

DELIVERABLE D.1.2.2

Identification of the risk prone areas and
tagging of the most sensitive CNH objectives

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Contents

A. Introduction	5
B. Risk analysis	6
CNH typologies	6
Hazards	14
Vulnerabilities	19
Resilience	21
C. Identification of risk prone areas for case studies	25
Italy	25
Austria	26
Czech Republic	28
Hungary	29
Germany	30
Poland	32
Slovakia	33
Croatia	34
D. Final remarks and conclusions	35

A. Introduction

This deliverable is part of the project activity A1.2, which aims to perform an in-depth investigation at national/local level on existing datasets, distribution maps, GIS platforms and other tools/products specifically developed for inventorying natural and cultural heritage sites in CE river basin districts. The research is particularly driven by guiding principles on protection and risk management included in UNESCO conventions and the Natura 2000 network, looking also over the RAMSAR Convention on wetland, evaluating synergies among them. This report investigates the CNH assets most sensitive to climate extreme events in relation to experienced environmental and socio economic impacts and shortcomings identified as results from A1.1. The methodology used in this deliverable exploits the active engagement of project partners in data collection, including local site managers of selected project case studies. More specifically, the following aspects of the pilot cases are investigated:

- Site name and location (GPS coordinates, region, country, EU id, city, municipality).
- Typology of cultural heritage assets involved (natural reserve, historic villages and gardens, historic buildings and archaeological sites, monumental complexes, historic parks and gardens).
- Hazard types (floods, windstorms, wildfires and drought).
- Vulnerabilities (weak points concerning the site such as geomorphological, hydrogeological, human factors but also managerial weaknesses, i.e. lack of funds etc.).
- Resilience characteristics (strengths which enable the site to absorb shocks such as disasters without undergoing major changes; these can be physical, managerial, economic and societal factors).
- Risk prone areas within the site.

The deliverable is structured as follows: section B outlines the CNH typologies, hazards and vulnerabilities of the pilot sites, providing a preliminary characterisation of risk; section C identifies the areas within the pilot sites considered more at risk, on which the detailed risk analysis carried out using the Web GIS and vulnerability evaluation tools (WP2) focuses. Finally, part D summarizes the main findings at the research and possible future work useful for the development of appropriate tools in the following phases of the project.

B. Risk analysis

The INACO project concentrates on particular typologies of heritage exposed to the impact of climate change. Three main groups are considered, defined according to the environmental and hydrological context: 1) Group A- Sea/River shore, 2) Group B- Lake shore and 3) Group C- Inland. The following paragraphs present the characteristics of the pilot cases analyzed in the project, outlining the cultural and natural heritage (CNH) typologies, hazards and vulnerabilities individuated in each case. This allows defining an overview of the risk components and preparing the ground for risk assessment at each pilot site. Vulnerability evaluation, hazards mapping, risk assessment methodologies and results are further discussed in WP2, with details of the conditions at each pilot case investigated in the project.

CNH typologies

- **GROUP A SEA/RIVER SHORE.** Natural reserve, historic villages and gardens in transitional river/sea shore environment

Po Delta River - Italy

The park includes a variety of cultural and natural heritage assets including built heritage, biodiversity gardens, cultural traditions and historical livelihoods.



Clockwise, from top left: Ponte Trepponti also known as Ponte Pallotta (Comacchio); Casone Donnalbana (Comacchio), Santuario della Celletta (Argenta) and Delizia di Benvignante (Argenta)

Along the low Reno River valley there are many historical centers or historical buildings; four municipalities of the Park are crossed by the river: Argenta, Alfonsine, Comacchio and Ravenna.

A list of the monuments in the municipality of Argenta: 1. Pieve di San Giorgio, 2. Historical water pump plant of Saiarino and Museum of the Land Claiming, 3. Casino di Campotto and

Museum of the Valli di Argenta, 4. Santuario della Celletta, 5. Duomo di San Nicolò, 6. Chiesa di San Domenico, 7. Delizia di Benvignante, 8. Delizia di Consandolo (Conventone).

A list of the monuments in the municipality of Alfonsine: 1. Chiavicone della Canalina, 2. Chiesa della Madonna del Bosco.

A list of the monuments in the municipality of Comacchio: 1. Cattedrale di San Cassiano, 2. Santuario di Santa Maria in Aula Regia and Loggiato dei Cappuccini, 3. Chiesa del Carmine, 4. Chiesa di Santa Maria del Suffragio, 5. Chiesa del Rosario, 6. Monastero di Sant'Agostino, 7. Ponte Trepponti also known as Ponte Pallotta, 8. Ponte degli Sbirri, 9. Ponte dei Sisti, 10. Ponte del Carmine, 11. Ponte Pizzetti, 12. Ponte San Pietro, 13. Ospedale degli Infermi with inside the History Museum "Delta Antico", 14. Palazzo Patrignani, 15. Palazzo Tura, 16. Loggia dei Mercanti del Grano and Torre dell'Orologio, 17. Palazzo Bellini, 18. Casone Donnabona, 19. Casone Serilla, 20. Casone Pegoraro, 21. Casone Foce, 22. Casone Coccalino, 23. Casone Paisolo, 24. Casone Fosse, 25. Casone Umana, 26. Casone Bellocchio, 27. Casone Confina, 28. First Roman Empire era villa ruins site inside the Valli di Comacchio, 29. High Medieval boat remains site in the eastern shore of Valli di Comacchio

Dubrovnik River - Croatia

The area of the Dubrovnik River is considered one of the oldest agricultural and rural landscapes of the former Republic of Dubrovnik. At the height of the power of the Republic of Dubrovnik, the nobles, fed up with the city bustle and the lack of free space within the city, "escaped" to the surroundings, and the region of Rijeka Dubrovnik stands out as a special natural phenomenon, which, thanks to the climate, freshness, and abundance of water, possesses exceptional beauty and atmosphere. About 300 summer houses have been established in the Dubrovnik area, of which 50 are in Dubrovnik River. The area of Rijeka Dubrovnik has the highest density of rural buildings, which were built from the 14th to the end of the 19th century. Among them, the most numerous are Renaissance summer houses from the 15th and 16th century.

As the primary spatial specialty of Dubrovnik River summer houses, their location right next to the water stands out. Precisely for this reason, the main communication with Dubrovnik took place by sea.





An additional specificity is that most of the route of the early Renaissance waterworks passes through it. The construction began in 1437, by Onofrio di Giordano de la Cava and Andriuzzo de Bulbito, and brought water from Šumet to Dubrovnik.

Given the extremely favorable climatic and biological conditions (pleasant climate, fertile soil, abundant spring water), various crops (vines, olives) were cultivated in this area. Precisely because of this, part of the summer houses of Rijeka Dubrovnik had terraced, agricultural gardens outside the fence walls. Such buildings were primarily used for storing summer crops, production, and sale of oil, wine, and brandy, and their owners could sleep in them during seasonal work, the so-called "casa padrone" (master's house). As another variant of summer houses in Rijeka Dubrovnik, the so-called stand-out "casagrande", is a building that is built exclusively for the countryside; its garden is located inside the fence wall, and in addition to its utilitarian role, it also has a representative role.

Dubrovnik country complexes were created almost at the same time as Italian summer houses, so the influence of Italian architecture is unmistakable. However, Dubrovnik summer houses are characterized by unique stylistic and organizational peculiarities, and they are designed and built by the nobles themselves with their masons and builders, while most Italian villas were designed by famous architects and garden masters. Most of the Renaissance summer houses were originally designed with expert hydro melioration measures: inside certain lawns, there were pools with brackish water, ponds, and water mirrors. Gardens and lawns were soaked by channels into which water flowed from the nearby slopes.

The area around the Dubrovnik river is an area where not so long ago there was the largest "collection" of historically important gardens, where architectural heritage is integrated with the natural environment. This especially concerns sacred monuments and rural architecture.

The summer houses of the Dubrovnik nobles are famous and the most significant examples of Dubrovnik's Renaissance and Baroque country architecture. About twenty of them have been preserved, among which stand out: Sorkočević's summer house (the largest, with a staircase to the sea and a painted gallery, 16th-18th centuries), Rastić's (with a porch next to the country house and a three-part garden, 16th-17th centuries), Gučetić-Đurđević from the 16th century (in

which the last deliberation of the Dubrovnik rulers was held in 1814), Bozdari-Kaboga (18th century).

There was a mill with mills perfected by Paskoje Miličević at the spring near Komolac. In the 19th century, a striking building with mills was erected, and then a small pasta factory was built nearby.

- **GROUP B LAKE SHORE.** Natural reserve, historic buildings and archaeological sites in a lakeshore environment

Lake Neusiedl - Austria

The CHN typologies that can be found in Lake Neusiedl are varied, including natural environment, traditional land use forms, historic villages, and archaeological sites.



The high natural heritage value is underlined by the fact that the pilot site is a nature park, a national park, a European nature reserve, Ramsar site, and UNESCO World Heritage site. Lake Neusiedl is a steppe lake (the westernmost in Europe) and has a high ecological value owing to its interconnected areas of water, wetlands, reeds, meadows, and extensive agriculture and its location at the cross-section of different geographical zones. Above all, Lake Neusiedl is of

supra-regional importance as a breeding, resting, and wintering habitat for birds. The current landscape has been shaped over thousands of years by unique land-use practices centered on livestock farming and viticulture, to a degree unmatched by other lake regions in Europe. This relationship is evident in the centuries-long continuity of its urban and architectural heritage, along with the varied traditional uses of both the land and the lake. Lake Neusiedl is encircled by an inner ring of sixteen settlements and an outer ring of twenty additional settlements. The region has experienced two main historical phases: from around 6000 BC to the 11th century, and from then to the present. From the 7th century BC, the lake shore was densely inhabited, and significant Roman villas emerged near most villages in the first centuries AD. The 12th and 13th centuries established the area's towns and markets, which prospered through animal and wine exports. Rust, a medieval free town, flourished particularly from wine trade, showcasing a blend of town and farming lifestyles. The region's notable rural architecture, alongside 18th- and 19th-century palaces, reflects its rich cultural heritage.

Fonyód town - Hungary

In this site there are 16 monuments under national protection, 99 monuments under local protection and 30 archaeological sites, old town, protected villas / cottages (mansion-like buildings), Kossuth-forest, Szaplóczay-promenade.



Furthermore, the protected natural heritage sites and areas are:

- loess high wall / high shore area (3800 m long),
- reed area (11.3 hectares and 38.9 hectares at Balatonfenyves)
- peet area (18 hectares, and 40 hectares at Balatonfenyves)
- Lake Balaton itself

- the so called “berek” (marsh-like areas near the lakeshores) under Natura 2000 protection, also Ramsar site
 - Bakony-Balaton UNESCO Geopark
 - Forest areas under local protection (19.52 hectares)
-
- **GROUP C INLAND. Monumental complexes, historic parks and gardens in inland river basin**

Valley of Wiesent and Regnitz - Germany

The CNH typologies in this site comprise historic villages and gardens, historic buildings and archaeological sites as well as natural heritage. Concerning natural heritage, the site includes the natural park of Franconian Switzerland and the tradition of cherry growing. These cultural and natural heritage (CNH) face all the challenges of climate change.



Left: Historic castle monument in the valley of river Wiesent; right: flooding meadows.

A very special area within the site is the valleys of Wiesent and Regnitz (the river Wiesent flows into river Regnitz in the city of Forchheim). The ancient river Regnitz flows beside the modern built European channel / waterway Rhine-Main-Danube. In these valleys the UNESCO just recently in December 2023 entitled the so-called “flooding meadows” as intangible cultural heritage.

Jelenia Gorà Valley - Poland

The Valley of Palaces and Gardens covers almost the entire area of the Jelenia Góra Basin in the Lower Silesia Region in the south-western part of Poland.

The most valuable parts of these mountains in terms of nature and landscape are protected within the borders of the Karkonosze National Park, two Landscape Parks - Rudawski and Bóbr Valley.

The Valley of Palaces and Gardens is an area of approximately 100 km² where there are almost 30 objects of secular architecture. In such a small area, we can find a variety of types of knights', noble and Prussian king's residences, starting from: medieval residential towers, castles, Renaissance manors, Baroque palaces and 19th century palace and park complexes that give the region a unique character.

The complex of residences surrounded by extensive landscape parks, in the Jelenia Góra Basin, was recently included in the Cultural Park. Within the park there are residences in Bukowiec, Dąbrowica, Janowice Wielkie, Jelenia Góra, Jelenia Góra - Cieplice-Zdrój, Jelenia Góra - Czarne, Jelenia Góra - Sobieszów, Karpniki, Komarno, Łomnica, Miłków, Mniszków, Mysłakowice, Radomierz, the Ruins of the Castle in Rybnica, Wojanów, Wojanów-Bobrow, Wojków and Stanisławów together with the areas of the former palace park covering Witosza Mountain and Grodna, as well as palaces in the city of Kowary: Nowy Dwór and Ciszyc.



Left: Wojanów Palace (photo by Tomasz Kolomanski); right: natural park.

The Park includes Chojnik Castle, Bolczów Castle and the Ruins of Sokolec Castle and Nieszytno Castle. The park also includes, among others, Tyrolean houses in Mysłakowice and the sanatorium-hospital complex Kowary.

Kosice Region - Slovakia



Left: Jasov Monastery Complex; right: Jasov Cave and surrounding area with its fauna and flora.

In this site CNH typologies are multiple. Protected National cultural heritage sites in Jasov, include: a vast Baroque complex of the monastery and Church of St. John the Baptist (1750-1766), including the monastery, church, entrance courtyard, park, fountain, enclosure wall, garden, and greenhouse; six historic buildings, two of which are national cultural monuments. The Monument Zone in Medzev includes, the following: Church of the Nativity of

the Virgin Mary: Gothic style from the 14th - 15th century, Burgher Houses from the 18th - 19th century, other historical buildings, including the Guesthouse and one administrative building; the Plague Column, a sculpture from the 18th century; as well as Medzev - and its surrounding area (Šugov Valley); Ironwork Hammer Mills, including five objects under national protection from the 18th and 19th century. Natural heritage sites include: the Slovak Karst National Park with over caves, valleys, and sinkhole systems, part of the UNESCO World Heritage; the Jasovská Cave, the oldest accessible cave in Slovakia, listed in World Heritage is a part of Slovak national Karst. The cave was partially made accessible in 1846 by monks from the Jasov monastery.

Central Bohemia Vltava River Valley - CZ

The studied Central Bohemia Vltava River Valley includes a section of the Vltava River from the confluence with the Berounka River through the capital city of Prague and the Troja basin to the cultural landscape of Veltrusy Chateau. A large number of natural and cultural monuments of world or national importance are concentrated in the area next to areas that are being prepared for sustainable development. The river's confluence territory is one of such vast areas of 1200 hectares for cultural landscape revitalization and development for which it will be necessary to prepare solutions that will reinforce its resilience and that take into account the risks of climatic influences. Most of Prague's embankments are in close contact with protected monuments, especially its historic city center, a UNESCO World Heritage Site. The city ends with a transition to the landscape suburban area of the Troja Basin with the last natural river rapids, large parks, the second largest listed monument of the Troja Chateau with gardens and important recreational destinations, the zoological and botanical gardens. The construction of the early Baroque Troja château began in 1679. The project was created by an architect of French origin, Jean Baptiste Mathey, whose design exploited his experiences from his sojourn to Italy and was inspired by a typical Roman suburban villa.



The selected river valley section ends with the Veltrusy Chateau and its protected landscape park, which are located on an island (“Ostrov”) delimited with the Vltava river and Mlýnský potok brook and represent the largest protected area in the Czech Republic. The floods of 1784 and 1785 were reflected in the new concept of the Veltrusy park and in the beginning of the regulation of the Vltava River. This was the culmination of the transformation of the area into a large natural landscape park in the form of a top type of so-called “ornamental farm” (ferme ornée), where economically used areas were a direct part of it, but also an aesthetic component. At the turn of the 18th and 19th centuries, a number of small architectures, pavilions, bridges, sculptures were created in the park. The chateau was built since 1704 with a generous Baroque concept as a complex of buildings graded in height surrounding the courtyard of honour along the north-south axis. Veltrusy Castle was one of the most important works of the peak period of Baroque architecture in Bohemia connected with the work of one of the most prominent creators of Baroque architecture in Bohemia at that time, Giovanni Battista Alliprandi.



Hazards

- **GROUP A SEA/RIVER SHORE.** Natural reserve, historic villages and gardens in transitional river/sea shore environment

Po Delta River - Italy

This site is very much exposed to floods, embankments erosion and collapse, rising of the sea water level, climate changes, earthquakes, ground subsidence

Dubrovnik River - Croatia

The case study is subjected to different types of hazards such as: floods, occurring during heavy rains and rising sea levels, with water reaching residential houses as well as historic summer houses; fires, on dry, summer days, frequent on the hills of Rijeka Dubrovnik; earthquakes, as Dubrovnik was built in the most seismically active area of Croatia, marked in red on the seismic map, in potential danger from the strongest earthquakes. This hazard, however, falls outside the scope of the project and it will not be discussed.



Left: wildfires; right: flooding.

- **GROUP B LAKE SHORE.** Natural reserve, historic buildings and archaeological sites in a lakeshore environment

Lake Neusiedl - Austria

This pilot site experiences mostly drought periods, heat waves, floods and wildfire (reed fires - even though beneficial from environmental perspective)

Fonyód town - Hungary

The main hazards affecting the site include flash floods, windstorms (when windstorms occur in a high water level period, Lake Balaton “spills over”, creating flash floods; also possible damages to lake flood protection barriers), vegetation fires in general (forest fires, reed fires, peat fires etc.) and drought.



Wildfire in a reed area, Fonyód 2021.

- **GROUP C INLAND. Monumental complexes, historic parks and gardens in inland river basin**

Valley of Wiesent and Rednitz - Germany

This site is especially endangered by floods, droughts and landslides, but not so much by windstorms or wildfires. The problem nowadays is that due to climate change very local heavy rains, that are spatially very unpredictable, produce floods and landslides.



Floods and landslides in Weilersbach, 2nd June 2024.

Jelenia Gorà Valley - Poland

In this site the Wojanów and Łomnica Palaces, focus of this project, are located near the Bóbr River, within a few hundred meters of each other, in a zone of direct hydrological threat. During periods of heavy rainfall, the flooding river regularly floods the palace park, also approaching the palace buildings, which are located slightly higher. Another problem is the left tributary of

the Bóbr River, the Lomnica, which flows into it nearby, which also contributes to an increased flood risk. During the thaw after the winter period, dangerous situations are created by the piled-up ice floes on the river. Ice jams can be several kilometers long. The ice floes stop in narrowings. This poses a risk of flooding.

Kosice Region - Slovakia

The Slovak case study is exposed to multiple hazards:

- **Floods:** Intense rainfall across the Bodva Basin, especially between Medzev and Jasov, threatens areas including the monastery in Jasov and Monument Zone Medzev. High water levels can damage cultural heritage and reduce the capacity of the river.
- **Fires:** Increased risk due to drought conditions threatens forest areas, particularly in the cadastral territories of Jasov and Medzev, putting both natural ecosystems and cultural landmarks such as the monastery at risk.
- **Drought:** Long-term drought conditions affect the flora and fauna across the region, causing species migration to cooler, more humid areas like canyons and valleys, which impacts biodiversity and ecological stability.
- **Windstorms:** Strong windstorms pose a significant threat to heritage buildings, especially in the urban center of Medzev and to the Jasov Monastery complex, leading to potential damage to roofs, facades, and other historical features.



Medzev Monument Zone 15th of April 2010.

Central Bohemia Vltava River Valley - CZ

The biggest threat to the places along the river is flooding. The largest recent flood in Central Europe in 2002 significantly damaged the castle complexes both in terms of buildings and vegetation or the shape of the terrain. Also the neighborhood of residential houses were affected and caused social and economic problems, especially in Prague. In Veltrusy also damage of small architecture, sculptures and trees in the park occurred together with relocation of the river channel.

Windstorms are also dangerous in all areas due to the high age of the trees in the protected parks usually accompanied with waterlogging of the soil.



Veltrusy Chateau with Park and Cultural landscape during 2002 flood



Deposits of sand dunes and fallen trees after 2002 flood in Veltrusy park



Damaged Vltava river bed and banks after 2002 flood

Vulnerabilities

- **GROUP A SEA/RIVER SHORE.** Natural reserve, historic villages and gardens in transitional river/sea shore environment

Po Delta River - Italy

This site is affected by the uprising of the saline wedge, a very strong summer transpiration that increases the salinity in the water. Also structural difficulties in introducing fresh water, water anoxia during nighttime, impacts made by tourism activities, lack of funds, erosion of the embankments, status and maintenance of the water pipes, low inflow of solid particles from the rivers, subsidence, rising water levels, erosion of islets, water turbidity.

Dubrovnik River - Croatia

In the second half of the 20th century, industrial, traffic, and residential construction damaged the landscape and ambient values of the entire sea bay of the Dubrovnik River. Due to its proximity to the Grabovica landfill in Dubrovnik, Ombla is on the list of ten most endangered karst phenomena in Croatia, although Grabovica, which was rehabilitated in 2001, is the only Croatian landfill with impermeable foils that meets strict ecological criteria and international standards. The Ombla Spring, unlike other smaller sources of drinking water, is located almost at sea level, and the deep channel even goes significantly below sea level. This means that this source is extremely threatened by the potential penetration of the sea into the interior due to the rise of the sea (climate change) and the reduction of deposited freshwater levels (drought; consumption in the upper part of the Trebišnjica watershed). Today, the Dubrovnik River is at a turning point given a whole series of new plans that have already drawn up a new network of communications, expansion of construction zones, and a drastic expansion of the ACI marina (port) in Komolac, to which should be added long-standing problems: disposal of rubble, garbage, soil, bulky waste next to the river, streams and sources of drinking water, the problem of Grabovica, which is located in the Omble water pumping zone, concreting the banks, filling the river, speeding up the construction of dry marinas, and renovation of summer houses.

- **GROUP B LAKE SHORE.** Natural reserve, historic buildings and archaeological sites in a lakeshore environment

Lake Neusiedl - Austria

The water level of the lake is primarily dependent on precipitation and evapotranspiration, which makes management challenging. Drought, heatwaves, and a shift of precipitation patterns may lead to a lowering of the lake water table, or in extreme cases even a complete dry-up of the lake. Prolonged heatwaves and droughts also lead to a higher water demand by agriculture, further exacerbating ground water level issues in the region that also affect the alkaline ponds. Increasing air and water temperatures may impact many aspects of the way of living in the area, from fishing, agri- and viticulture, to tourism (e.g., physical comfort, water quality, landscape aesthetics, etc.). What makes the pilot site so special are the natural and cultural value and history that are closely intertwined since centuries. However, this makes the management of this region also challenging because of many different, partly connected issues and the number of stakeholders involved, that may have diverging priorities and management goals.

Fonyód town - Hungary

This site presents the following vulnerabilities: to floods, erosion (the damages done to the loess wall / high shore area, which is in itself a natural phenomenon under protection, but also because the damages an eroded, 3,8 km long plateau-like structure can do to its surrounding), financial issues in connection with the loess wall / high shore area (reinforcing the wall structures already cost several million HUF, and more is needed), windstorm and the human factor (the overbuilding of reed areas, cleaning out too much vegetation which weakens soil structures)

- **GROUP C INLAND.** Monumental complexes, historic parks and gardens in inland river basin

Valley of Wiesent and Regnitz - Germany

The main challenge at Wiesent and Regnitz valleys, related to the geomorphological aspect, is the mountain-valley situation (highlands versus lowlands). A lot of water comes aside the valleys from the highlands of Franconian Switzerland. The hydrogeological aspect is the dominance of limestone in Franconian Switzerland with a lot of caverns and holes that accelerates the water flow downhill. Human factors are of course the intensive agriculture damaging the flooding meadows but also more and more buildings and infrastructure sealing the soil. Managerial weaknesses are the lack of regional planning, collaboration between the local municipalities and administrations and the lack of funds for water management.

Jelenia Gorà Valley - Poland

During heavy rainfall, the river often overflows, flooding the palace park and reaching the nearby palace buildings, which are situated at a slightly higher elevation. Another contributing factor to the flood risk is the Łomnica, a left tributary of the Bóbr River, which flows into it nearby. Additionally, during the thaw after winter, ice floes that accumulate on the river can create dangerous conditions. These ice jams, which can stretch for several kilometers, tend to form in narrow sections of the river, increasing the risk of flooding.

Kosice Region - Slovakia

The Monastery Complex is highly vulnerable due to its proximity to the Bodva River, increasing the risk of damage during floods. Its proximity to the forest areas also increases the risk of wildfires, while windstorms can cause significant damage to the roofs and other structural elements of the complex. The historical gardens of the Monastery are highly sensitive to drought, leading to vegetation loss and reduced ecological and cultural value. The Monument Zone Mezev is, instead, highly exposed to flooding, especially as almost the entire heritage zone is within the Q50 flood probability area. Floodwaters significantly threaten cultural value and the structural integrity of these buildings. Additionally, it is sensitive to damage from strong windstorms, which can cause major damage to roofs and facades. Forest areas around Jasov and Medzev are vulnerable to fires, threatening biodiversity and the stability of forest ecosystems. Part of these forests lies within the Slovak Karst National Park area. The Slovak Karst National Park and Jasovská Cave are sensitive to hydrological changes, increased erosion, and droughts that can destabilize cave structures and ecosystems, particularly affecting 19 bat species identified in the cave population. The limestone bedrock of the right-side tributaries of the Bodava from the Slovak Karst is significantly more permeable and sensitive to the increasing risk of drought.

Significant settlements of marginalized communities, particularly in Jasov, face socio-economic challenges, including waste management due to their proximity to the river. This increases waste in the Bodva River, reduces flow capacity, and raises flood risks, impacting both heritage and resident safety.

Central Bohemia Vltava River Valley - Czechia

The size of the endangered area does not allow complete territorial protection and therefore all risks of flooding remain strong in the future when a flood of high intensity occurs. Only the Center of the City of Prague can be protected with permanent or temporary barriers and there the high water risks are reduced. Vulnerability is also increased by a general lack of funds and a rapid loss of access to some parts of the territory inundated during flooding. Small architecture, sculptures and private buildings are more vulnerable due to usually insufficient inspection and maintenance. In the case of parks, it is necessary to consider the vulnerability of trees to the increasing frequency of storms.

Resilience

- **GROUP A SEA/RIVER SHORE.** Natural reserve, historic villages and gardens in transitional river/sea shore environment

Po Delta River - Italy

In this site, resilience measures include water channels management in and out the marsh and the sea, embankments restoration and improvement.

Dubrovnik River - Croatia

Resilience building measures have not been put in place, and regardless of the Register of prior hazard events, there are no measures nor actions taken to increase the resilience. Some cultural assets and gardens are surrounded by a thick high dry stone wall that might prove efficient in case of windstorms or flooding.

- **GROUP B LAKE SHORE.** Natural reserve, historic buildings and archaeological sites in a lakeshore environment

Lake Neusiedl - Austria

From an ecological point of view, even a complete dry-up of the lake is deemed acceptable/natural (at least by some stakeholders). Lake Neusiedl is a steppe lake, for which large amplitudes of water table fluctuations are characteristic, including falling-dry. Lake Neusiedl has indeed fallen dry several times throughout history without lasting damage to the ecosystem; the biocoenosis is adapted to these extreme conditions.

Flooding has become less probable since the installation of a channel (Einserskanal) that allows a drainage of high water levels. Although there are still some knowledge gaps (e.g., concerning the role of the reed belt in evapotranspiration, sustainable restoration of alkaline ponds), the pilot site region is generally well studied and monitored, from physico-chemical (water cycle, water quality, temperature, meteorology, etc.) to biological parameters (birds, fishes, reed belt, etc.).

The pilot site (or parts of it) is a UNESCO World Heritage Site, National Park, Ramsar site, Nature Park, European nature reserve, and landscape conservation area. Accordingly, several conservation measures are already implemented. This also means that the value as a CNH is clearly recognized by different authorities and organizations. Consequently, despite partially diverging viewpoints, the conservation of the site has a high importance and priority among different stakeholders, decision makers, and the general public.

The pilot site is probably one of the best studied regions in Austria. Numerous studies on various topics from hydrology, to ecology and sociology, including effects of climate change and socio-demographic developments provide a solid data basis. There is also no scarcity of strategies, measures and options for actions - the challenge is more in choosing the right measures that are able to simultaneously fulfill the different requirements of the stakeholders and preserve the natural and cultural heritage of the region.

Fonyód town - Hungary

The local government and the local and district fire departments have a strong connection, and have experience in disaster management (past experiences include several thunderstorms, floods and other disaster events).

The past disasters where the loess wall / high shore area structures suffered erosion damages, are utilized as a template for future instances.

- **GROUP C INLAND.** Monumental complexes, historic parks and gardens in inland river basin

Valley of Wiesent and Regnitz - Germany

Since medieval times the flooding meadows have been a way of traditional agricultural use of the valleys. Hence the resistance to absorb climate change shocks seems very high. The crucial point is the water management including water regulation and distribution at the right time. One strength would be to preserve the water management of the flooding meadows. These include management forms, like the current organization as a water co-operative (“Wassergenossenschaft”) but also the preservation of infrastructure (small trenches and dams).

Jelenia Gorà Valley - Poland

Work is underway to regulate the Bóbr and Łomnica rivers on the section adjacent to the palace. However, there is controversy over the method of regulation. Residents demand regulation in the traditional form, i.e. concreted river banks, which in their opinion will protect them from the effects of flooding. Ecological organizations are against it, considering such a solution ineffective and killing the river and demand leaving natural barriers and floodplains for rivers.

Kosice Region - Slovakia

Resilience building measures in place at the site include:

- Monastery and Historic Buildings: thick stone walls provide protection against wind and floods.
- Jasovská Cave and Slovak Karst NP: strict protection regime enhances resilience 3rd - 5th level of protection.
- The Monastery is surrounded by a protective stone enclosure: This reduces the speed of flash floods during heavy rains and mitigates destructive effects.

Flood protection measures are crucial not only for CNH but also for the livelihood of the local population living close to the river, thus strengthening the justification of investments for flood protection infrastructure.

Central Bohemia Vltava River Valley - Czechia

Repairing the damage after the Central Europe catastrophic flood also included the construction of a number of measures against the effects of future floods. In the Centre of Prague and a residential part of Troja a combination of permanent and temporary barriers against high water has been provided. Their efficiency was proved during a subsequent flood in 2013. There was completed a reconstruction and reinforcement of the heavily damaged bank of the Vltava River in Veltrusy with the related reclamation of the adjacent protected area of the park.



Reconstruction and reinforcement of the heavily damaged bank of the Vltava River in Veltrusy

Similar permanent physical measures were carried out on the foundations and surroundings of the buildings in the parks. Furthermore, temporary protection procedures are designed and secured by technical means for closing openings, lining water-sensitive surfaces or their protective impregnation in historic buildings in the territory. In Veltrusy, the water does not reach a very high height when flooded, but the buildings are built using dried clay bricks, which require protection against wetting and loss of strength even during drying. Periodic inspections of the condition of buildings and trees, regular maintenance and preparedness of employees for natural disasters are very important among the management measures. Management of historic assets in the territory has risk plans as well as a general manual for owners and managers of monuments issued in ITAM. It would be appropriate to create a more detailed tool focused on specific situations. Resilience measures should also involve moveable heritage including that in families.



Erected temporary flood barriers in Prague-Holešovice

C. Identification of risk prone areas for case studies

Italy



Site name: Valli di Comacchio and low Reno River valley.

Location: 44.607158 N 12.173735 E, Emilia-Romagna Region, Italy, IT, Municipalities of Comacchio, Argenta, Alfonsine and Ravenna.

The pilot site is the biggest brackish marsh in Italy; the freshwater enters in the marsh through two groups of two water pipes crossing the bank of the Reno River; the sea water enters or exits in the marsh from three water gates connecting the wetland to channels open on the Adriatic Sea. This is crucial to maintain a correct water salinity for the whole ecosystem, habitat and species living in the Valli di Comacchio.

Risk prone areas within the site: the Boscoforte peninsula, Vene di Bellocchio, urban area of Comacchio, Reno River mouth and in general all the Valli di Comacchio, in particular the small islets, nesting sites of important colonies of waterbirds.



Islets identified as specific threatened areas within the site.

Austria

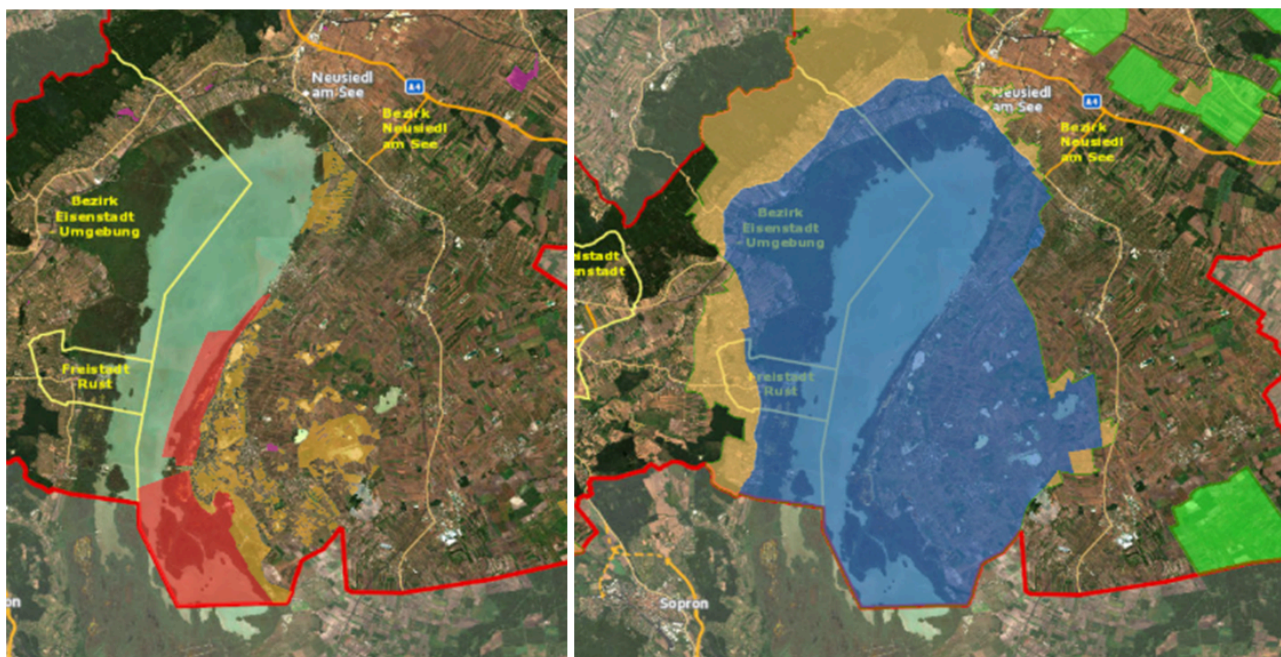
Site name: Lake Neusiedl

Location: 47° 50'28.7"N 16° 45'54.4"E (centre of Lake Neusiedl, WGS84); AT1 Eastern Austria (Ostösterreich) | AT11 Burgenland | AT112 North Burgenland (Nordburgenland), Austria

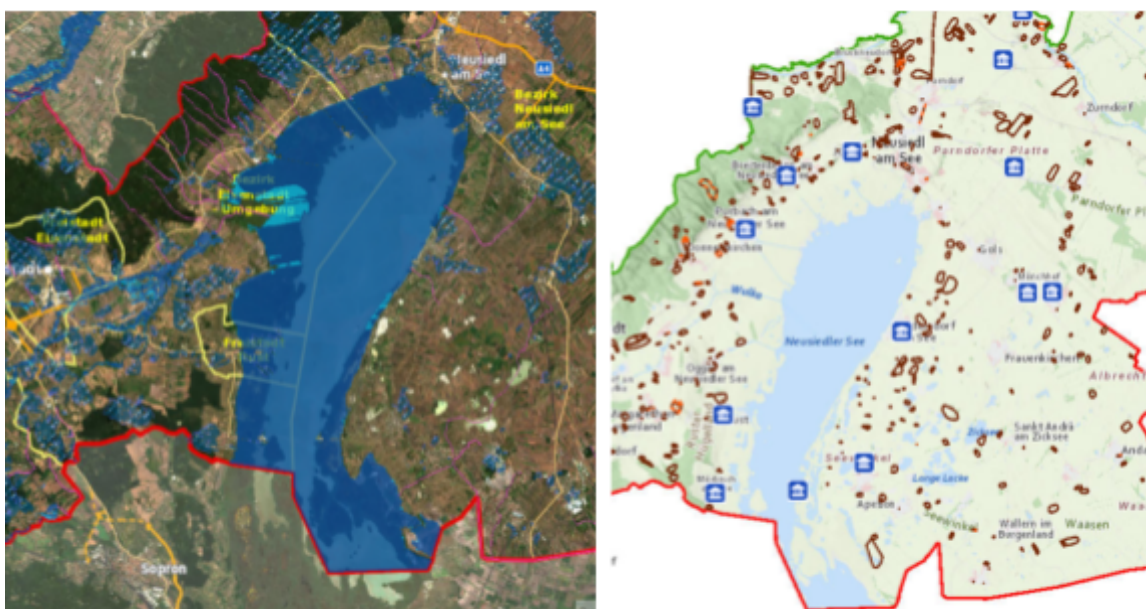
The pilot site is situated at the Austrian-Hungarian border region, 50 km south from Vienna and 200 km west from Budapest. The lake has an area of 322 km² (234 km² in Austria), the core area of the UNESCO World Heritage site, which includes the majority of the relevant CNH assets, is approximately 680 km² (including the Hungarian part). Lake Neusiedl is the westernmost steppe lake in Europe and an important natural habitat, especially for birds. An extensive reed belt and several groundwater-fed, small- to medium-sized alkaline lakes further contribute to the extraordinarily high ecological value.

Risk prone areas within the site: The pilot site is part of the Small Hungarian Lowlands and is closely intertwined with the lake. The region is world-known for its viticulture, but also traditional land use forms such as reed harvesting or pasturing, a historic, but still prevalent rural architectural style of the settlements, and a special way of living are vital components of the pilot site's cultural heritage.

Particularly at risk, being very valuable, is the National park Lake Neusiedl - Fertő and high-ranking natural protection areas. Also important archaeological sites are very sensitive and considered risk prone areas within the site.



Left: core zone in red, protection zone in orange; right: Ramsar area in blue, Birds Directive in orange+blue, FFH-Habitats Directive in green+orange+blue.



Left: Flood hazard map of the region, dark blue areas are in HQ30-zone, light blue areas in HQ100-zone, dashed areas are under risk for pluvial floods; right: Museums (symbols) and archaeological sites (brown polygons) around the Neusiedler See; ©burgenland.at.

Czech Republic

Site name: Central Bohemia Vltava River Valley, Czech Republic, Central Bohemia Region, Prague Region,

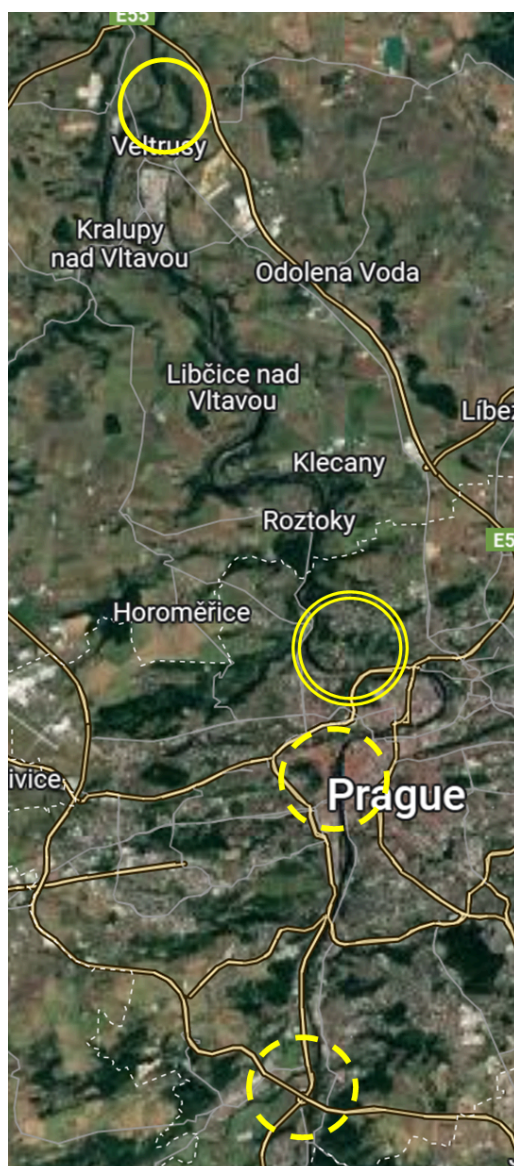
Location:

50.2776506N, 14.3298489E, Veltrusy Chateau with park and Cultural landscape

50.1164169N, 14.4128781E, Troja Chateau, Troja Basin Periurban Park

50.0865031N, 14.4112594E, Charles Bridge, Historic Center of Prague UNESCO World Heritage Site

49.9779531N, 14.3921786E, Zbraslav Castle, Vltava and Berounka River Junction Confluence Periurban Park



Risk prone areas within the site: There are four risk prone areas with different levels of risk reflected in various problems. The core area is located in the Prague-Troja Municipal District which is characterized with a high density of cultural and natural heritage only partly protected by permanent and temporary technical measures. Such a combined protection system is a challenge for risk management involving various types of owners and managers of the endangered assets.

Veltrusy Chateau complex has a similar composition of built and natural heritage, fortunately under one owner and site manager, which enables adoption of more focused and directive measures.

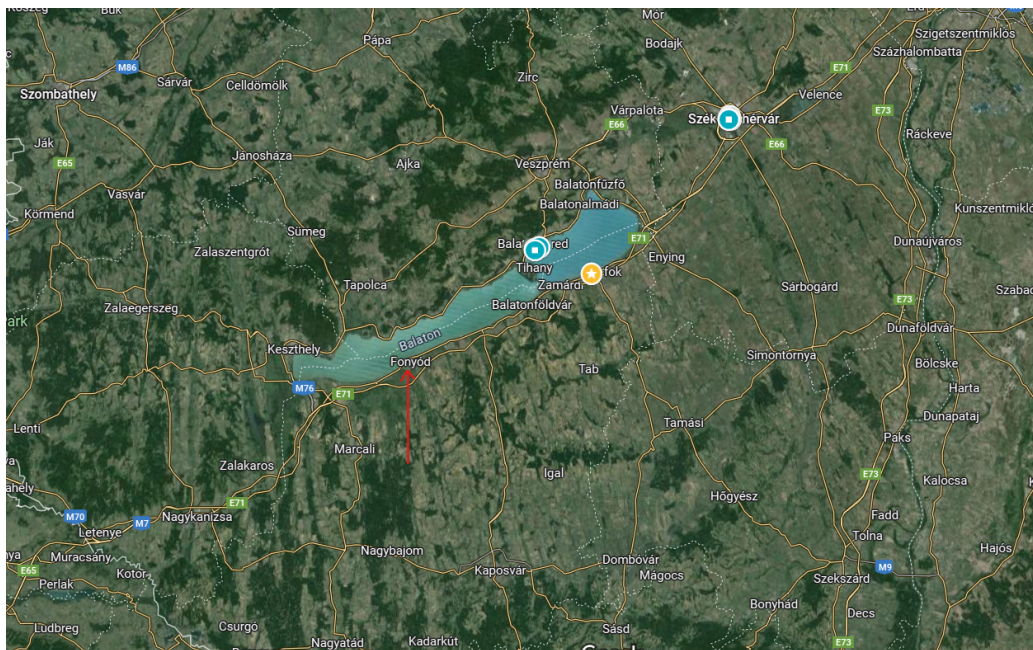
The City of Prague has a centralized system of protection highly sensitive to risks of managerial quality of the City government.

The river floodplain at the confluence of the Berounka and Vltava rivers is a significant area of over 1,300 hectares, which lacked a clear concept for further development and was threatened with gradual degradation. Confluence Periurban Park project is an opportunity for river floodplain revitalization, periurban recreation, sustainable agriculture, and landscape interventions to mitigate the impacts of climate change. The aim of the competition was to select a development team to design the future shape of the riverscape and, together with residents, find a vision for the long-term development of the area in the form of a periurban park.

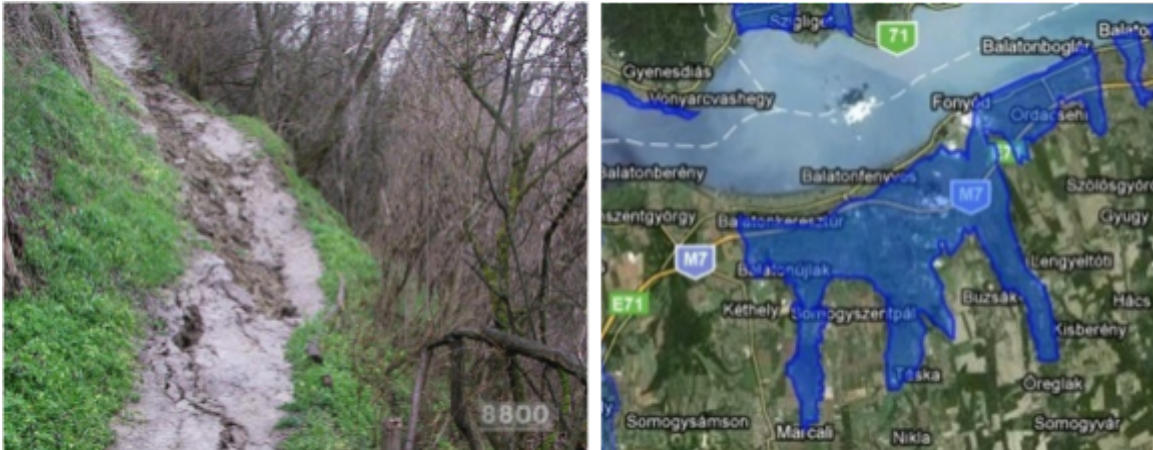
Hungary

Site name: Fonyód

Location: 46.733 / 17.550, E, Hungary, Southern Transdanubian Region, Somogy County, Fonyód district, Fonyód city



Risk prone areas within the site: particularly exposed are the loess wall / high shore area, the Fonyód „Villa Row” (a row of villas, or mansion-like buildings used at vacations taken by Lake Balaton, built 120-130 years ago, are protected CH buildings), the reed natural protection sites, featuring important ecosystems and the peat areas.



Left: Loess wall/high shore area; right: natural heritage areas of peat around Fonyód.

Other risk areas can be found in one km wide strip alongside the shoreline. This is considered especially risk-prone due to the following factors:

- Storms coupled with heavy rains sometimes result in the "spilling" of Lake Balaton. This is a natural phenomenon in which the water levels rise to a certain point where heavy winds effectively blow some water out of the lake basin, causing floods along side the shorelines. 100 km/h wind speeds were measured during the event, resulting in 110 cm tall waves which flooded specific areas of the pilot site Fonyód.
- Winds damage the flood barriers; flood damages the shore promenades, beaches, buildings close to the shoreline etc.
- Floods during low temperature periods can cause serious damages due to freeze.

The lake as well, especially the shoreline, is risk prone during drought.

Germany

Site name: Landkreis Forchheim (District Council)

Location: GPS coordinates: 49° 43' 16.68 N 11° 4' 11.64 E, Central Europe, Germany, Bavaria, Region DE24 (Oberfranken, NUTS2), District Forchheim DE 248 (NUTS3), City of Forchheim.



The whole district (Landkreis) covers an area of 643 square km and a population of 115.000 inhabitants. Landkreis Forchheim is situated at the heart of Franconia (Franken) in northern Bavaria between the metropole city Nuremberg area and the Upper Franconian centers of Bamberg and Bayreuth. The location Landkreis Forchheim is situated between the “highlands” of Franconian Switzerland (Fränkische Schweiz) and the “lowlands” at the river valleys Regnitz, Aisch and Wiesent. Hence the hydrogeological situation is very diverse and the population lives in urban as well as very rural areas.



Left: rock fall at street (near national road Bundesstrasse B470), Wiesent valley, year 2013

Risk prone areas within the site: some parts of the CNH valleys are at special risk: Due to economical pressure the maintenance of the flooding meadows is in danger. More and more soil has been sealed and used for agriculture, infrastructure and building purposes. There are some special sensitive areas in the valleys like Wiesent villages near the river, e.g. municipalities

Ebermannstadt or Weilersbach. The risk prone areas face floodings but also landslides and rock falls at infrastructure that already happened at streets (national road, Bundesstrasse B470 along the Wiesent valley).

Poland

Site name: Jelenia Góra Valley

Location: the Wojanów Palace(50°52'32"N 15°48'50"E) is located in the village of Wojanów in the Lower Silesian Voivodeship, in the Karkonosze County, in the Mysłakowice Commune, on the border of the Jelenia Góra Valley and the RudawyJanowickie in the Western Sudetes. the Łomnica Palace (50°52'36"N 15°48'32"E) is located in the village of Łomnica, in the Lower Silesian Voivodeship, in the Karkonosze County, in the Mysłakowice Commune, along the Łomnica River, in the Jelenia Góra Valley at the foot of the RudawyJanowickie in the Western Sudetes.



Left: Wojanów Palace; right: Łomnica Palace.

The Wojanów Palace is a 17th-century palace located in Wojanów on the southern side of the road from the city of Jelenia Góra, the capital of the Karkonosze district to Janowice Wielkie. The Łomnica Palace is a 17th-century Baroque palace located in the northern part of Łomnica, at the split of the roads to Karpniki and Wojanów, about five kilometers from the city of Jelenia Góra, the capital of the Karkonosze district.

Risk prone areas within the site: the threats will be presented using the example of two neighboring palaces: in Wojanów and Łomnica. Both are part of the Valley of Palaces and Gardens. The area has been affected by floods in the past, notably during significant flooding events in 1997, 2010 and 2024.

Wojanów Palace lies within a moderate to high flood risk zone, where the probability of flooding is significant. The palace's proximity to the river means it is at direct risk from river overflow during heavy rain. The flat surrounding terrain can lead to water stagnation, which increases flood duration. Limited modern drainage infrastructure in the area can exacerbate the impact of floods, as older drainage systems may not cope well with high water volumes.

Like Wojanów, Łomnica has experienced significant flooding in past decades, especially during the large-scale regional floods. Łomnica Palace falls into a high flood-risk category, particularly

vulnerable to both riverine flooding from the Bóbr and flash flooding from nearby tributaries. The presence of tributaries joining the Bóbr River near Ľomnica increases the potential for backflow and water accumulation during periods of intense rainfall. Ľomnica Palace's historic foundations are at risk, as they are often not equipped to handle prolonged water exposure. Prolonged rainfall can cause the surrounding land to become saturated, reducing the natural absorption capacity and heightening flood risk.

Slovakia

Site name: section of the Bodva river basin between Medzev and Jasov



Location: The Bodva Basin area includes the region around the towns of Medzev and Jasov, located in the Košice Self-Governing Region, in the district of Košice- vicinity, Slovakia, European Union.

- GPS Coordinates Medzev: 48° 42'00.0"N 20° 53'32.5"E
- GPS Coordinates Jasov: 48.682387° N, 20.967193° E

The area is characterized by rich cultural and natural heritage, including significant historical monuments such as the Premonstratensian Monastery in Jasov, the heritage zone of Medzev, and the Medzev hammer mills. The area also borders with the Slovak Karst National Park, which is inscribed in the UNESCO World Heritage List.

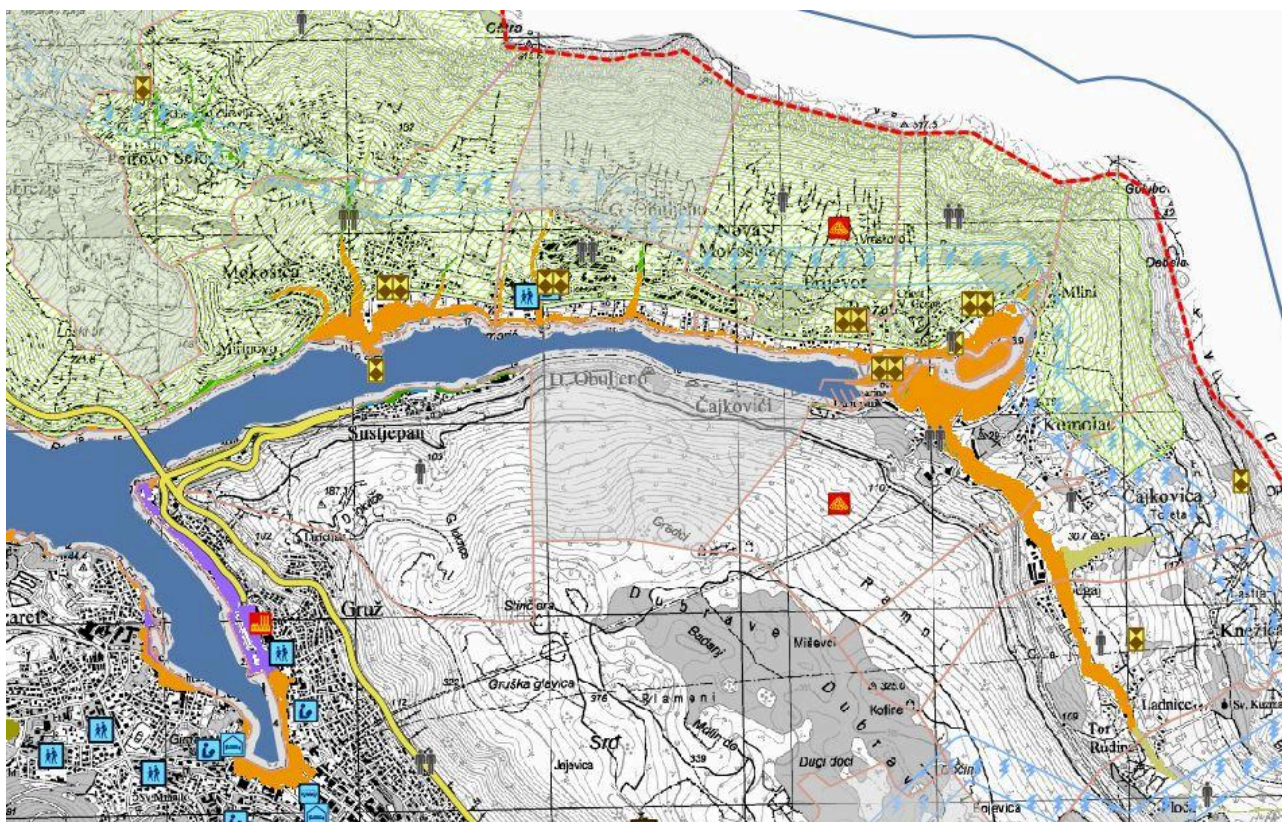
Risk prone areas within the site:

1. Jasov Monastery Complex with Adjacent Historic Park and Garden: Risk associated with floods, fires, windstorms, and drought.
2. Urban Heritage Zone - Medzev Center: Historic buildings face risks of floods and windstorms.
3. Šugov Valley near Medzev: Cultural heritage at risk from flooding.

4. Slovak Karst National Park: Threats to fauna and flora due to heatwaves, drought (protected species and biodiversity), fires (forest and grasslands), and strong winds (forest areas)

Croatia

Site name: Rijeka dubrovačka - Ombla



Flood hazard map of the River Ombla area

Location: 42 40' 04", 18 04' 42"; **Region:** Dubrovnik-Neretva County, **Country:** Republic of Croatia, **EU ID:** HR037, **City:** Dubrovnik, **Municipality:** Dubrovnik.

The Dubrovnik River (Ombla), a deep river-sea fjord surrounded by high hills, begins on the eastern side of the port of Gruž. 5 km long, 200-400 m wide, northwest of Dubrovnik - the mouth of the river Ombla (ancient Arion), which was mentioned as Rijeka as early as 1169, actually sank. About thirty meters from the source of the river Ombla there is a small waterfall about 70 cm high, after which the Ombla flows through the 5 km long bay of the Dubrovnik River to Komolac. It is believed that its watercourse is only 30 meters long and that Ombla is therefore named the shortest river in the world. The Dubrovnik River is the main source of drinking water for the area of the City of Dubrovnik.

Risk prone areas within the site:

...Within the site, there are many attributes of the Historic Urban/ Rural Landscape as well as the Significant landscape of River Ombla which is exposed to threats to fauna (Natura 2000 species) and flora due to heatwaves, drought, fires, and windstorms.

The main risk-prone area is a strip on the shoreline with a rich cultural-historical inventory of old Dubrovnik summer houses and parks.

Risk-prone areas within the site:

1. Summer villas with Adjacent Historic Park and Garden (Bunić Kaboga, Gučetić Lazarević, Restić, Bosdari Škaprlenda) : Risk associated with floods, sea-level rise, earthquake, fire, drought and windstorms.
2. A renaissance Dubrovnik aqueduct: Historic infrastructure at risk from soil erosion and landfall.
3. Franciscan Monastery and the Church of the Visitation of Mary: Risk associated with floods, sea-level rise, and windstorms.
4. Railway infrastructure from the 19th century: Historic infrastructure at risk from soil erosion and landfall.

D. Final remarks and conclusions

This research shows how climate change poses a significant risk to both cultural and natural heritage in Central Europe, where rising temperatures, more frequent extreme weather events, and shifting precipitation patterns threaten historic sites, monuments, and landscapes. Increased rainfall and flooding can damage delicate structures, artworks, and archaeological sites, while prolonged heatwaves and droughts accelerate the deterioration of building materials like stone, wood, and plaster. Natural heritage, including forests, wetlands, and ecosystems, is also at risk from changing climatic conditions that disrupt biodiversity and degrade habitats. Additionally, the combined effects of climate change—such as fluctuating humidity and temperature—can harm the preservation of archives, manuscripts, and other sensitive cultural objects. Addressing these threats is essential to protect both built and natural heritage for future generations.

Vulnerability evaluation, hazard mapping and risk assessment for the presented pilot sites are discussed in more detail in WP2. Please refer to its deliverables for more information.