CULTURAL HERITAGE RESILIENCE

Manual for Owners and Managers

Vulnerability self-assessment, criticality identification and resilience focused measures in emergency and disaster situations

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Contents

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Notes

1 Introduction

This manual was produced within the framework of the Interreg Central Europe project ProteCHt2save (Risk assessment and sustainable protection of Cultural Heritage in changing environment). Its main aim is to endorse the involvement of citizens and the general public in ensuring better preparedness of local communities concerned with crisis situations, in particular natural disasters. It provides advice to lay users, such as heritage owners, on how to inspect and assess the vulnerability of their properties while enabling them to identify criticalities that can be treated to reduce the impact of catastrophic events. The information provided includes instructions related to measures that can be implemented in various disaster scenarios: (i) pre-disaster prevention measures, (ii) emergency measures, and (iii) disaster recovery measures and activities that can contribute to improving disaster preparedness. The goal of the manual is twofold. Firstly, it strives to raise awareness about the fragility of cultural heritage and the need to adequately protect it against climate-change-induced disasters; secondly, it aims to optimise the resilience of cultural heritage by spreading basic knowledge of appropriate risk mitigation strategies.

The manual is composed of the following sections: section 2 explains the notions of cultural heritage risk, vulnerability and resilience and introduces the concept of criticality, section 3 summarises the main issues related to cultural heritage vulnerability and discusses how these can be mitigated by means of resilience building measures, section 4 presents concluding remarks on use of the manual and its limitations.

2 Risk and vulnerability assessment for cultural heritage protection

Risk refers to the probability of damage to cultural heritage properties. It is a combination of hazard and vulnerability. In contrast to hazards, which are usually clearly defined in dedicated maps, vulnerability represents a crucial aspect within the context of risk management that requires informed and thorough investigation in order to be properly assessed. Vulnerability is generally referred to as the extent to which a system is susceptible to damage, i.e. it equals the susceptibility (the intrinsic properties of the asset) plus the exposure (the value susceptible to damage) minus the resilience of a system. This clearly implies the importance of resilience as the only factor that contributes to the reduction of vulnerability. Resilience indicates the capacity of a system to withstand shocks without undergoing changes or transitioning to a different state. Vulnerability assessment can be quite complex due to its heterogeneity and multidisciplinary nature. In order to enable the owners and users of cultural heritage to perform assessments of the condition of their property themselves, it is necessary to simplify the methods of risk and vulnerability assessment. In light of this need, the novel concept of criticality is introduced.

Criticality is a controllable **aspect** of a cultural heritage system **that impacts its resilience** to natural disasters and climate change.

Criticalities set the priorities that resilience and risk management measures should address. There are two main groups of critical elements that characterise a system, namely managerial criticalities (related to the operation, administration and care of cultural heritage assets) and physical criticalities (involving the material composition and structural conditions). Each group is composed of a number of specific critical elements related to cultural heritage systems (please refer to D.T2.1.3, available on the ProteCHt2save website, for further reading and a complete list). Criticalities are central to the condition self-assessment presented in the next section.

3 Condition self-assessment and possible measures

This manual considers three main criticality groups relating to the physical scale at which an assessment is carried out:

- Site criticalities.
- Building criticalities.
- Moveable heritage criticalities (family heritage in particular).

Each criticality is presented on a separate card containing the following information:

- A hazard scenario related to the criticality considered. The ProteCHt2save project focuses on floods, heavy rain and drought.
- A description of the criticality.
- Typical damage resulting from the criticality and the occurrence of a disaster.

▶ Recommended resilience measures distinguishing between preventive, emergency, and post-disaster scenarios. Each measure is provided with a colour-coded label:

Do-it-yourself	Measures which can be performed by the owners themselves.
Skills necessary	Measures that require the involvement of skilled labour and should not be performed by the owners themselves.
Engineer required	Measures that require professional assessment prior to implementation.

▶ To individuate the hazards applying to a specific context, the following icons are used in the cards:

Floods – river, flash, tidal 

Heavy rain, wind-driven rain 

Heavy rain / hail  Windstorms  Landslide 

Earthquake  Heavy snow precipitation 

Frost periods  Combined wind and icing 

Utility pipe failures  Drought 

This manual is to be used in preliminary vulnerability assessment of cultural heritage assets and should be employed as a reference only.

HAZARDS

Floods – river flash tidal

The toe of a slope near a river bank or inundation area where strong currents may develop during flooding events.

Typical damage

Washing out and disposition of soil or the undermining of foundations due to water flow around the slope surface.

Undermining of foundations and subsequent failure of masonry walls of a family house.

Resilience measures

Engineer required

PREVENTION

Line the slope surface with heavy stone or concrete pavement. Deepening of foundations and/or deep anchoring of slope lining should be considered.

Skills necessary

EMERGENCY

Evacuate the building and install temporary supports if cracks in the masonry arrise as warning signs.

Engineer required

POST-DISASTER

Support the partially failed walls with temporary shoring to prevent total collapse. Build new foundations and masonry walls. Pave the slope surface.

HAZARDS

Floods – river flash tidal

Foundations built on subsoil consisting of fine particles vulnerable to washing out. Fillings and embankments are typical subsoils of this type.

Typical damage

Fine particles washed out from the subsoil layer resulting in the subsequent loss of its load-carrying capacity and the collapse of supported walls.

Additional settlement of partition walls founded on soil weakened by internal erosion.

Resilience measures

Engineer required

PREVENTION

Upgrade or strengthen subsoil with grouting. Deepen foundations.

Skills necessary

EMERGENCY

Temporarily support damaged walls to prevent failure due to additional settlement of foundations or the creation of voids.

Engineer required

POST-DISASTER

Fill in voids or replace unsuitable subsoil with more water-resistant materials. Damaged walls, including footings, usually need to be rebuilt

HAZARDS

Heavy rain  Landslide  Earthquake 

Slopes with a dangerously steep inclination and geotechnical conditions that may cause landslides after intense exposure to water.

Typical damage

Repositioning of large volumes of earth causes displacement of heritage objects, collapses and heavy structural defects.

A house with cracks due to displacement.

Resilience measures

Engineer required

PREVENTION

Stabilize the slope toe, e.g. by constructing a load imposing wall, decreasing the load on the slope, planting stabilizing trees with deep roots, draining water from the threatened area.

Skills necessary

EMERGENCY

Immediate evacuation – ideally before landslide initiation when warning signals occur – and rescue activities.

Engineer required

POST-DISASTER

Usually no repair is possible due to heavy damage. Stabilizing adjacent slopes by planting trees with deep roots and draining water from the landslide prone area is useful.

HAZARDS *Drought*

Long-term drought on sensitive soils, namely clay. The effect may be multiplied due to trees in the vicinity of buildings.

Typical damage

Shrinkage of clay subsoil creates additional settlement and cracks in masonry.

A crack generated by the shrinkage of a clay subsoil intensely dried out by the roots of nearby tall trees.

Resilience measures

Do-it-yourself

PREVENTION

Drain rainwater into the clay subsoil in order to keep it wet even during drought periods.

Do-it-yourself

EMERGENCY

Water the clay subsoil near buildings regularly. Cut down trees with deep roots in the vicinity of buildings.

Skills necessary

POST-DISASTER

Water the subsoil. Stabilize foundations (substantial deepening). Repair cracks in masonry.

HAZARDS

Floods – river flash tidal *Heavy rain*

Danger of surface erosion due to flowing rain-water along slopes.

Typical damage

Destructive effects include soil erosion, road-pavement damage, possible initiation of mud flow and debris avalanches.

Reinforcement of a subsurface layer with geonet, prepared for planting a grass layer.

Resilience measures

Skills necessary

PREVENTION

Permanent consolidation or enrockment and pavement of slopes and the banks of rivers, brooks or streams. Protect with grassed geo-textiles and/or bushes and trees with stabilizing roots.

Do-it-yourself

EMERGENCY

Create temporary capacity water run-off drainage channels and dikes, e.g. using sand bags.

Skills necessary

POST-DISASTER

Repair damage to the pavement and enrockment of slopes as well as on capacity water run-off drainage canals and dikes.

HAZARDS

Floods – river flash tidal

Heavy rain + windstorms

Changes in subsoil characteristics that affect the stability of cultural and natural heritage.

Typical damage

Decreased anchoring of tree roots; buoyancy effects loosen the subsoil and may cause differential settlement or uplift of buildings or their parts, subsequently tilting or cracking masonries.

The permanent anchoring of a pine tree near the castle in Ravello (I).

Resilience measures

Engineer required

PREVENTION

Only local and partly effective measures are possible and economically justified. They involve e.g. additional anchoring of trees against the combined action of wind and a change in subsoil.

Engineer required

EMERGENCY

Anchor trees with superficial root systems.

Engineer required

POST-DISASTER

Drain the area and restore natural soil moisture and compactness.

HAZARDS

Floods – river flash tidal

Rendered masonries with clay mortars vulnerable in flood situations.

Typical damage

Clay mortars washed out from masonry joints after long periods of flooding or due to water flow around the masonry surface.

A stone wall with fragile plaster not able to protect the masonry joints.

Resilience measures

Do-it-yourself

PREVENTION

Repair all rendering discontinuities and detachments. Apply water-resistant plaster or paint to the the walls (if possible), or seal masonry joints with water resistant mortar.

Do-it-yourself

EMERGENCY

Wrap the walls in plastic foil for temporary protection against direct contact with flood waters.

Skills necessary

POST-DISASTER

Support the walls with temporary shoring to prevent buckling or failure of outer wall leaf. Perform deep re-pointing of the walls.

HAZARDS

Floods – river
flash
tidal

Heavy rain

Non-rendered masonries with clay mortars vulnerable in flood situations.

Typical damage

Clay mortars washed out from masonry joints after long periods of flooding or due to water flow around the surface.

A destroyed stone-masonry retaining wall constructed with clay mortar.

Resilience measures

Skills necessary

PREVENTION

Render the walls with water-resistant plaster or paint (if possible), or seal masonry joints with water-resistant mortar.

Skills necessary

EMERGENCY

Wrap the wall in plastic foil supported with formwork of stiff boards (plywood, OSB) for temporary protection from direct contact with flowing water.

Skills necessary

POST-DISASTER

Support the walls with temporary shoring to prevent buckling or failure of outer wall leaf. Perform deep re-pointing of the wall.

HAZARDS

Floods – river
flash
tidal

Heavy rain

Materials that are vulnerable to intensive moistening – dried brick or adobe masonries.

Typical damage

Reduction of strength and load carrying capacity. Loss of material integrity, including during drying.

A mixed dry brick /stone wall threathened with a loss of integrity during drying after plaster removal..

Resilience measures

Do-it-yourself

PREVENTION

Repair all wall rendering discontinuities and defects. Protect the masonry from direct contact with water – also against wind driven rain, e.g. by sufficiently over-lapped roof eaves.

Do-it-yourself

EMERGENCY

Wrap the wall in plastic foil for temporary protection against flood waters or heavy rain. Install temporary shoring of walls and protective sheets on both sides.

Do-it-yourself

POST-DISASTER

Dry the wall without removing the render.

HAZARDS

Floods – river flash tidal *Heavy rain, wind-driven rain*

Materials vulnerable to dripping or jetted water – dried brick or adobe masonries and renders.

Typical damage

Material disintegration due to the long term effects of dripping or jetted water.

A mudbrick wall destroyed by a water stream jetted through a small hole in a broken glass window during a flood.

Resilience measures

Skills necessary

PREVENTION

Protect the masonry from direct contact with dripping water by means of sufficiently over-lapped roof eaves; protect ground masonry from spraying water.

Skills necessary

EMERGENCY

Temporarily shore walls with protective sheets on both sides. Wrap protective foil over façade parts threatened by dripping or spraying water.

Skills necessary

POST-DISASTER

In case of partial failures or damage, support the walls with temporary shoring and repair the defects as soon as possible.

HAZARDS

Floods – river
flash
tidal

Heavy rain

Slender structures made of materials that are vulnerable to intensive moistening – burnt brick or water-sensitive stone masonries.

Typical damage

Reduction of strength and load-carrying capacity of stone or brick masonry – up to 50% for bricks. The danger exists of a total building collapse.

Total failure of a house with ground-floor brick pillars that lost their load-carrying capacity during a flood.

Resilience measures

Engineer required

PREVENTION

Assess the load-carrying capacity of critical elements under water-saturated conditions. Design and implement strengthening measures.

Engineer required

EMERGENCY

Temporary shoring or strengthening of threatened structural elements.

Engineer required

POST-DISASTER

Remove debris after shoring adjacent structures still standing. Implement stabilization based on a careful structural survey, condition assessment and engineering design.

HAZARDS

Floods – river, flash, tidal

Windstorms + Earthquake

Timber structures damaged by biological agents, e.g. wood-destroying insects or fungi.

Typical damage

Massive soaking and subsequent partial or total failures due to decreased strength and increased dead load.

Partially failed timber ceiling biodegraded by insects and fungi during total inundation.

Resilience measures

Skills necessary

PREVENTION

Replace or strengthen damaged structural elements. Repair structural defects. Restore an environment that naturally inhibits biodegradation – decrease RH, prevent contact with moisture.

Skills necessary

EMERGENCY

Install temporary shoring of threatened parts.

Skills necessary

POST-DISASTER

Remove shoring after structural elements are complete dry. In case of damage or failure, subsequently repair structural defects.

HAZARDS

Floods – river tidal

Possible flooding of levels above ceiling structures resulting in the saturation of structural and stored materials and a significantly increased dead load.

Typical damage

Overloading and excessive deflection of ceiling structures; failures of ceilings or floors may occur.

Destroyed light ceiling-boards overloaded by a water – or mud – saturated thermal -insulation layer.

Resilience measures

Do-it-yourself

PREVENTION

Remove stored materials with a high water-absorptive capacity. Install temporary support of ceilings and floors.

Do-it-yourself

EMERGENCY

Install temporary shoring of threatened parts. Temporarily removel absorptive thermal -insulation materials if possible.

Do-it-yourself

POST-DISASTER

Remove shoring after structural elements dry completely. Restore damaged – or replace removed – water-absorptive thermal-insulation layers.

HAZARDS

Floods – river tidal

Materials that significantly increase in volume when saturated – mainly wood – causing changes that cannot be accomodated by dilation joints. Such elements act as loading jacks.

Typical damage

Cracks in masonry are typical defects caused by the expansion of timber elements, the buckling of timber beams and floors, or the displacement of masonry parapet walls.

Buckling of a wooden floor structure.

Resilience measures

Do-it-yourself

PREVENTION

Create appropriate dilation gaps between masonry walls and ceiling joists, floor beams and wood based floor structures.

Do-it-yourself

EMERGENCY

Evacuate releasable wooden elements.

Skills necessary

POST-DISASTER

Repair masonry damage – grout larger cracks or partially restored masonry walls. Restore floors. Create dilation gaps if missing.

HAZARDS

Floods – river flash tidal

Elements composed of layers with varying sensitivity to moisture, e.g. plywood or wood with paint layers.

Typical damage

Deformation of wood is irreversible and irreparable, and causes the separation and detachment of composite layers.

A destroyed door wing. Detached paint layers on the door and a wooden ceiling.

Resilience measures

Do-it-yourself

PREVENTION

Reduce water-sensitive layered systems in the building.

Do-it-yourself

EMERGENCY

Evacuate releasable wooden elements if possible, e.g. doors.

Do-it-yourself

POST-DISASTER

Remove paints to accelerate the drying of massive timber elements and structures. Restore paints after complete drying. Replace deformed elements, e.g. door.

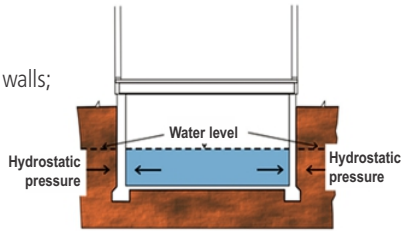
HAZARDS

Floods – river
flash
tidal

Elements threatened by large horizontal loads – typically water pressure on the walls of underground spaces.

Typical damage

Heavy cracks and the deformation of walls; partial or total failure.



Protection of walls using a counter-balance of water pressure.

Resilience measures

Skills necessary

PREVENTION

Prevent the moistening of walls with extrados waterproof insulation of cellars – useful only in combination with intentional flooding of the cellar space during flood situations (see Table 26).

Do-it-yourself

EMERGENCY

Fill the cellar with water to create a counter-balance against the outer forces. In buildings with extrados waterproof insulation it is helpful to coat the inner surface with a watertight foil and fill the cellar space with tap water.

Do-it-yourself

POST-DISASTER

Maintain equilibrium between inside and outside water levels via the controlled pumping of water from cellars. Dry the walls.

HAZARDS

Floods – river flash tidal

Elements threatened by large horizontal loads – typically water pressure on free standing walls.

Typical damage

Total destruction of walls.

A destroyed mixed-masonry garden wall.

Resilience measures

Engineer required

PREVENTION

Install reinforcement and deep -anchoring of the threatened walls. Install additional support if possible. Prepare wall openings which allow water to flow through the threatened wall.

Engineer required

EMERGENCY

Short walls may be temporarily protected by additional supports. Longer walls can be saved using an approach similar to that described for cellar walls, i.e. balancing the forces on either side by breaking openings in the wall for flood water to pass through.

Engineer required

POST-DISASTER

Conduct a thoroughinspec-tion survey – including the site around the walls. Repair identified defects and instabilities.

HAZARDS

Floods – river
flash
tidal

Heavy rain
+ windstorms

Elements threatened by large horizontal loads – typically water pressure on facade doors and windows.

Typical damage

Glass sheets are cracked or totally destroyed.

Permanent shutters which can be closed quickly in disaster situations.

Resilience measures

Skills necessary

PREVENTION

Install waterproof window shutters that can be closed quickly.

Do-it-yourself

EMERGENCY

The typical measure consists of installing temporary sealed shutters to protect the opening.

Do-it-yourself

POST-DISASTER

Remove temporary protecting shutters. Clean and store demounted technical shutters and fastening fixtures.

HAZARDS

Floods – river flash tidal

Lightweight objects vulnerable to detachment from their foundations due to buoyancy; elements and objects in danger of easily being washed away.

Typical damage

Displacement of light or floating objects over long distances, their overturning and severe damage.

An example of anchoring a lightweight structure with additional ballast (water containers) during a flood. (This can also prevent floor bowing resulting from vertical hydrostatic water pressure).

Resilience measures

Skills necessary

PREVENTION

Install appropriate anchoring for lightweight structures, log houses, cottages, boats and ships. Refrigerators or airtight plastic or metal containers are at risk of floating.

Skills necessary

EMERGENCY

Temporarily anchor releasable and floatable objects – timber roofs, boats, containers, etc. Remoel such objects from areas around rivers if possible.

Skills necessary

POST-DISASTER

Remove temporary anchoring, and repair damage.

HAZARDS

Floods – river flash tidal

Danger of creating barriers that prevent rescue workers from entering buildings; objects with greater height than base losing stability during flooding.

Typical damage

Floating, unhinged doors and gates blocking access to buildings.

A typical case where an open gate/door gets unhinged due to vertical uplift and can freely float inside a flooded object.

Resilience measures

Do-it-yourself

PREVENTION

Secure gate and door hinges against free unhinging. Secure refrigerators and tall furniture against overturning.

Do-it-yourself

EMERGENCY

Remove doors and gates that can get unhinged, or lock them to prevent spontaneous opening.

Do-it-yourself

POST-DISASTER

Unblock interior spaces to provide access to professionals performing condition surveys, and to allow for safe cleaning.

HAZARDS

Floods – river flash tidal

Heavy rain, wind-driven rain

Ancient or unknown canals, forgotten waste disposal pipes or ventilation ducts, and other similar defects in the sealing of water barriers.

Typical damage

Soaked materials, spaces and structures, with subsequent initiation of local damage and failures. Water can reach significant heights even in buildings protected by anti-inundation barriers.

Water penetration beyond a protective barrier via sewage pipes.

Resilience measures

Do-it-yourself

PREVENTION

Implement the shutting and sealing of all possible water-pentration sites – install automatic shutters / flaps on ventilation ducts andwaste -disposal pipes (spherical valves).

Do-it-yourself

EMERGENCY

Temporarily close ventilation openings with prepared shutters.

Do-it-yourself

POST-DISASTER

Remove temporary closings. Clean waste-disposal pipes and drainage systems.

HAZARDS

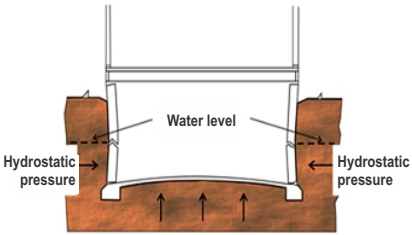
Floods – river flash tidal

Heavy rain, wind-driven rain

Vertical hydrostatic water-pressure on floors in contact with subsoil – typically in combination with horizontal pressure.

Typical damage

The bowing, cracking and breaking of floors.



Forces acting on an underground space with upward vertical pressure on the floor structure.

Resilience measures

Skills necessary

PREVENTION

Reinforce the cellar floor structure in order to make it able to sustain the vertical hydrostatic pressure.

Do-it-yourself

EMERGENCY

Temporarily increase the live load on the floor – the simplest is to flood the space as in the case of protection against horizontal pressure, or bags with sand and similar (See anchoring of light objects above).

Do-it-yourself

POST-DISASTER

Do controlled pumping of water from cellars, keeping the water level inside and outside in equilibrium. Dry the structures. Repair generated damage.

HAZARDS

Floods – river flash tidal

Heavy rain + windstorms

Shortage of watertight walls and shutters that are able to prevent water penetration into objects.

Typical damage

Soaking of floors and walls; soiling of spaces with mud and debris.

A tight shop window and rails prepared for the insertion of a barrier as temporary protection of the shop door.

Resilience measures

Skills necessary

PREVENTION

Install permanent water-tight shutters or prepared fixtures for fast installation of closing shutters. Build elevated door steps in areas with shallow inundation.

Do-it-yourself

EMERGENCY

Install temporary barriers against the water penetration of objects.

Do-it-yourself

POST-DISASTER

Remove temporary measures, dry the walls, clean and disinfect soiling (mud) in interiors, and repair defects and damage.

HAZARDS

Heavy rain + Windstorms

Defects in roof cladding causing water penetration into floors, accumulation in water traps, and vulnerability to wind damage.

Typical damage

Soaked masonries and timber structures, material degradation, fungi colonization.

Situation presents a roof damaged by the combined effects of strong wind and hail.

Resilience measures

Skills necessary

PREVENTION

Repair the roof cladding. Increase the number of fastening elements fixing the roofing tiles or metal sheeting.

Skills necessary

EMERGENCY

Use fabric tarps for covering unrepaired defects.

Skills necessary

POST-DISASTER

Repair roof damage as soon as possible.

HAZARDS

Heavy rain

Defective and malfunctioning water run-off systems causing wet facades, excessive soaking of masonry, and subsoil instabilities.

Typical damage

Permanent soaking of facade masonries.

A long term absence of gutters and down-pipes resulting in soaked walls.

Resilience measures

Do-it-yourself

PREVENTION

Repair and clean the gutters and rainwater downpipes, and maintain them in perfect condition. Clean and maintain the rainwater run-off drainage systems.

Do-it-yourself

EMERGENCY

Remove obstacles from surface drainage canals.

Do-it-yourself

POST-DISASTER

Repair and properly maintain gutters, rainwater downpipes and drainage canals.

HAZARDS *Floods – river tidal* *Heavy rain + Windstorms*

Roof framework joints and elements weakened by biodegradation – fungi or wood-destroying insects – or mechanical damage.

Typical damage

Partial or total destruction of roof structures.

A degraded / rotting roof-frame joint.

Resilience measures

Skills necessary

PREVENTION

Replace damaged parts of the roof framework, inspect and repair small defects with a skilled carpenter. Restore a naturally wood protective environment (low RH, permanent ventilation).

Skills necessary

EMERGENCY

Temporarily support weakened structures with shoring based on stable walls or reinforced vaults or ceilings.

Skills necessary

POST-DISASTER

Repair defects and maintain roof structures in perfect condition.

HAZARDS

Floods – river
flash
tidal

Heavy rain

Post-disaster damaging effects on wet surfaces – increased biodegradation due to the colonization of fungi, moss and bacteria – e.g. damage to paints on walls, wall-paintings and wall-papers.

Typical damage

Growth of moss, bacteria or fungi on the wet surfaces, staining, change of types of colonization due to a cyclic nutrition.

An affected corner where walls and floor meet and drying takes longer.

Resilience measures

Do-it-yourself

PREVENTION

Use paints on walls that can be cleaned easily.

Do-it-yourself

EMERGENCY

Do-it-yourself

POST-DISASTER

Clean and disinfect the surfaces selectively according to the type of biological attack. Do not postpone disinfection. Dry the walls and surfaces. Use paints that contain disinfection additives.

HAZARDS

Floods – river flash tidal

Heavy rain, Frost periods

Combined weather effects – typically frost after intense precipitation. Dangers associated with late-autumn floods or heavy rain.

Typical damage

Material disintegration due to repeated freezing / thawing.

Sculptures made of porous stone protected from getting wet by using winter covers.

Resilience measures

Do-it-yourself

PREVENTION

Install ventilated winter covers after intensive wetting or generally before winter.

Do-it-yourself

EMERGENCY

Provide short-term protective foil wrapping of frost sensitive objects, typically stone, stucco, terracotta and artificial-stone sculptures.

Do-it-yourself

POST-DISASTER

Remove temporary winter covers, repair minor damage which may have occured due to the cover microclimate, and restore protective surface treatments.

HAZARDS *Windstorms*

Light roofs not sufficiently anchored in masonry walls sensitive to wind suction or open to direct uplift wind action.

Typical damage

Uplift of the roof and relocation – total or partial, usually causing heavier failure of supporting walls.

Damaged masonry after roof uplift and setting back in a slightly different position – see large open gates.

Resilience measures

Do-it-yourself

PREVENTION

Check roof anchoring and install additional anchors if necessary. Reduce any possibility of wind entry under the roof.

Do-it-yourself

EMERGENCY

Keep large openings (gates) closed.

Skills necessary

POST-DISASTER

Carefully inspect the roof system and anchoring, and repair discovered defects as soon as possible. Another windstorm may hit soon.

HAZARDS

Windstorms *Combined wind and icing*

Large old trees that may fall down in the vicinity of a building.

Typical damage

Usually heavy damage and partial failures caused by the fallen trees.

A house damaged by a fallen tree.

Resilience measures

Do-it-yourself

PREVENTION

Inspect the building neighbourhood, checking the health of trees in the vicinity. Remove large trees in the building vicinity.

Do-it-yourself

EMERGENCY

Immediately fell trees that endanger buildings.

Engineer required

POST-DISASTER

Carefully inspect the damaged building from the statics point of view and repair discovered deficiencies.

HAZARDS

Floods – river flash tidal

Heavy rain, Utility pipe failures

Paper saturated with water during flooding, water penetrated through roofs, or leaked from broken utility pipes.

Typical damage

Saturation with water; usually soiled with mud or chemicals; imidiate danger of biodegradation.

Paper documents after a flood, fully saturated and soiled with mud.

Resilience measures

Do-it-yourself

PREVENTION

Store paper stuff in dry spaces safe from water penetration. Evacuate paper objects from cellars and spaces in danger of flooding or high moisture.

Do-it-yourself

EMERGENCY

All paper objects can be saved. Gently washing and removing mud and corroding elements is useful. It is urgent to freeze wet paper – packed in paper – ideally within 8 hours after flooding. Mark sorted paper packages with pencil.

Do-it-yourself

POST-DISASTER

Thawing and drying is possible even after a number of years.

HAZARDS

Floods – river flash tidal *Heavy rain, Utility pipe failures*

Books saturated with water during flooding, or water penetrated through roofs, or leaked from broken utility pipes.

Typical damage

Hardening of the bundled sheets of paper if left for partial drying – immediate freezing is required, similar as with paper.

Wet and soiled books.

Resilience measures

Do-it-yourself

PREVENTION

Store paper stuff in dry spaces safe from water penetration. Evacuate paper objects from cellars and spaces endangered with floods or high moisture.

Do-it-yourself

EMERGENCY

Gentle washing and removal of mud and corroding elements is useful. Keep books immersed in clean water. Freezing of wet books packed in paper is urgent. Mark packages with graphite pencil.

Do-it-yourself

POST-DISASTER

Thawing and drying is possible even after years.

HAZARDS

Floods – river, flash, tidal

Heavy rain, Utility pipe failures

Flooded photographs.

Typical damage

Delamination of sensitive layer from the baryts' carrier during thawing after freezing and drying.

Situation presents an example of a photograph after flooding.

Resilience measures

Do-it-yourself

PREVENTION

Store photographs in dry spaces safe from water flooding. Evacuate pictures from cellars and spaces in danger of flooding or high moisture.

Do-it-yourself

EMERGENCY

Wash gently with clean water. Freeze photographs individually separated with wax paper or PE/PPE/PES foil in packages properly marked.

Do-it-yourself

POST-DISASTER

Dry individual pieces freely in the air. Frozen photographs should undergo thawing immersed in technical alcohol to prevent delamination of the sensitive layer and drying, which is possible even after years. Photographic records of wet pictures after thawing are useful.

HAZARDS

Floods – river flash tidal

Heavy rain, Utility pipe failures

Flooded furniture – wooden, with veneer, polished, with intarsia, painted.

Typical damage

Irreversible deformation, veneer delamination, cracks in and peeling of surface lacquer layers, fast biological attack (moss).

Damaged furniture with polished surfaces.

Resilience measures

Do-it-yourself

PREVENTION

Store furniture in dry spaces safe from water penetration. Evacuate furniture from spaces in danger of flooding or high moisture.

Do-it-yourself

EMERGENCY

Wash gently with clean water and disinfect (fungicide without Cl or alcohol).

Do-it-yourself

POST-DISASTER

Dry (slowly) without delay – there is danger of biodegradation in warm periods or frost disintegration of paint layers. Substantial joinery repair and restoration necessary.

HAZARDS

Floods – river flash tidal

Heavy rain, Utility pipe failures

Chipboard, MDF or similar board furniture.

Typical damage

Irreversible deformation, usually accompanied with total material disintegration and total structural failure.

A pile of destroyed furniture from one houshold collected for disposal.

Resilience measures

Do-it-yourself

PREVENTION

Store furniture in dry spaces safe from water penetration. Evacuate furniture from spaces in danger of flooding or high moisture.

Do-it-yourself

EMERGENCY

Wash gently with clean water and disinfect (fungicide without Cl or alcohol) if the artifact has not lost its integrity.

Do-it-yourself

POST-DISASTER

The damage is usually so severe that any safeguarding activity is useless and economically not justified.

HAZARDS

Floods – river
flash
tidal

Heavy rain

Upholstery, cushioning, vachette, leather material on furniture.

Typical damage

Growth of moss, bacteria or fungi on the wet surfaces, staining caused by corrosion of metal parts or connecting elements. Maceration of vachette.

A chair with upholstery and metal fixtures after flooding.

Resilience measures

Do-it-yourself

PREVENTION

Store furniture in dry spaces safe from water penetration. Evacuate furniture from spaces endangered with floods or high moisture.

Skills necessary

EMERGENCY

Dismantle furniture with upholstery or leather.

Do-it-yourself

POST-DISASTER

Upholstery must be dried isolated from the furniture, leather laying flat. Use warm not hot air with controlled drying. Disinfection of leather can be performed in a closed space, e.g. in a PE bag, in vapour of 90% water solution of n-butanol for one week.

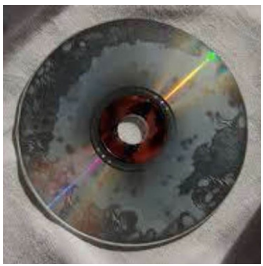
HAZARDS

Floods – river flash tidal *Heavy rain, Utility pipe failures*

Audio recording media, vinyl discs.

Typical damage

Biodegradation of plastic materials (applicable to plastic objects and sound recording carriers - audio tapes; unfortunately CDs and DVDs as seen on the picture cannot be saved), mechanical damage and deformation.



A CD after flooding.

Resilience measures

Do-it-yourself

PREVENTION

Store artifacts in dry spaces safe from water penetration. Evacuate audio media from spaces in danger of flooding or high moisture.

Do-it-yourself

EMERGENCY

Wash artifacts with clean water and alcohol as soon as possible.

Do-it-yourself

POST-DISASTER

Dry in cool air.

HAZARDS

Floods – river flash tidal

Heavy rain, Utility pipe failures

Photographic material, film, slides.

Typical damage

Biodegradation of gelatine layer. Swelling and total detachment from the carrier.

A damaged lantern slide – irreversible loss of the gelatine layer.

Resilience measures

Do-it-yourself

PREVENTION

Store film, negatives and slides in dry spaces safe from water penetration. Evacuate film, negatives and slides from spaces in dangered of flooding or high moisture.

Do-it-yourself

EMERGENCY

Roll out the film slowly and wash with clean water and alcohol as soon as possible. It can be kept wet in PE bags in cool spaces for max one week before treatment.

Do-it-yourself

POST-DISASTER

Dry in cool air under control. There is the danger that film can block during fast drying.

HAZARDS

Floods – river flash tidal

Heavy rain, Utility pipe failures

Paintings.

Typical damage

Depending on the support plate or canvas. Wood and canvas deform irregularly, initiating cracks in.paint layers, which deform namely if they contain polysaccharides, PVAC and polyacrylic dispersions. Biodegradation of organic materials may occur.

Moisture fluctuation result on a paint layer.

Resilience measures

Do-it-yourself

PREVENTION

Store paintings in dry spaces safe from water penetration. Evacuate paintings from spaces in danger of flooding or high moisture.

Do-it-yourself

EMERGENCY

Remove paintings from the wet environment and place in a dry space with mild temperature, and protection against frost. Consultation with a restorer necessary.

Do-it-yourself

POST-DISASTER

De-frame and carefully clean with wet tampons. Subsequent treatment must be carried out by a professional restorer or conservator.

HAZARDS

Floods – river flash tidal

Heavy rain, Utility pipe failures

Sculptures, models, musical instruments.

Typical damage

Swelling of wooden artifacts, disintegration of joinery, damage of surface paint layers, biodegradation.

A damaged pianino after Prague Troja flood 2002.

Resilience measures

Do-it-yourself

PREVENTION

Store artifacts made of sensitive materials in dry spaces safe from water penetration. Evacuate artefacts from spaces in danger of flooding.

Do-it-yourself

EMERGENCY

Remove from the wet environment quickly and place in a dry space with mild temperature, and protection against frost. Consultation with a restorer necessary.

Do-it-yourself

POST-DISASTER

Wash with clean water immediately. Subsequent treatment must be carried out by a professional restorer or conservator.

4 Concluding remarks

This manual is supplementary to the institutionally provided civil protection tools aimed at increasing the resilience of assets having cultural and historical value and which are threatened by critical scenarios or have been hit by natural or man-made disasters. It is primarily intended for the owners, administrators, or users of such cultural heritage properties and objects, but also provides useful information and advice to citizens and institutions in crisis, especially civil protection rescue teams and their auxiliary units.

The manual focusses solely on floods, heavy rain and drought hazards; its scope is limited to the presentation of the foremost examples of lessons learnt from past Central European disasters. In addition, a purposely simplified approach to risk assessment is proposed for the sake of endorsing the active engagement of heritage owners in resilience building strategies. With this in mind, it is strongly recommended to seek professional advice before making any decisions and carrying out any measures that may further undermine the preservation of the asset. Lastly, the manual does not take into account synergic effects that may derive from the co-existence of multiple criticalities in a cultural heritage system – the combined effect being greater than the sum of individual effects. Therefore, in such cases, seeking expert analysis of property conditions is advised.

The manual should be read in conjunction with D.T2.1.3 Decision Support Tool, D.T2.2.1 Manual of Good and Bad Practices and D.T2.2.2 Resilience Controllable Criticalities, available on the ProteCHt2save website (www.interreg-central.eu/Content.Node/ProteCHt2save.html).