISBN 978-92-79-73945-3, (catalogue) NC-05-17-059-EN-N. DOI:10.2766/224310

Bonazza A., Messina P., Sabbioni C., Grossi C. M., Brimblecombe P. 2009a. Mapping the impact of climate change on surface recession of carbonate buildings in Europe. Science of the Total Environment 407, pp. 2039-2050.

Bonazza A., Sabbioni C., Messina P., Guaraldi C., De Nuntiis P., 2009b. Climate change impact: Mapping thermal stress on Carrara marble in Europe. Science of the Total Environment 407, pp.4506–4512.

Brimblecombe P., 2014. Refining climate change threats to heritage, Journal of the Institute of Conservation, 37:2, 85-93, DOI: 10.1080/19455224.2014.916226

Brimblecombe P., Grossi C.M., 2005. Aesthetic Threshold and blackening of stone buildings. Science of Total Environment 349:175-189.

Caneva G., Nugari M. P., Salvadori O., 2009. Plant Biology for Cultural Heritage: Biodeterioration and Conservation, ISBN 978-0-89236-939-3, Getty Conservation Institute.

Gomez-Bolea A., Llop E., Arino X., Saiz-Jimenez C., Bonazza A., Messina P., Sabbioni C., 2012. Mapping the impact of climate change on biomass accumulation on stone. J. Cult. Herit. 13 (3), 254–258.

Gomez-Heras M., McCabe S., Smith B. J. Fort R., 2009. Impacts of Fire on Stone-Built Heritage An Overview, Journal of Architectural Conservation, DOI: 10.1080/13556207.2009.10785047

Grossi C.M., Brimblecombe P., Menéndez B., Benavente D., Harris I., Déqué M. 2011. Climatology of salt transitions and implications for stone weathering. Science of the Total Environment 409, 2577–2585.

Sendai Framework for Disaster Risk Reduction: http://www.unisdr.org/we/coordinate/sendai-framework, last visit 8/11/2018.

La Russa M. F., Belfiore C. M., Comite V., Barca D., Bonazza A., Ruffolo S. A., Crisci G. M., Pezzino A., 2013. Geochemical study of black crusts as a diagnostic tool in cultural heritage, Applied Physics, 113, pp 1151–1162.

Morigi G., 2000. Il restauro del Perseo di Benvenuto Cellini, within “Meteo e Metalli, Conservazione e Restauro delle sculture all’aperto. Dal Perseo all’arte contemporanea.”, edited by Salvi A., Nardini Press.

Ruffolo S. A., Comite V., La Russa M. F., Belfiore C. M., Barca D., Bonazza A., Crisci G. M., Pezzino A., Sabbioni C., 2015. An analysis of the black crusts from the Seville Cathedral: A challenge to deepen the understanding of the relationships among microstructure, microchemical features and pollution sources, Science of The Total Environment, 502, pp. 157-166.

Sabbioni C., Brimblecombe P., Cassar M., 2012. The Atlas of Climate Change Impact on European Cultural Heritage Scientific Analysis and Management Strategies, Anthem Press.

Török Á., 2003. Surface strength and mineralogy of weathering crusts on limestone buildings in Budapest., Building and Environment 38,1185 – 1192.