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Transnational monitoring strategy to monitor tourism impacts on the environment in conservation areas

Photos: Lúresh Galambos

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Introduction

This transnational monitoring strategy proposes a framework for the development, testing, and evaluation of a monitoring system that supports visitor management activities of pilot sites within the INTERREG Central Europe project HUMANITA.

The main goal of the INTERREG CE project HUMANITA is to produce a proposal for a more complex monitoring system for conservation areas (CAs) in regard to environmental impacts of outdoor tourism on natural assets. Together, project participants test different innovative monitoring methods and approaches. Our results and analyses will enable us to draw up policy recommendations and develop local action plans for pilot sites in five regions: Bükk National Park in Hungary, Mala Fatra National Park in Slovakia, Tuscan-Emilian Apennine National Park in Italy, Significant landscape Lower Kamenjak and the Medulin Archipelago in Croatia and Karawanken-Karavanke UNESCO Global Geopark on the border between Austria and Slovenia.

The action plans will provide a framework for the administration of five CAs to monitor visitor impacts, further engage local people and tourists in monitoring and nature protection, develop proactive programmes for managing ecosystems and their use by visitors, and properly manage human-nature conflicts respecting the local context and legal framework. The final project report and monitoring catalogue will provide policy recommendations and summarize the most important and feasible monitoring activities that can be recommended for a long-term monitoring of tourism impacts on the environment in CAs in Central Europe.

Firstly, we aim to collect information about **touristic infrastructure**, **visitor movement** within CAs and **visitor attitudes** towards the environment. Secondly, we develop and test different innovative methods to **monitor impacts of visitors on the environment (vegetation, erosion, wildlife, pollution monitoring)**. With the participation of local stakeholders, experts and visitors in monitoring efforts our project aims to develop **citizen science tools** and to develop a **new common-heritage narrative** to respect and protect natural values within CAs.

For the development of the transnational monitoring strategy, HUMANITA project partners employ a comprehensive framework and workflow for biodiversity monitoring, that was developed by Dalton et al. (in press) as a **new standard for biodiversity monitoring**. This framework is supported by **International Union for Conservation of Nature's World Commission on Protected Areas (IUCN WCPA)** and is designed to provide CA managers and their partners with a unified approach, enabling the production of valid and comparable data. The biodiversity monitoring framework will be adapted to target the needs for planning and conceptualizing a monitoring plan that focuses on monitoring human pressures on the environment.

The four-phase monitoring framework is structured in the preparatory, the conceptual, the implementation, and the re-evaluation phases (Figure 1). Within the **preparatory phase**, each of the five CA partners produced reports identifying the impacts of tourism within their respective regions. These reports offer crucial baseline insights into areas experiencing tourism pressures and vulnerable zones affected by tourist activities. Pilot sites serve as focal points of the project's investigation and are presented in detail, outlining their characteristics in regard to their natural values and touristic activities, monitoring requirements and information gaps.

The transnational monitoring strategy emerges as the final output of the **conceptual phase** of the monitoring framework. It is not solely a strategic document but it can rather be seen as a planning document for HUMANITA project partners. It serves as a guide for addressing basic questions about the intended monitoring programme. The strategy, developed collaboratively by project partners, outlines a unified approach to monitoring that is modular and applicable to different situations, reflecting the current state of biodiversity and the impacts of tourism at each site. By establishing a priority list of monitoring targets, the **transnational monitoring strategy sets the stage for the subsequent implementation and re-evaluation phases**, driving the project activities towards effective, adaptable, and sustainable visitor management practices in CAs.

In regards to potential resource limitations of CAs, the results and insights of the HUMANITA monitoring programme will allow partners to exchange their experiences and to **identify a minimum number of representative indicators** that can be recommended for inclusion into a **general monitoring catalogue**. This body of experience will provide a **basis for a continuous monitoring programme for CAs** focusing on impacts of tourism within CAs of Central Europe.

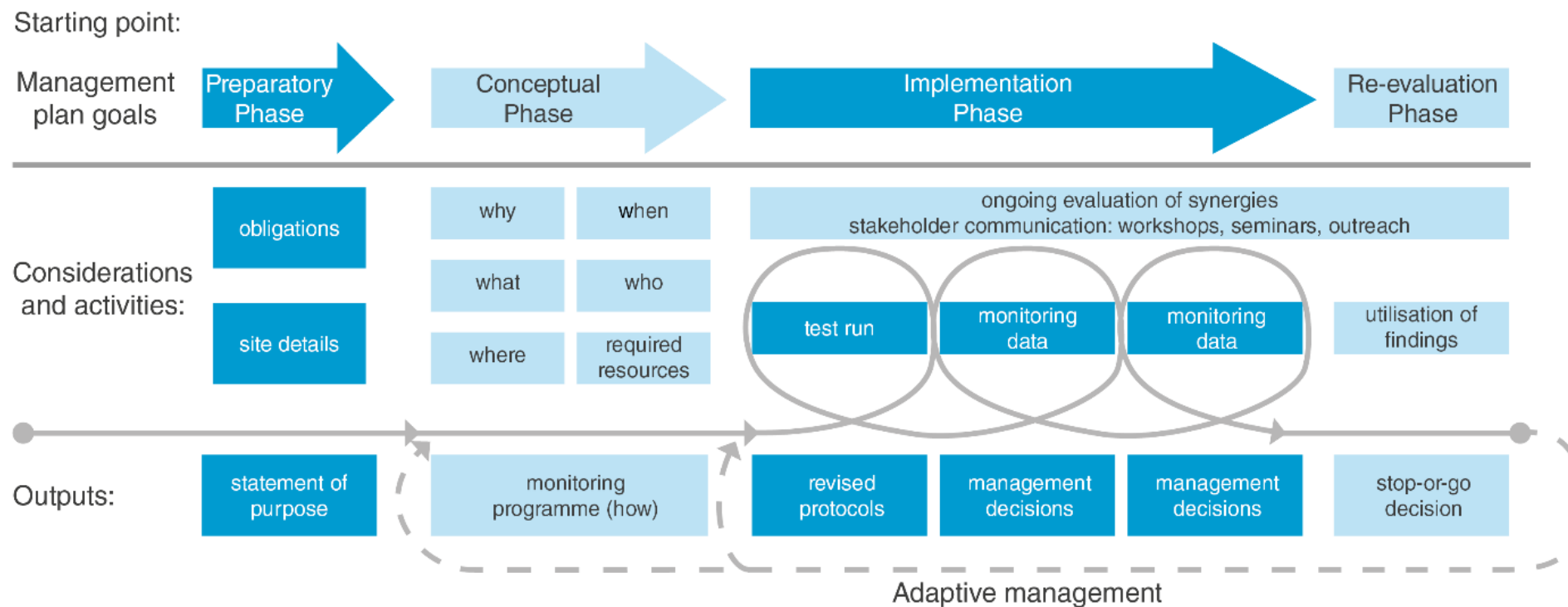


Figure 1: Workflow of the biodiversity monitoring framework. The framework is employed to correspond with site management goals of HUMANITA pilot sites. In the preparatory phase, a basic investigation of the site details and monitoring obligations was conducted. Five reports on the impacts of tourism at pilot sites were produced that outline the results of this basic investigation, resulting in a monitoring statement of purpose at each site. The transnational monitoring strategy is the result of the conceptual phase, where a series of basic questions were addressed by partners that define the intended monitoring programme. The result is a strategy that maps out how the monitoring will be implemented. In the implementation phase the monitoring programme is tested and refined. The results of the monitoring programme will guide management decisions. Detailed re-evaluation of the programme occurs at mid-term and at the end of the project, providing opportunities for adaptive management. (Source: Dalton et al., in press).

1. Preparatory phase: Report on impacts at pilot sites

In the preparatory phase of the HUMANITA project, the first step involved the identification of the primary monitoring objectives for each pilot site. Subsequently, project partners generated five comprehensive reports that focused on showcasing the impacts of tourism at the defined pilot sites, which are considered touristic hotspots within the respective CAs. These reports not only provide an overview of the monitoring obligations of CAs to meet national and international conventions and standards, but also summarize the baseline situation of threatened natural values impacted by tourism. The reports draw upon existing data, documents and monitoring results, offering insights into important biodiversity assets and site-specific indicators.

Within the context of the HUMANITA project's ongoing progress, regional stakeholders are set to play a crucial role. Their involvement is solicited through interviews and workshops, providing an opportunity to incorporate their perspectives into the identification of tourism pressures, impacts and interactions. This collaborative approach aims not only to assist CA managers in implementing effective management measures for biodiversity conservation, but also fosters local engagement.

The reports, integral to the preparatory phase, concentrated on various aspects of management plan goals, protected assets, and touristic activities of the area as well as potential threats induced by tourism. Demands of regional stakeholders are also considered. Reports encompass legal obligations and site-specific background information, revealing knowledge gaps. Through this basic site investigation, major threats to the sites and conservation challenges were identified, enabling CA managers to define site-specific goals and management objectives. The investigation culminated in the formulation of clear, site-specific **statements of purpose** for each pilot site, outlining priority questions for monitoring in the subsequent phases of the project.

Statement of purpose: Bükk National Park Directorate

The Bükk National Park Directorate is primarily concerned within its regular monitoring activities with the continued research on the state of habitats and changes in population size of the natural values within the different units found within its operational area, as indicated by the Hungarian National Biodiversity Monitoring System. As tourism in CAs is increasing and the priorities and behaviour of tourists change, the monitoring and better understanding of tourist-related pressures is becoming ever-more important for the Directorate. Gaps and missing research topics regarding the subject include:

- Up-to-date, comprehensive data matrix/map of frequent littering spots, unofficial tourist infrastructure, hiking and downhill trails.
- Visitor numbers besides some frequent tourists' spots and visitor centres, as well as visitor number monitoring in the Landscape Protection Areas and Nature Protection Areas managed by the Bükk National Park Directorate.
- Research on how to limit negative impacts of tourism.

Having actual and up-to-date data on this matter will be much appreciated for carrying out management plans, which should help conservation specialists, local communities, municipalities, and other organisations manage the human-nature conflicts within the area.

Statement of purpose: Significant landscape Lower Kamenjak and the Medulin Archipelago

Public Institution Kamenjak (PIK) perceives the importance and the needs: to research and monitor the environmental impacts of tourist activities on natural values at the pilot area; to create a basis for directing the movement of visitors in the area more efficiently; and to reduce the pressure caused by visitors in specific locations as well as to reduce the loss of biodiversity. The focus is on the improvement of the sustainable management of the CA of Lower Kamenjak and the Medulin Archipelago by developing, monitoring and testing new methods and solutions. The role of the PIK in the HUMANITA project is to contribute to the project to better understand the spatial and temporal distribution of visitors, as well as the most affected zones. The project activities will focus on defining the areas where the impact of visitors is the most intense. Monitoring of visitor activities, soil pollution and coastal areas will contribute to a more targeted distribution of vehicles in the CA, thereby reducing the pressure of vehicles and visitors in specific locations. The envisioned results are for improved seasonal adjustments, a more appropriate distribution of visitors in the area, better management of visitors and more effective nature protection.

Statement of purpose: Karawanken-Karavanke UNESCO Global Geopark

The Karawanken-Karavanke UNESCO Global Geopark recognizes the pressing need to study the environmental impacts of tourist activities on natural values in the pilot areas of Mt. Petzen/Peca and Hochobir/Ojstrc. By monitoring visitors and their impacts on the environment, the management organization of the Geopark hopes to gain a better understanding of the locations of touristic hotspots, visitor numbers, and unofficial user activities. This information will support informed decision-making and targeted visitor management, ultimately leading to the development of greener and smarter tourism practices and the creation of a more sustainable green destination. The Geopark is especially interested in implementing an active spatial planning strategy that balances the needs of tourism and nature protection to enhance the quality of life in the region.

Statement of purpose: Mala Fatra National Park

The priority of the Mala Fatra National Park is to monitor the impact of mass tourism on erosion, vegetation and wildlife; to develop monitoring methods that provide solutions to protect and restore degraded places; to correlate the information about spatial and temporal distribution of visitors and their impacts; to develop and test various technological and traditional monitoring methods; to share gained knowledge nationally and with other partners. To address these priorities, this project proposes to investigate the impact of visitors on the behaviour of large carnivores; on water pollution in the park; on soil health.

Statement of purpose: Tuscan-Emilian Apennine National Park

The Tuscan-Emilian Apennine National Park recognizes the need to study the environmental impacts of tourist activities on natural values in the pilot areas of Pietra di Bismantova, Monte Cusna- Lama Lite and Alta Val Parma forest, Lago Santo, Monte Marmagna. By monitoring visitors, the Tuscan-Emilian Apennine National Park management organization hopes to gain a better understanding of the impact of visitors on natural resources, visitor numbers, and good management practices, as well as making tourists aware of the value of the frequented areas and the impact that their behaviour can have on them. This information will support informed decision-making and visitor management, leading to the development of greener and smarter tourism practices involving local communities.

2. Conceptual phase: Towards a transnational monitoring strategy

The **monitoring concept worksheet** is the basis for the development of the transnational monitoring strategy. This worksheet, comprising six essential questions, serves as a guide for CA managers to develop their specific monitoring plans. It plays a pivotal role in identifying and structuring primary objectives within the monitoring plan, offering a means to justify the necessity of monitoring in alignment with management objectives. As a key resource for our project, this worksheet is instrumental in drafting a field manual for the implementation of the monitoring programme.

The monitoring concept worksheet acts as a focal point, helping to concentrate the many considerations and providing a structured frame of discussion for stakeholders. The relevant questions are as follows (Figure 2):

1. Why establish a monitoring programme?
2. What will be monitored?
3. Where will the monitoring take place?
4. When will the monitoring take place?
5. Who is involved in the monitoring programme?
6. What resources are required for the monitoring programme?

By addressing these questions comprehensively, clarity emerges on "how" monitoring could proceed and the potential "synergies" with other monitoring programmes. HUMANITA Partners actively contributed to this process by completing the monitoring concept worksheet, aiding in the logical development of the transnational monitoring strategy. This exercise proved instrumental in defining indicators for monitoring and identifying proxies that can be utilized to track these indicators. The template is adaptable and can be employed to aggregate the indicators, providing a versatile approach to monitoring the degree of human influence on an ecosystem. This collaborative effort sets the stage for a well-informed transition into the conceptual phase of the monitoring strategy that will be carried out in further stages of the HUMANITA project.



Figure 2: Questions of the monitoring concept worksheet. These leading questions provide a comprehensive structure to define the monitoring plans of pilot sites that will be carried out in the conceptual phase of the HUMANITA project (Source: Dalton et al, in press).

The monitoring concept worksheet serves as the initial stage for the collaborative formulation of the transnational monitoring strategy. During the April 2023 HUMANITA project kick-off meeting in Bükk National Park, the biodiversity monitoring framework was introduced to project partners. The objective was to acquaint partners with the framework's structure and design, fostering a workshop environment conducive to brainstorming on planned monitoring activities linked to the recognized impacts of tourism within the CAs.

In the subsequent phase, the online collaboration tool "Miro" facilitated the ongoing refinement of the monitoring concept worksheet (see results in Appendix 1). Miro is a collaborative online platform specifically designed to foster interactive work among teams, allowing users to generate, share, and collaborate on digital whiteboards, diagrams, mind maps, and other visual aids in real-time. The scientific and practical partners of the HUMANITA project were tasked with collaborating on the Miro Board to fine-tune their monitoring requirements and delve into the six foundational questions underpinning the monitoring plan through online workshops.

The following chapter 2.1. provides a summary of the planned monitoring activities for all partners. It is organized into subchapters that follow the monitoring concept worksheet. Furthermore, the chapters are structured according to the main monitoring foci, namely visitor monitoring, vegetation monitoring, erosion monitoring, wildlife monitoring as well as pollution monitoring. The subsequent chapter 2.2 includes the final worksheets for all planned monitoring activities, outlining the **why, what, where, when, who, required resources as well as a general statement on how monitoring may proceed** for each activity. The worksheets are organized according to activities at individual pilot sites.

2.1 Monitoring programme

Why establish a monitoring programme?

The first question of the monitoring concept worksheet elaborates on the question why a monitoring programme to monitor visitor impacts on the environment needs to be established. It refines the statement of purpose from the preparatory phase of the monitoring framework, defines the expected outcomes of the monitoring plan and explains the site requirements as well as the scientific, cultural and management value of the programme. On a general level the CAs have defined overall goals that they would like to address with the monitoring programme:

The monitoring programme will...

- address monitoring obligations and management objectives of pilot sites;
- provide a framework for the monitoring of visitor impacts at pilot sites;
- engage local people and tourists into the monitoring and nature protection;
- identify human-nature conflicts within the pilot sites.

The results of the monitoring programme will...

- provide data to adapt and implement effective conservation strategies;
- provide an argumentative basis to change the conservation status of sensible areas in order to protect sensible habitats or species from excessive or inappropriate touristic use;
- support management activities of CAs;
- provide materials for outreach, education and instructional purposes;
- be the basis to develop a new common-heritage narrative to respect and protect natural values within CAs;
- inform CA managers and decision makers on whether desired outcomes of management activities have been achieved.

The CAs have selected pilot sites for the monitoring programme within their respective territories that experience high touristic pressures on natural values. The pressures that they experience are detailed within the reports on tourism impacts. The general aims and priorities of each monitoring programme are furthermore summarized in the statement of purpose for each park (see Chapter 1).

There are a **number of common monitoring activities that are performed in all CAs in a similar way**. Furthermore, based on the individual pressures, monitoring obligations and conservation objectives of the CAs, **complementary methods will be developed and tested at the individual pilot sites**:

Visitor monitoring

On a common level, all CAs aim to understand the spatiotemporal behaviours of hikers and/or bikers in areas of high conservation importance. Results of digital visitor monitoring activities will support the Parks and tourist associations to understand the frequency of hikers and/or bikers on official and promoted trails, to identify frequencies of hikers and/or bikers on unofficial or unpromoted trails and to better understand in which areas high-frequency visitation may result in negative environmental impacts.

A visitor survey performed at each CA aims to understand how visitors plan, navigate and track their activities. It sheds light on how visitors perceive the role of the natural environment and perceived pressures that visitors pose on the area. In terms of stakeholder and local expert involvement, all CAs organize various interviews and/or workshops to collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.

Bükk National Park will deploy visitor counters to monitor the frequency of visitors that make use of the newly developed educational trail at Hór Valley. Also, the Park aims to correlate visitor numbers with the activity of bat species in highly frequented caves.

Karawanken-Karavanke Geopark plans to position visitor counters on selected hiking and mountain biking trails within the area of Mt. Petzen/Peca and Hochobir to correlate the visitor numbers from the counters with information from digital visitor monitoring. GPS loggers are used to identify local and temporal hotspots.

Mala Fatra National Park will install visitor counters near the pilot sites on Mt. Chleb locations to correlate visitor numbers with erosion and trampling processes.

Public Institution Kamenjak will install car counters at 10 parking zones on the Lower Kamenjak Peninsula. The investment will be linked in a broader parking management project. The information will support to work against the problem of illegal parking along roadsides and within the protected grassland.

Tuscan-Emilian Apennine National Park will position counters at pilot sites Pietra di Bismantova, Sella del Marmagna as well as Lama Lite Pilot site to monitor the number of hikers, bikers and cars, correlating the numbers with erosion and trampling monitoring.

Vegetation monitoring

Regarding vegetation monitoring HUMANITA partners will implement complementary monitoring methods.

Bükk National Park will focus on the monitoring of trampling processes along highly frequented hiking trails on sensible rocky grasslands at two pilot sites to understand the visitor impact on vegetation.

Karawanken-Karavanke Geopark will monitor invasive species location, abundance and their translocation caused by hikers and mountain bikers. Involving citizen scientists in monitoring will raise their awareness of the problem and help the Park localize areas that need to be managed.

Mala Fatra National Park will focus on the monitoring of trampling processes at their pilot sites at Mt. Chleb, to identify species that are threatened by visitor impacts.

Public Institution Kamenjak experiences an increasing fragmentation of the landscape. To target the problem, they will monitor the formation of wild trails and shortcuts through the protected grasslands at Lower Kamenjak.

Tuscan-Emilian Apennine National Park will monitor trampling processes as a result of high visitor numbers at their pilot sites using standard and technology-based methods. Furthermore, a dendroisotopic method will be used to determine tree ring growth. The analysis will differentiate between climatic influences and human disturbances caused by touristic infrastructure (ski slopes, hiking trails).

Erosion monitoring

To develop and test erosion monitoring methods the **University of Parma (UNIPR)**, Italy and **University of Žilina (UNIZA)**, Slovakia test various technology-based methods in four of five CAs that are pilot sites within the HUMANITA project.

In **Karawanken-Karavanke Geopark** the impact of mountain biking on trail erosion will be monitored. In **Mala Fatra National Park** and **Tuscan-Emilian Apennines National Park** monitoring will be conducted to determine trail erosion along highly frequented hiking trails. At the pilot site of the **Public Institution Kamenjak**, erosion processes will also be considered, separate from trampling affects (vegetation monitoring).

Wildlife monitoring

Bükk National Park will monitor the activity of humans and bats inside of three highly visited caves. This will allow determination of the influence of visitors on behaviours different bat species. Furthermore, the spread of *Batrachochytrium dendrobatiodis* (BD) infection and ranavirus infections in amphibian populations has led the Park to study a possible influence of human activities on the spread of the disease, investigating whether more infections are detected near touristic infrastructure compared to more remote areas.

Karawanken-Karavanke Geopark aims to document wildlife activities alongside trails at selected locations where target species are predicted. The documentation will inform visitors about the co-existence of humans and nature and allow a baseline documentation of wildlife in the area.

Mala Fatra National Park aims to gain data on large carnivores and the influence of habitat fragmentation caused by tourism. Furthermore, it investigates the abundance of soil mites to test whether this indicator is suitable to monitor soil health. Another activity investigates whether human activities pose a potential threat to bird health.

The **Tuscan-Emilian Apennine National Park** plans to collect data on animal species activity alongside touristic infrastructure to determine whether fragmentation of the landscape poses a potential threat to wildlife in the area.

Pollution monitoring

In **Bükk National Park**, a citizen science approach will allow the monitoring of trash type and location near the educational trail in Hór Valley and raise visitor awareness on the problem.

Mala Fatra National Park will analyse water pollution. High-elevation, forested watersheds are particularly vulnerable to stresses from tourism industry development. Steep slopes and thin soils rapidly transmit water, nutrients, and sediment when disturbed by different human activities.

The **Public Institution Kamenjak** plans to monitor macro litter on beaches, involving citizen scientists and raising their environmental awareness.

What will be monitored?

The emphasis on monitoring within the HUMANITA project encompasses the development of innovative monitoring approaches of an extensive array of indicators, designed to assess and comprehend the ecological dynamics and potential threats posed by tourism in CAs. A detailed framework for recording, measuring, and documenting these selected indicators and proxies will be developed, with the intent to facilitate future time-series evaluations. The criteria for these indicators and proxies require sensitivity to change, site specificity, and ease of sampling. The **monitoring activities at the pilot sites will be complementary to each other**, meaning that not all monitoring activities will be performed at all sites. The **choice of indicators** is dependent on the **site-specific details, imposed threats, monitoring obligations and management objectives** within the pilot sites.

The selected indicators that will be monitored in the frame of the HUMANITA project can be grouped into **1) visitor monitoring 2) vegetation monitoring 3) erosion monitoring 4) wildlife monitoring and 5) pollution monitoring**. The **development and testing of diverse monitoring methods** at selected sites aims to **enhance the understanding of the correlation between visitor activities** and corresponding **ecological processes**. This comprehensive approach ensures a thorough understanding of the intricate interactions between tourism and the ecological integrity of the CAs.

There is neither a single method that can be used for all the investigated indicators, nor one method that can answer all questions. Usually, a combination of different approaches and methods is necessary. Consequently, the most suitable methods must be selected according to the specific on-site circumstances.

Visitor monitoring

The visitor monitoring activities within HUMANITA aim to enhance the understanding of the spatiotemporal distribution of visitors and their attitudes towards nature.

Of primary concern is the evaluation of the **degree of land transformation** within pilot sites, with a specific focus on monitoring visitor infrastructure of hikers, bikers, and motorized vehicles, utilizing complementary monitoring methods. All pilot sites have collected data on the official touristic infrastructure, like paths, trails and streets within their pilot sites that are promoted for touristic use. This data collection was performed during the basic investigation and further information on this official infrastructure can be found within the reports of tourism impacts at pilot sites.

Carinthia University of Applied Sciences (CUAS) will perform **digital visitor monitoring** for all pilot sites that are part of the HUMANITA project. Data from various outdoor and fitness apps (i.e. Outdooractive, Komoot, Alltrails, Trailforks, STRAVA) will be analysed in regard to user activities and digital information on official and unofficial trail network.

The data from online sources will be compared with data from **automatic visitor counters** within the CAs. There are already existing visitor counters in place within the areas. The CA partners plan to install further counters at pilot sites to monitor visitor numbers:

Bükk National Park Directorate is set to install visitor counters at a pilot site designated for the development of an educational trail. Presently, a counter tracks visitors ascending

toward a tourist cave. The forthcoming installation will enable monitoring of individuals utilizing the path along the educational trail.

Karawanken-Karavanke Geopark will deploy automated visitor counters at the pilot sites of Mt. Petzen/Peca and Hochobir to monitor visitor traffic along popular hiking and mountain biking trails, as well as access roads to gain a better understanding of visitor flow on officially promoted trails and unofficial mountain biking activities.

Mala Fatra National Park is planning to install visitor counters at selected monitoring sites to correlate the frequency of visitors with erosion and trampling.

Public Institution Kamenjak is implementing a new system featuring visitor counters in parking lots within the park to monitor the flow of entering and exiting cars. Counters will be connected to a display board that informs visitors about available parking spaces, thereby mitigating instances of roadside parking caused by crowded lots.

Tuscan-Emilian Apennine National Park is planning to install electric visitor counters and cameras to count the number of passing people, bicycles and vehicles at selected sites.

Within the **Karawanken-Karavanke Geopark**, **CUAS** will hand out **GPS loggers** to hikers to track their activities at pilot sites. The aim is to identify spatial and temporal hotspots, identify places where visitors rest for a longer period of time and to analyse spatial distribution patterns.

Eurac research developed a **questionnaire** in the frame of the project which was administered by CA partners. It examines the behaviour and the attitude of visitors toward the environment they are visiting. It investigates the digital platforms employed by visitors to gather information about the area, plan trips, and navigate on-site. In particular, it explores their attitudes towards the CA, nature protection, and their awareness of the environmental impact they may have.

Vegetation monitoring

The **HUMANITA** project aims to comprehensively assess the impacts of visitors on sensitive habitats and plant species. The identification of **trampling**, in conjunction with touristic infrastructure, emerges as a pertinent proxy for biodiversity monitoring. Vegetation monitoring will concentrate on assessing the **richness, distribution, and diversity of protected species** as well as the **distribution of invasive plant species** alongside trails.

Bükk National Park Directorate is planning to conduct phytocoenological surveys along transects in two sites to monitor tourist-related pressures on rocky grassland habitats. The aim of the study is to compare the effects of touristic activity on the botanical composition of the pre-selected habitats.

Within the **Karawanken-Karavanke Geopark** a correlation between tourism activities, infrastructure, and the spread of invasive species is being investigated. A twofold monitoring approach is elaborated in collaboration with **CUAS**. Environmental DNA samples obtained from soil from hiking shoes and bike tyres are analysed in the laboratory with genetic methods to detect traces of invasive species within the samples (Figure 3). Furthermore, a citizen science approach, using the platform **iNaturalist**, will allow visitors to collaborate on monitoring of invasive species by mapping their location and abundance alongside trails within the pilot areas.

In **Malá Fatra National Park** the quality of vegetation will be monitored alongside trails, detecting changes in habitats and plants at pilot sites. Trampling effects will be investigated along defined transects at highly frequented trails. UNIZA will evaluate the spatial and environmental characteristics of trails at pilot sites, which are quite heterogeneous. This heterogeneity can hinder our understanding of different types of direct human impacts across the landscape. That is why UNIZA will collaborate with the Administration of Malá Fatra National Park, to try to develop a full picture of trail conditions in space and their change through time by a combination of different methods. The quality of vegetation will be assessed by LiDAR remote sensing and standard field studies as well.

The **Public Institution Kamenjak** is planning to apply the same citizen science approach as Karawanken-Karavanke Geopark by using the platform iNaturalist for invasive alien species monitoring. Visitors will be invited to collect the following data: species name, location, date, abundance, habitat description and to observe and share information on species location and abundance in the CA.

The **Tuscan-Emilian Apennine National Park** plans to perform an expert-based vegetation survey to detect species abundance, species richness and distribution on selected transects along hiking path at pilot sites. Within the same pilot sites, UNIPR will collect tree samples (tree wood cores) along selected trails, ski slopes and undisturbed areas, in order to detect indicators of anthropogenic disturbance on the surrounding vegetation.



Figure 3: Monitoring the spread of invasive alien species within the Karawanken-Karavanke Geopark, using eDNA approaches and involving Citizen Scientists.

Erosion monitoring

UNIZA focuses on the monitoring of tourist-induced erosion on selected hiking trails. UNIZA will use a UAV-based LiDAR scanner (Lidaretto) in the area of the strict nature reserve of Mount Chleb in **Malá Fatra National Park**. The purpose of the spatial measurement and data collection in the pilot site is to capture the real terrain status and its conditions (Figure 4). The analysis of the measured data enables the observation and interpretation of the deformation effects in real-time. After measurements performed in predefined time epochs, it is possible to compare the terrain status and calculate the changes according to the erosion effects. A correlation between erosion and various impact factors such as number of tourists, soil parameters, shape of terrain etc. will be evaluated.

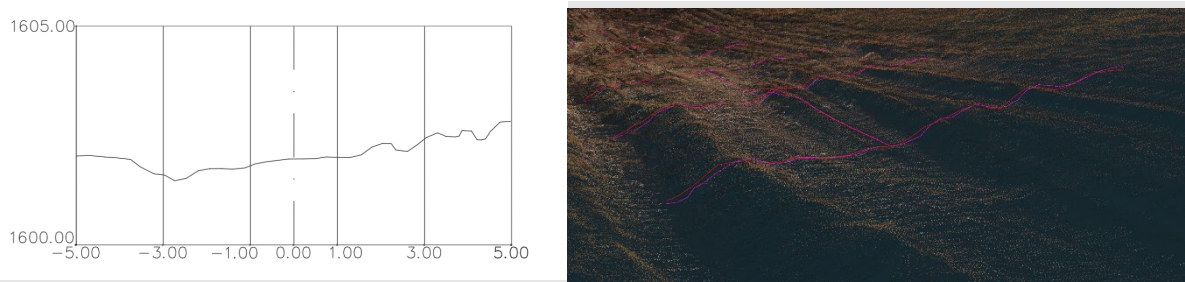


Figure 4: Digital terrain model and profiles are used for calculating erosion volume at trail transects.

UNIPR carries out erosion monitoring alongside selected hiking trails within the **Tuscan-Emilian Apennine National Park**. UAV-based photogrammetric surveys of the trail network are carried out, both with high- and low-altitude flights for different levels of detail. Furthermore, UNIPR carries out ground-based photogrammetric surveys with a 360-degree panoramic camera. A dendrogeomorphological analysis within the **Tuscan-Emilian Apennine National Park** will be performed, sampling tree roots on the central portion of the trails. This method allows to understand past erosion processes on the trail. All methods are used to measure topographical changes caused by soil erosion. Collected data will be integrated with information regarding temperature and humidity of soil and air, recorded with automatic dataloggers installed on-site.

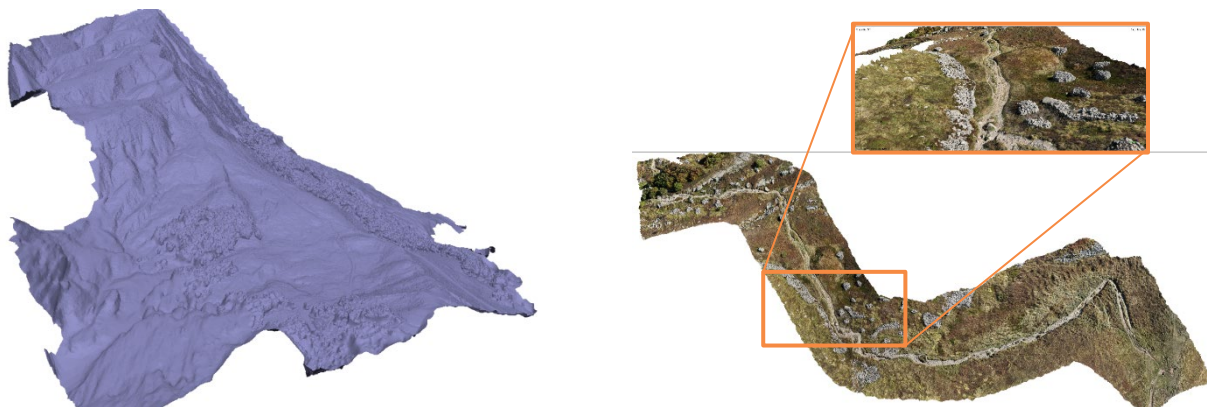


Figure 5: Digital surface model of the area obtained from high-altitude UAV-based photogrammetry (left). Digital surface model of specific trails from low-altitude UAV-based photogrammetry for higher detail (right).

The UAV-based erosion monitoring approaches are also carried out at the **Significant landscape Lower Kamenjak** to survey the development of ‘wild’ paths within the pilot site. Multiple UAV-based photogrammetric surveys in the summer season 2023 allowed the establishment of a complete orthophoto of the entire pilot site (Figure 6). Low-altitude UAV-based survey with photogrammetric and LiDAR sensors on five selected areas as well as a ground-based photogrammetric survey of a forest trail near the entrance will allow the monitoring of small-scale changes.



Figure 6: UAV-based photogrammetric survey of Nature Park Kamenjak

UNIZA and UNIPR will carry out erosion monitoring in the **Karawanken-Karavanke Geopark** at the Bike Park Petzen. They will use the mentioned monitoring methods to detect erosion processes on selected segments of the trails. CUAS will install visitor counters at the selected monitoring locations to correlate the number of passing bikers with the erosion.

All involved partners plan to present a protocol for high-resolution mapping and monitoring of recreational trail conditions using different equipment and methods such as UAV surveys, data processing, and geographic information systems analysis to derive spatially coherent information about indicators of trail degradation and associated trail characteristics.

Wildlife monitoring

The impact of visitors on wildlife activities will specifically target large carnivores, birds of the grouse family, bats, amphibians, and soil mites, analysing their responses to visitor presence.

Malá Fatra National Park will monitor large carnivores using telemetry collars and camera traps. The movement of animals and their behaviours will be monitored to gain more data on how their biological and ecological needs are satisfied, and influenced by habitat fragmentation and different tourist activities. Soil mite abundance and their biodiversity will be investigated as a good indicator of soil health will help to assess the condition of soil on trails and proximal areas. Soil biotic factors will be evaluated by comparing and quantifying soil mite communities at different levels of environmental stress from tourist traffic. The results can be correlated with the degree of erosion assessed by erosion monitoring. A potential negative impact of tourism on natural values in CAs will also be analysed in an experimental approach by detecting pathogenic bacterial species in avifauna droppings, where droppings will be collected in areas with a high frequency of tourists, especially at mountain peaks and surroundings of mountain chalets or cableway stations.

Bükk National Park Directorate is planning to monitor human disturbance on the bat population in three frequently visited caves. Together with CEEWeb the Directorate plans to position acoustic monitoring devices to correlate human-wildlife soundscapes. Four acoustic sensors were received from CUAS for the duration of the project. Since the project began their capabilities have been tested and they will be used in the caves of Hór Valley and Forrás Valley to monitor human activities and their disturbance on the bat population (Figure

7). To gather more data on the different tourist activities happening in front of the cave entrances, the use of two wildlife cameras is planned at two of the caves.



Figure 7: Touristic caves in Bükk National Park experience disturbance of bat populations due to touristic activities.

Another monitoring focus of **Bükk National Park Directorate** is the monitoring of amphibian population diseases (Chytridiomycosis, *Batrachochytrium dendrobatidis* pathogen), comparing data from sampling sites close to touristic areas and more remote habitats (Figure 8).

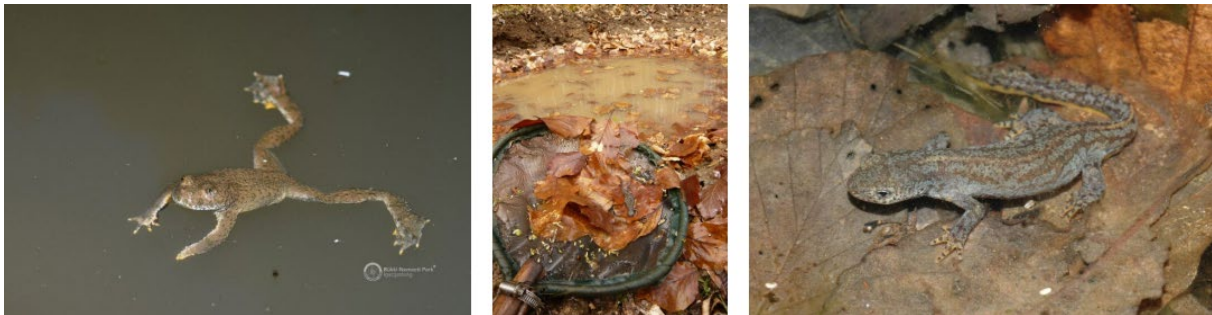


Figure 8: Amphibians are threatened by diseases. Bükk National Park is interested if human activities influence the spread of diseases among populations.

Tuscan-Emilian Apennine National Park will monitor the number of species and species activity with bioacoustics methods, investigating the presence of certain species in proximity to selected roads and assessing biodiversity in the area. These activities will be supported by expert-based surveys focused on the identification of avifauna and amphibian species in the pilot area.

The Public Institution Kamenjak will monitor the distribution of earthworms (Oligochaeta: Crassicitellata) with special assessment of endemic species *Octodrilus istrianus* within the Significant Landscape Lower Kamenjak. The aim of the research is to determine the pressures and threats that affect earthworms and their habitats with special focus on the impacts of microplastics in the soil.

The Karawanken-Karavanke UNESCO Global Geopark plans to monitor activities of wild animals alongside hiking and mountain biking trails on selected locations within their pilot sites. Wildlife cameras will be installed at selected locations during the breeding season of target species (western capercaillie *Tetrao urogallus*, black grouse *Lyrurus tetrix*, mountain hare *Lepus timidus*, brown bear *Ursus arctos*) to document their activities alongside the trails with the aim to investigate their presence. To ensure data privacy of passing hikers and mountain bikers and to reduce the storage demand of the video footage, an object detection algorithm (Megadetector) is used, that differentiates animals, people and

vehicles. Passing people are pixelated and the original files are replaced by low resolution images or videos, while animal image or video footage is saved in original quality (Figure 9).



Figure 9: Automatic object detection of animals, people and vehicles and pixelization of people to address data privacy concerns. The maximum number of people per video is saved to a .csv file which allows an estimation of visitors passing the camera.

The wildlife footage will be used by the park for outreach and educational purposes. The algorithm count of passing hikers and bikers will allow a complementary information in regard to visitor counting.

Pollution monitoring

As a proxy for visitor impacts on the environment, pollution monitoring will employ various methods to analyse macro-pollution and quantify the presence of microplastics and other hazardous pollutants in both soil and water.

Bükk National Park plans to monitor trash type and location using a citizen science approach.

Water quality in two mountain streams Stohový potok and Varínka in **Malá Fatra National Park** will be monitored to provide relevant information about the susceptibility of these ecosystems to anthropogenic disturbance. The water quality effects of ski resort development and other human activities in the park will be assessed. The preliminary analysis indicates elevated concentrations of total suspended solids. Stream water chemistry also indicates contamination by de-icing salts.

The **Public Institution Kamenjak** will engage experts from the Center for Marine Research, Rođer Bušković Institute, into the collection of macroplastics on selected beaches to monitor pollution of coastal areas within the Significant landscape Lower Kamenjak. Monitoring of soil composition will reveal microplastics pollution of soils in proximity to 10 parking zones. Furthermore, the impact of microplastic on the distribution of earthworms will be analysed by experts from University J.J. Strossmayer of Osijek.

Where will monitoring take place?

The monitoring locations within the HUMANITA project span a diverse range, extending from plot level to site level, habitat scale, and beyond. The selection of monitoring locations involves a comprehensive understanding of the indicators and their environments to enhance the accuracy of spatial distribution predictions.

The project implements complementary monitoring methods across five distinct CAs in Central Europe, namely Malá Fatra National Park in Slovakia, Bükk National Park in Hungary,

the Significant landscape Lower Kamenjak and Medulin Archipelago in Croatia, Tuscan-Emilian Apennine National Park in Italy, and Karawanken-Karavanke UNESCO Global Geopark on the Austrian-Slovenian border.

Pilot sites within each CA, experiencing high visitor pressures, have been strategically chosen for monitoring activities to assess and address the negative impacts of tourism on natural values. Detailed information about natural and touristic values of all monitoring sites is provided in the reports on impacts at pilot sites, prepared for each CA involved in the HUMANITA project. Below map representations of the involved CAs give an overview of the locations of pilot sites within the CAs (Figure 10).

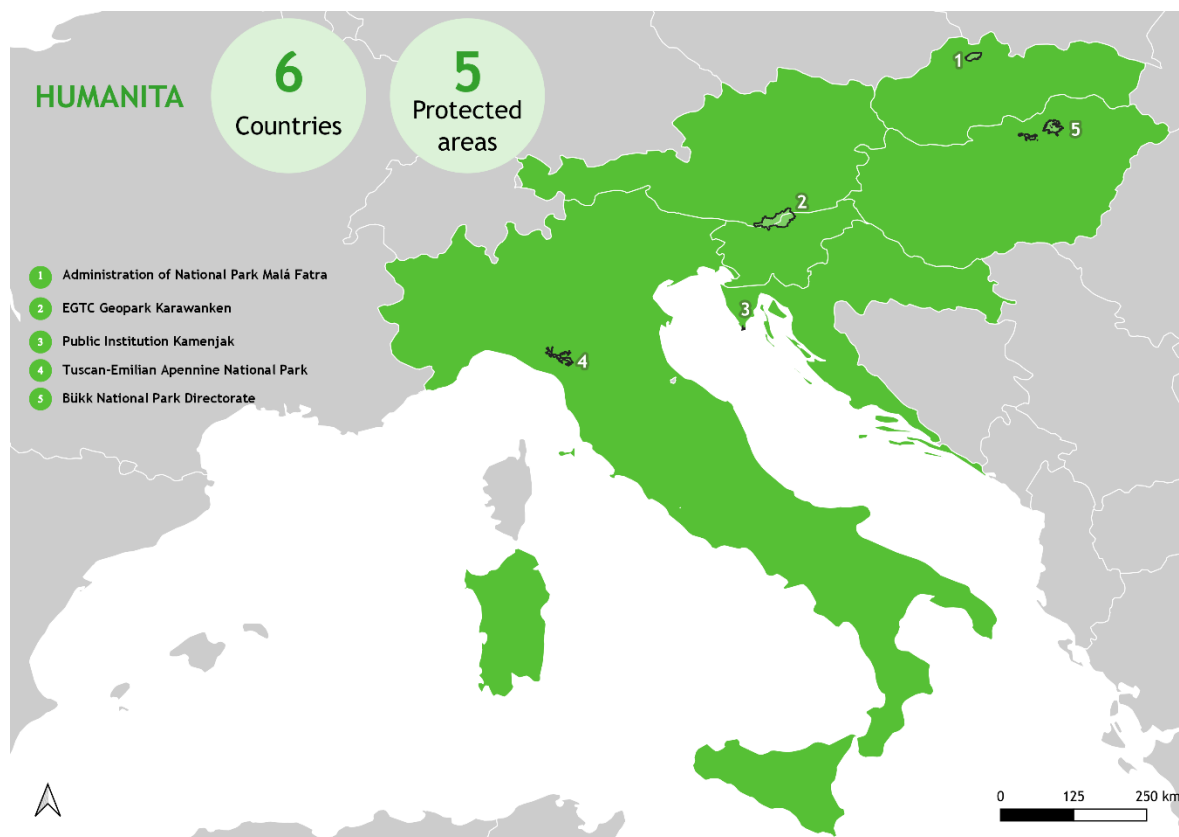


Figure 10: Overview map of CA partners involved in the monitoring programme of the INTERREG CE project HUMANITA (Map: Zuzanna Kieliszek).

Bükk National Park Directorate

Bükk National Park Directorate selected four pilot sites, where three are located within Bükk National Park and one is located in the Mátra Landscape Protection Area (Figure 11). The first pilot site within the Park is Hór Valley. It is one of the longest valleys of the Bükk and is fed by springs on the Triassic limestone and Jurassic shale border. In the lower part of the valley is the Ördögtorony Educational Trail, which includes cultural attractions of Cserépfalu (cave dwellings, lime burning) and the geology of the Bükk Foothills and the Southern Bükk, biological and prehistoric (Suba-lyuk) values, the formation of the rhyolite tuff that built up Bükk Foothills (Miocene volcanism), its unique surface formations and cultural and historical specialities, the beehive rocks (Ördögtorony). The botanical values of the area include wooded pastures, mountain meadows, hornbeam oak woods, gorge forests and karst scrub

forests. The second pilot site, Forrás Valley, is known for its caves that are located at the head of the valley. Furthermore, a large gorge leads out into large non-karstic rocks. They hide important paleontological and archaeological sites. The third pilot site in the Park is Tar-kő Peak. This limestone cliff rises high above its surroundings and is a remarkable asset of Bükk National Park. The sample area covers 11.1 hectares, a large part of it is visited by tourists. The site is very important from a tourist point of view, as it is crossed by the national blue trail and is also a stopover for several hiking tours. The fourth pilot site is located in Mátra Landscape Protection Area. This precipitous east-west mountain range is a member of the inner volcanic range of the Carpathians. Two sites of high touristic interest and two less popular sites were selected within this landscape protection area for the HUMANITA project. The two sites are located in the western block of the Mátra Landscape Protection Area; a large part is under strict protection due to amphibian habitats. On the other hand, it is a busy touristic area with a hub for tours to and from the Western Matras. The less exposed sites are mainly located in one higher and two slightly lower regions of the northern side of the mountain range in the Galya and Kékes blocks, where there are no or only scattered tourist roads with little to no traffic.

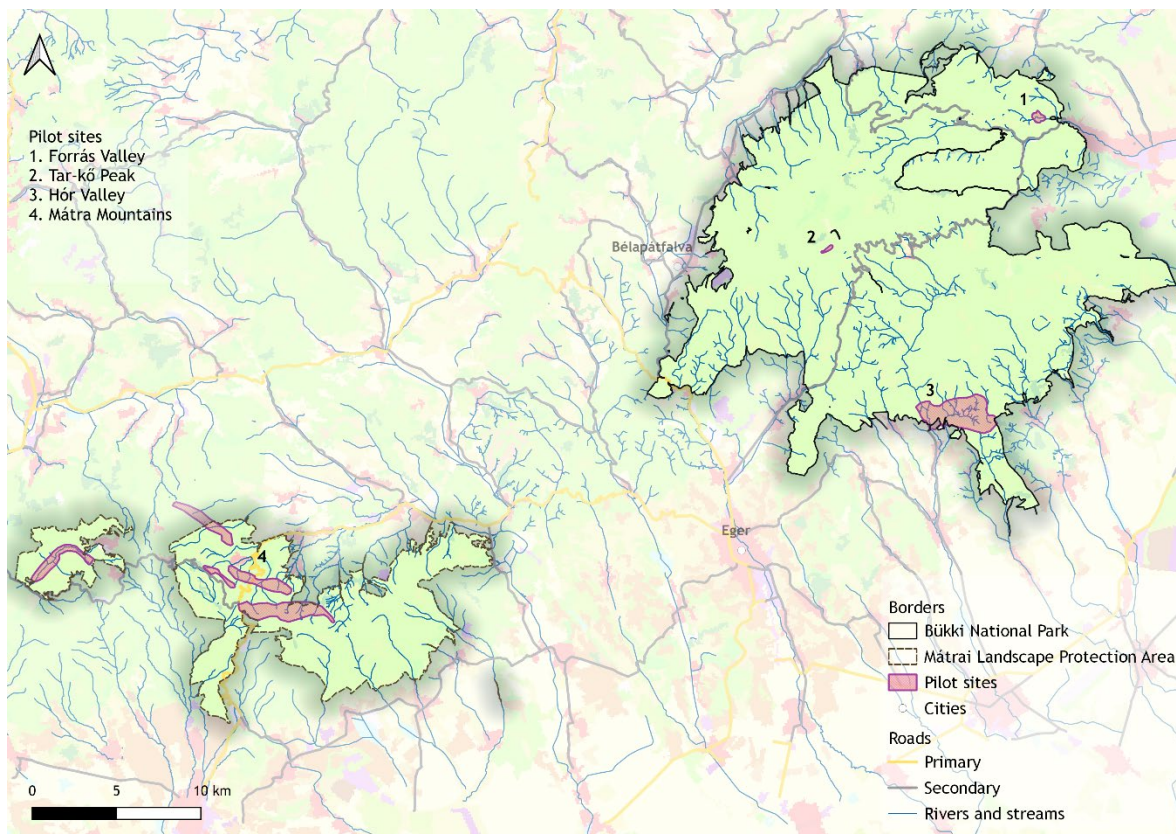


Figure 11: Map of pilot sites within the area of the Bükk National Park Directorate (Map: Zuzanna Kieliszek).

Karawanken-Karavanke UNESCO Global Geopark

In the Karawanken-Karavanke UNESCO Global Geopark two pilot sites were chosen for HUMANITA project - Mount Petzen and Hochobir (Figure 12). They serve as primary attractions due to their excellent accessibility. Mt. Petzen/Peca (2,126 m) is a carbonate mountain massif located on the border between Austria and Slovenia. This area stands out as a hydrogeological and ecological treasure. Its distinctive mountain karst landscape is

characterised by surface and underground karst phenomena and processes. Beyond its hydrogeological uniqueness, the Petzen/Peca area offers exceptional floristic and faunistic diversity, marking the easternmost boundary for high-mountain alpine plants, habitats, and animal species in the Alps. Mt. Petzen/Peca pilot site stands out as a vibrant tourist destination, offering a broad range of activities for visitors during both summer and winter. It offers cable car, mountain biking park and extensive networks of trails. The second pilot site, Hochobir mountain massif, featuring the prominent highest peak at 2,139 m, offers not only a mountaineering highlight but also several other summits. It stands out as a hydrogeological and ecological hotspot. This massif incorporates a complex underground water drainage system, with most of the water flowing in an easterly direction. The Hochobir Alpenstraße is the biggest touristic highlight of the pilot site. It attracts thousands of tourists and provides accessibility to the hiking trails at higher elevations.

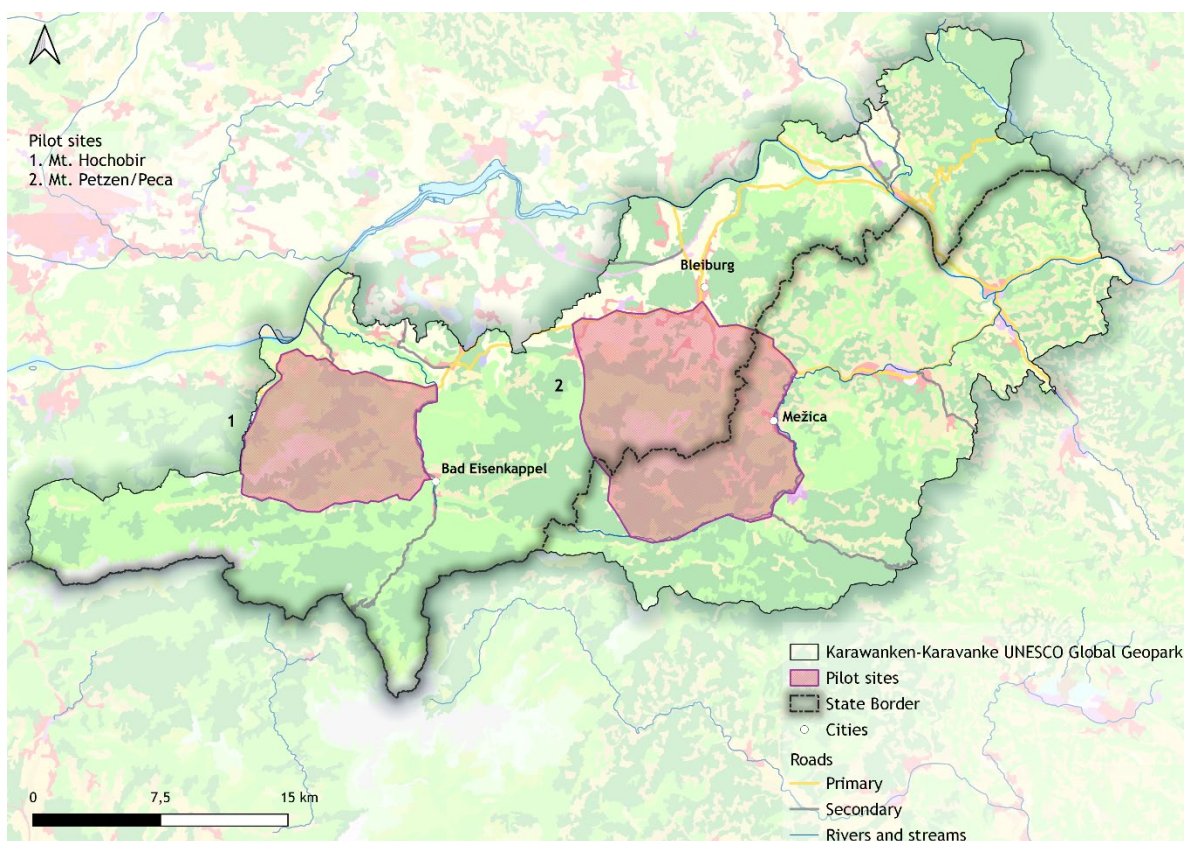


Figure 12: Map of pilot sites within the area of the Karawanken-Karavanke UNESCO Global Geopark (Map: Zuzanna Kieliszek).

Malá Fatra National Park

The Malá Fatra National Park Administration together with lead partner UNIZA selected four places within the park as HUMANITA pilot sites (Figure 13). Three of them are situated in the nature reserve Chleb (Snilovské sedlo, Chleb-hrebeň (ridge), Chleb-juh) and one in a location called Chrapáky on blue hiking trail. Pilot sites in Chleb nature reserve are frequently visited and are the most affected places by tourism in the national park. The popularity of these sites is connected with easy accessibility due to close proximity of a cable car. This area is mainly made up of limestone and dolomites, supporting species-rich alpine meadows. On the other hand, pilot site Chrapáky is less visited by tourists. However, this area is made up of

Carpathian Keuper (slate), which is not that common in the national park area. All pilot sites in Malá Fatra National Park are facing the problem of extended hiking trail erosion. In the case of the Chleb area, erosion is caused mostly by the high number of tourists that do not follow the main path but create parallel trails. The case of the Chrapáky pilot site is slightly different. Due to the slate composition of the bedrock, the area is more prone to erosion, although it is not a very frequented trail. In all Malá Fatra National Park pilot sites hikers are obliged to use only designated and marked official tourist trails.

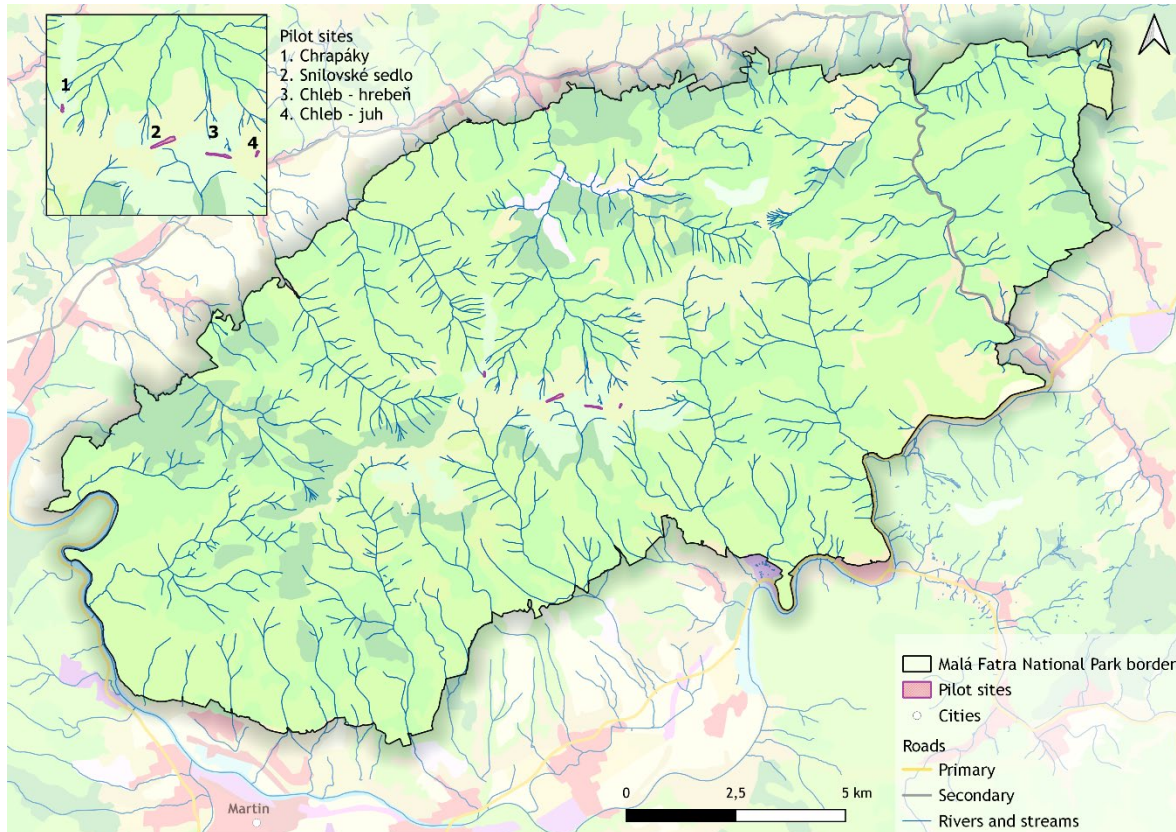


Figure 13: Map of pilot sites within the area of the Malá Fatra National Park (Map: Zuzanna Kieliszek).

Lower Kamenjak and the Medulin Archipelago

Lower Kamenjak and the Medulin Archipelago are the Croatian pilot sites in the HUMANITA project Figure 14. These significant areas are located in the southern part of the Istrian Peninsula and are known for their stunning landscapes and geological features. The coast of Kamenjak represents one of the richest sites of rudist limestone in Europe. The significant landscapes of Lower Kamenjak and the Medulin Archipelago are most frequently visited during the summer months, when the tourism-related pressure on the protected area becomes extremely high and in certain locations exceeds capacity. The touristic offers of Lower Kamenjak include 30 different coves, several bars on the beaches, bicycle paths, a dinosaur path, a family farm with restaurant, sport centres, a windsurf station, the eco centre "Kamenjak Nature House" Premantura and the possibility of guided individual or group visits and educational offerings. This pilot site faces many problems due to the high number of tourists including increased numbers of unofficial hiking and biking trails, illegal activities - camping, leaving garbage, parking vehicles in prohibited areas, soil and air pollution. Moreover, excessive numbers of vessels in coves and bays with sensitive and protected maritime habitats are a big issue in the pilot site.

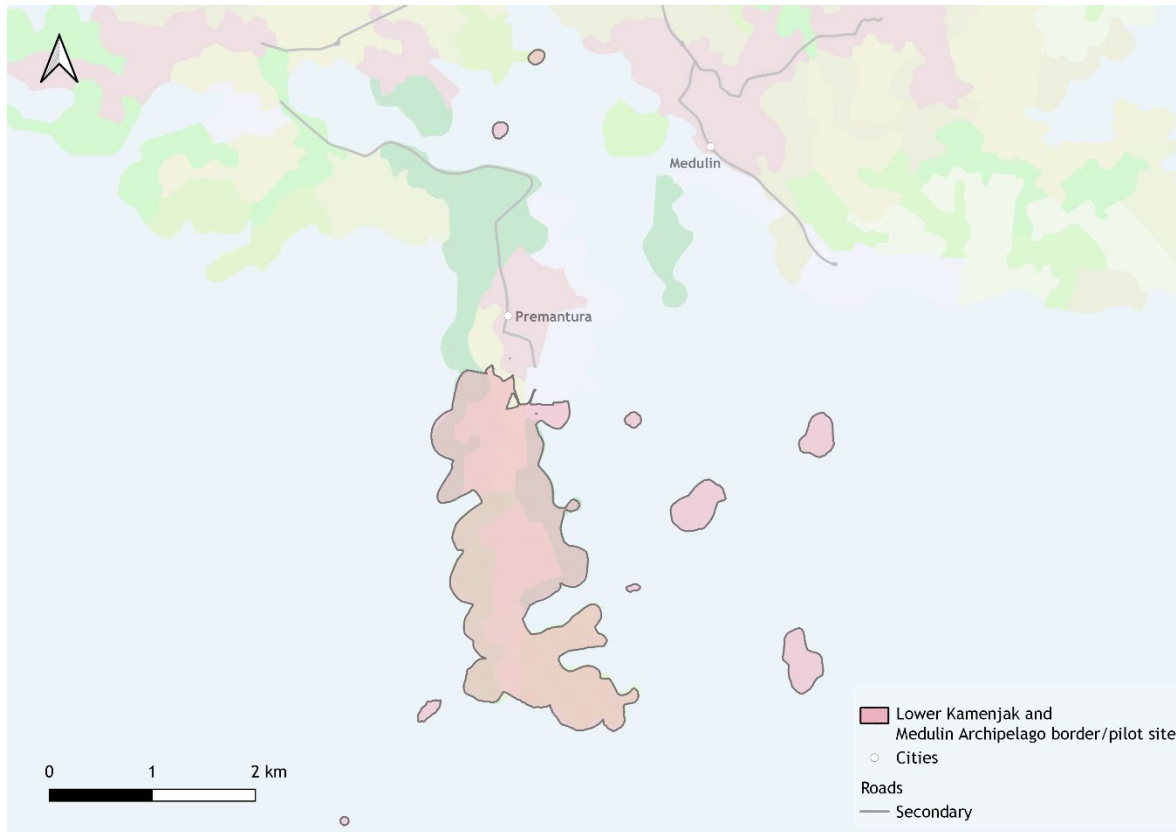


Figure 14: Map of pilot sites within the area of the Significant Landscape Lower Kamenjak and Medulin Archipelago (Map: Zuzanna Kieliszek).

Tuscan-Emilian Apennine National Park

The Tuscan-Emilian Apennine National Park contains three pilot sites - Pietra di Bismantova, Monte Cusna and Lago Santo Monte Marmagna (Figure 15). All of the sites are frequently visited by tourists, whereas they differ in terms of geological origin and possible outdoor activities. Pietra di Bismantova concerns the territory of an isolated massif surrounded by clay sediments. It is characterized by high, vertical overhanging walls dominated by a summit plateau. The pilot site attracts climbers, fossil hunters and hikers with a passion for geology. The second pilot site is characterized by the imposing massifs of Monte Cusna (the highest peak in the Park) and Monte Prado. The alpine grasslands and bilberry scrub, interspersed with cliffs, rocky crags and scree, cover significant areas and house rare and relict arctic-alpine flora. This area is characterised by a large number of hiking trails and is popular among botanists. The third pilot site, Lago Santo Monte Marmagna, is significant for its glacial landforms, which are among the most southerly in Europe. The area features scree, rocks, lakes of varying sizes and peat bogs in a landscape that was shaped by the last ice age and the signs of which are still clearly evident. The pilot site contains many hiking trails of different difficulty levels, many shelters with barbecues and picnic structures and one chair lift.

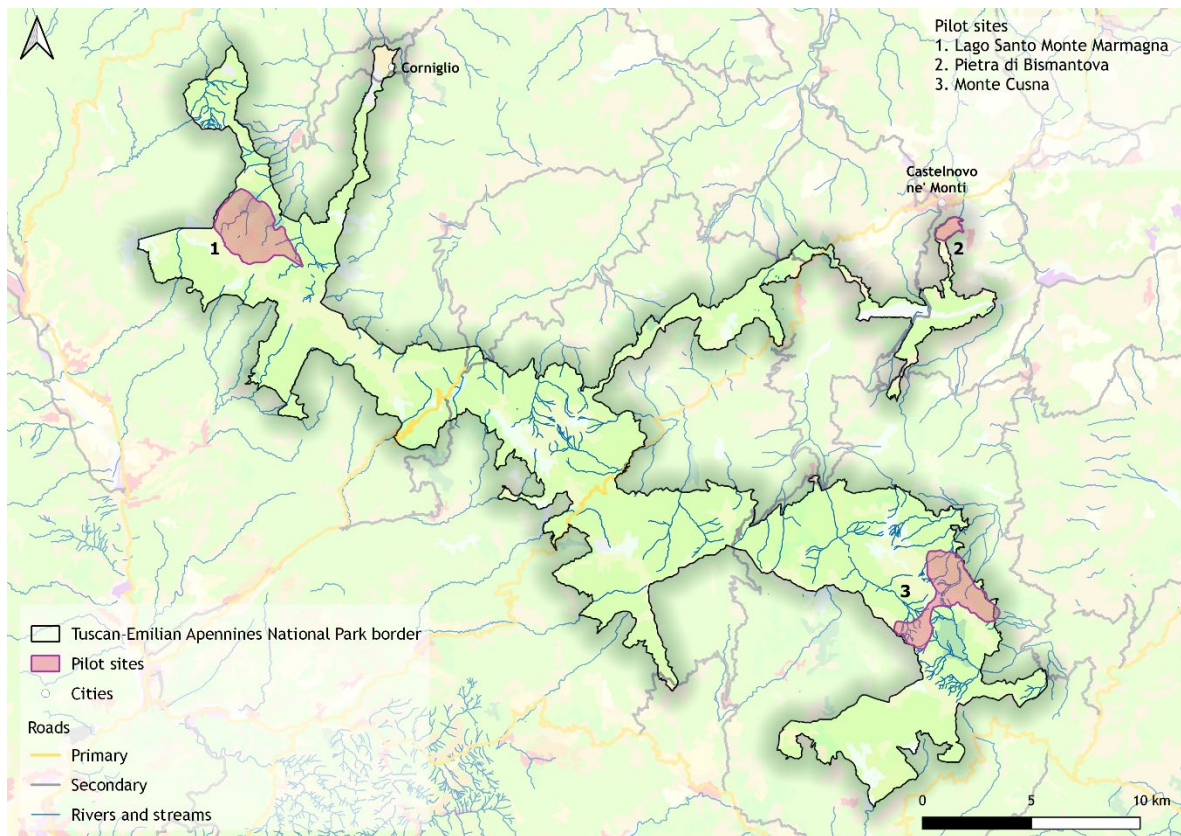


Figure 15: Map of pilot sites within the area of the Tuscan-Emilian Apennine National Park (Map: Zuzanna Kieliszek).

When will the monitoring take place?

The HUMANITA project facilitates the monitoring of baseline conditions for indicators impacted by tourism pressures. When developing the monitoring programme, three essential principles regarding timing are crucial: 1) the timing of programme initiation, 2) programme duration, and 3) the interval between monitoring events. The duration of time series monitoring should be sufficiently long to discern trends or changes over short, medium, and long terms. For instance, the monitoring of species listed on the IUCN Red List requires at least a 10-year observation period or three generations, whichever is longer, to detect declines. Clearly this timespan for monitoring cannot be achieved within the HUMANITA project, but the project will establish baseline information for continued monitoring.

In particular, commitment to the monitoring programme needs to be sufficiently long-term to allow a change to be detected over and above the natural temporal fluctuations. A clear articulation is necessary about what constitutes success and specifying what degree of change would be considered sufficient to trigger a management response. Monitoring should be capable of detecting the level of the change triggering further action if it occurs. Only considering this aspect will it be possible to select targeted and adequate management measures.

The HUMANITA project considers the implemented monitoring activities as a starting point, suggesting suitable time series to continue the documentation of trends of identified indicators within the action plans for each pilot site. Regarding the interval of monitoring activities, the initial stages, guided by Dalton et al. (in press), recommend frequent

monitoring intervals that can be gradually reduced as trends and variability become known, and methods are well-established. This approach enables swift responses to methodological or technical errors, emphasizing the importance of maintaining complete records of monitoring protocols and objectives for continuity amid personnel and institutional changes. Because the main focus is the monitoring of impacts of tourists, the time interval is defined to include information before, during and after the most critical time periods (e.g., summer season).

Visitor monitoring

Digital visitor monitoring analysing the activities of users on various outdoor and fitness apps will be carried out twice a year starting in 2024. In this way CA managers can react to information that is promoted on these apps on a regular basis.

Automatic visitor counters will be installed at pilot sites before the start of the summer season 2024. They will document the number of passing visitors on an hourly basis. Depending on the type of counter the data will be transferred via the GSM network or be collected in the field on a monthly basis.

The **Bükk National Park Directorate** will place a new counter at the educational trail and to the path leading to the nearby caves.

The **Karawanken-Karavanke Geopark** will place visitor counters at strategic positions alongside hiking and mountain biking trails in the pilot sites of Mt. Petzen/Peca and the Hochobir massif. GPS loggers will also be utilized during the summer season of 2024. If management decisions are made in the future to redirect visitors from trails that are highly sensitive to visitor impacts or if educational trails or other points of interest are introduced within the area, it is recommended to conduct additional GPS logger monitoring sessions in parallel to discern any shifts in movement patterns.

Questionnaires were administered to visitors in the period from July to October 2023. It is recommended to repeat the administration of questionnaires annually or every two years to understand changes in visitor behaviour or attitudes towards the environment.

Vegetation monitoring

The **BÜKK National Park Directorate** is planning to perform vegetation monitoring of protected plant species in the growing seasons of 2024 and 2025. Monitoring activities on the rocky grasslands of the Tar-kő and near the Suba-lyuk Cave in the Hór Valley pilot site will be done by a scientific expert.

The **Malá Fatra National Park** is planning to monitor trampling effects of tourism two times per year before and after the growing season.

The **Tuscan-Emilian Apennine National Park** plans to perform the vegetation survey approximately 3 times each year along every transect selected in the CA. The dendroisotopic analysis is performed once for each pilot site and will enable to analyse climatic and anthropogenic disturbance for a time period of 30 years backward.

In the **Karawanken-Karavanke Geopark**, invasive species will be monitored starting in summer 2024 during the flowering season of targeted species and continuously carried out by citizen scientists until the project's conclusion. The test run for eDNA collection and subsequent analysis was carried out in Summer 2023 and will be repeated in July and August 2024 during moist soil conditions.

Public Institution Kamenjak is planning to use a citizen science approach to monitor invasive alien species during the active vegetation period of targeted species. Monitoring will start in spring 2024 and be carried out continuously until the end of the project.

Erosion monitoring

As accelerated erosion is a complex process it is necessary to develop a monitoring scheme that identifies the causes. This includes monitoring of the microclimate to understand the effects of humidity and temperature of soil and air.

The **Bükk National Park Directorate** is planning to monitor erosion and trampling during the growing seasons of 2024 and 2025 on Tar-kő Peak and near the Suba-lyuk Cave in the Hór Valley pilot site. The central promise of this activity is to measure the touristic pressures on highly visited trails leading through rocky grasslands.

UNIZA will monitor the pilot sites in **Malá Fatra National Park** at least twice a year, at the start of the spring season and in the late autumn. In addition, it will be necessary to quantify soil losses produced by extreme rainfall events. The main idea is to compare various data collection methods and also to assess the seasonal changes.

The **Public Institution Kamenjak** is planning to monitor the formation of ‘wild’ trails by periodically using a drone before, during and after the tourist season. At the same time, the condition of protected grassland areas will be monitored with the aim of observing the impact of visitor activities on their condition and fragmentation.

The **Tuscan-Emilian Apennine National Park** plans to perform periodic surveys with both aerial and ground-based sensors on selected trails with the support of UNIPR. Monitoring activities will be performed before and after the summer season, for a minimum of two surveys per year in each individual pilot site within the Park. Dendromorphological analysis and sampling of tree roots is performed once for each pilot site.

In the **Karawanken-Karavanke Geopark**, erosion monitoring along mountain bike trails Petzen/Peca will occur in the summer season 2024.

Wildlife monitoring

Bükk National Park Directorate plans to monitor the effects of tourism on amphibians in the years 2023 and 2024. The central premise of the amphibian monitoring is to research the effects of tourism in the yellow-bellied toad and common frog population, with regards to the spreading of infections by *Batrachochytrium dendrobatidis* (BD) and Ranavirus. Already existing data from previous years will be included in the analysis. Acoustic monitoring will take place in the years 2024 and 2025 in three well-visited caves to measure the impacts of human disturbance on the local bat population and to survey the types of activities and the length of human presence within the caves. To support this research, wildlife cameras will be installed in front of two of the caves beginning in 2024.

Malá Fatra National Park will monitor soil mite populations on trails twice a year, at the start of the spring season and in the late autumn. Monitoring of large carnivores will be performed regularly or continuously throughout the year. Bird droppings will be collected in areas with a high frequency of tourists, especially on mountain peaks and surroundings of mountain chalets or cableway stations once per year.

Tuscan-Emilian Apennine National Park plans to perform bio-acoustic surveys two times per year to evaluate ecosystem complexity. Expert-based surveys will involve 2 monthly

samplings within a narrow time frame and with different tourist loads (e.g. Tuesday and Sunday of the same week) for each identified area, each consisting of 3 sessions of 20 minutes (first session within 1 hour of sunrise; second session in the middle of the day; third session near sunset).

Public Institution Kamenjak is planning to monitor the distribution of earthworms (Oligochaeta: Crassicitellata) with special assessment of endemic species *Octodrilus istrianus* in the spring 2024, together with monitoring of microplastics in the soil.

The monitoring of animal activity along hiking and mountain bike trails in the **Karawanken-Karavanke Geopark** will take place at selected locations during the mating season of targeted species in the summer season of 2024 and 2025.

Pollution monitoring

Bükk National Park will monitor pollution alongside the educational trail in the summer seasons of 2024 and 2025.

Malá Fatra National Park will monitor the quality of water in streams at least twice a year at the start of the spring season and in the late autumn. This allows comparison of data immediately before and after the main tourist season.

Public Institution Kamenjak will monitor macro-litter pollution on beaches four times, starting in spring 2024. Monitoring will include all seasons. The soil sampling will be done in spring 2024 together with monitoring the earthworms, and the analysis of microplastics in the soil and earthworms' population will be done in the next 2-3 months.

Who is involved in the monitoring programme?

The monitoring procedures within the HUMANITA project involve a diverse set of individuals and organizations with specific responsibilities. The project partners, comprising CA managers and scientists, collaborate with directly involved residents, local experts, and consultants. Institutional support and external collaborators were identified early in the project. These include our associate partners, which will be periodically involved in the monitoring process to ensure a high quality of monitoring outcomes.

To bridge traditional ecological knowledge and scientific findings with policy recommendations, the project partners will actively engage stakeholders, including those who may be sceptical about the monitoring programme. This inclusive approach aims to prevent vandalism and conflicts with stakeholders, fostering a collaborative environment for effective conservation strategies.

Volunteers, including students, nature enthusiasts, citizen scientists and visitors will contribute to certain aspects of monitoring. The project emphasizes support measures for effective training, recognizing the manifold benefits of involving non-scientists. This inclusive approach enhances scientific output, contributes to educational objectives, and enhances programme visibility. The collaborative efforts of the core team, external collaborators, and volunteers ensure a well-rounded and comprehensive monitoring strategy within the HUMANITA project.

The **Bükk National Park Directorate** involves the ranger service as well as the department of nature conservation. Furthermore, sub-contractors will be involved for the installation of visitor counting devices as well as botanical-coenological experts will be involved for vegetation and trampling surveys. Trail designation authorities and educational trail

managers will be integrated into the planning and implementation of the educational trail. Citizen scientists and other volunteers will be involved in the monitoring.

Malá Fatra National Park involves local stakeholders, personnel from the National Park as well as personnel and students from UNIZA. Tourists and hikers will also be involved into monitoring activities.

The **Tuscan-Emilian Apennine National Park** is planning to involve personnel from UNIPR and University of Pavia. Local environmental associations, park guards, technicians and Italian Alpine Club members will participate in the monitoring activities. Mountain guide associations, hiking guides, visitor centre managers and local volunteers will contribute to the activities as well.

The **Public Institution Kamenjak** will involve external experts from the University J.J.Strossmayera of Osijek and the Center for Marine Research, Ruđer Bošković Institute from Rovinj.

The **Karawanken-Karavanke Geopark** involves local and regional nature conservation authorities as well as touristic associations from Austria and Slovenia. The municipalities that administer the territory of the pilot sites, local companies such as Petzen Bergbahnen, and visitors are involved in the project activities. For invasive alien species monitoring hikers and mountain bikers will be involved in providing soil samples from their shoes and bike tyres. For the citizen science approach, the associate partner, Citizen Science Network Austria, will support the promotion of the project.

What resources are required for the monitoring programme?

While research questions for the established biodiversity monitoring programme will be identified, they may not be worked out in detail during the HUMANITA project. The achievement of the monitoring concept worksheet will be refined in the subsequent phases, outlining the specifics of how monitoring activities will be performed in the future and which methods can be recommended for further activities. This process will also identify potential synergies with other elements of the management plans of involved CAs, contributing to a comprehensive and integrated approach to monitor the impacts of tourism on the environment.

The elaboration of the five reports on the impacts of visitors at CAs revealed common weaknesses and gaps in the collection, analysis, reporting, and responses to the results of environmental monitoring data. One important fact is that monitoring often takes place ad hoc and does not have financial coverage to continue over a longer period.

The resources, that are needed for the individual monitoring activities that are performed during the HUMANITA project are detailed within the monitoring worksheets (see chapter 2.2). This gives a first overview on potential costs for continuation of the monitoring programme after the project's end.

2.2. Monitoring worksheets

This chapter aims to enhance comprehension of individual monitoring activities within each pilot area of the HUMANITA project. This section comprises monitoring worksheets dedicated to each monitoring activity, addressing key questions of Why, What, Where, When, Who, Which resources, and How. These inquiries offer a comprehensive overview of the individual monitoring plan. Figure 16 offers a comprehensive overview of the individual activities outlined herein.

	Bükk National Park	Karawanken-Karavanke UNESCO Global Geopark	Mala Fatra National Park	Significant Landscape Lower Kamenjak and Medulin Archipelago	Tuscan Emilian Apennine National Park
Visitor monitoring	Digital visitor monitoring Automatic visitor counters Questionnaire Expert interviews Stakeholder Workshop	Digital visitor monitoring Automatic visitor counters Questionnaire Stakeholder Workshop GPS-loggers, indirect data	Digital visitor monitoring Automatic visitor counters Questionnaire Expert interviews	Digital visitor monitoring Automatic visitor counters Questionnaire Expert interviews	Digital visitor monitoring Automatic visitor counters Questionnaire Expert interviews
Erosion monitoring		Erosion along bike trails	Erosion along hiking trails	Erosion along hiking and bike trails	Erosion along hiking and bike trails
Vegetation monitoring	Trampling along hiking trails Invasive species monitoring	Invasive species monitoring (eDNA & Citizen science)	Trampling along hiking trails	Trampling along hiking and bike trails Invasive species monitoring	Trampling along hiking trails Tree growth monitoring
Wildlife monitoring	Influence of human activities on bat populations Amphibian monitoring	Presence of wildlife along trails	Soil mites Large carnivores Bird illness	Microplastics in earth worm casts	Animal species presence and activity
Pollution monitoring	Mapping of location and trash type		Water pollution	Mapping of location and trash type	

Figure 16: Overview of the monitoring activities performed at the pilot sites of the HUMANITA project.¹

¹ Tuscan-Emilian Apennine National Park also plans to perform a spring water monitoring to analyse water demand.

Bükk National Park



Bükk NP

Visitor monitoring

Digital visitor monitoring

Why

- Identify the frequency of hikers and mountain bikers on official and unofficial trails in sensible natural areas.
- Identify promoted digital trails.

When

- Geopark summer seasons of 2024 and 2025.
- Other CAs summer season 2025.
- *Recommended to repeat periodically after the tourist seasons.*

What

- Spatial-temporal movement of hikers and mountain bikers.
- Digital trail data on outdoor apps.

Who

- CUAS is responsible for the data collection and evaluation.
- CA partners support in the data collection.

Where

- Pilot sites at all CAs
- Bükk NP
 - Karawanken-Karavanke Geopark
 - Mala Fatra National Park
 - Lower Kamenjak
 - Tuscan-Emilian Apennine NP.

Required resources

- GNSS data from various apps.

How?

- Geostatistical analysis of GNSS Data from outdoor apps.

Bükk NP

Visitor monitoring

Automatic visitor counters

Why

- Identify the frequency of hikers on selected trails.

When

- For the summer seasons of 2024 and 2025.
- *Recommended to monitor continuously.*

What

- Monitoring of the spatial-temporal distribution of visitors.

Who

- External expert will do the installation of counters
- Evaluation of data will be performed by Bükk, geostatistical analysis supported by CUAS

Where

- Already existing counters at pilot sites Tar-kő peak and near the Suba-lyuk cave entrance
- New counters will be installed near the educational trail in Hór-valley

Required resources

- Automatic counters

How?

Counter data will be related to other monitoring activities:

- Geostatistical analysis of spatial and temporal hotspots
- Correlation of visitor numbers with trampling impacts
- Correlation of visitor number with wildlife activities

Bükk NP

Visitor monitoring

Field survey / Questionnaire

Why

- Understand visitor behavior and attitudes towards the environment and awareness about their own environmental impact.
- Understand visitor's use of digital platforms.

When

- From June to October 2023.
- *Recommended to repeat yearly or every two years.*

What

- On-site visitor paper survey.

Who

- Eurac and partners prepare the structure.
- CA partners collect the data.
- Eurac evaluates the data.

Where

- Hór-valley pilot site:
- Suba-lyuk cave,
 - along the valley,
 - at the Oszla Ranger House (within the valley).

Required resources

- Personnel for data collection.
- Paper questionnaires.
- Statistical software for data analysis.

How?

- On-site visitor survey.
- Statistical analysis.

Bükk NP

Visitor monitoring

Expert interviews

Why

- Collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.
- Collect data on relationship of local stakeholders with tourists, and their mutual interactions.

When

- Continuous but with focus on winter/spring 2023/2024

What

- Interviews with experts and stakeholders

Who

- Bükk NP
- CEE Web
- Landscape conservationist
- Local municipality

Where

- Online or on-site interviews

Required resources

- Personnel for performing interviews.
- Digital hosting platform and/or recording device.
- Protocol of interviews.

How?

- Interview guidance and inclusion of results into the report on impacts at pilot sites.

Bükk NP

Visitor monitoring

Stakeholder Workshop

Why

- Collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.

When

- February 2024.

What

- Stakeholder workshop.

Who

- Bükk NP and CEE Web organize the event.
- Tourist authority and forestry company participate.

Where

- Online

Required resources

- Moderator for the workshop
- Digital hosting platform and/or recording device.

How?

- Presentation, Group discussions, recorded statements.

Bükk NP

Vegetation monitoring

Trampling along hiking trails

Why

- Understand the trampling impact of visitors on trail vegetation on frequented trails.

When

- Active vegetation season 2024/2025.

What

- Phyto-coenological survey along transects.
- Plant diversity, vegetation height, marker species.

Who

- Bükk will contract external service of phyto-coenological expert.

Where

- Rocky grasslands of the Tar-kő and near the Suba-lyuk Cave in the Hór-valley

Required resources

- Vegetation ecologist

How?

- Field survey and evaluation of trampling impacts on specific plant communities.

Bükk NP

Wildlife monitoring

Influence of human activities on bat populations

Why

- Monitor human disturbance on the local bat population and to survey the types of activities and the length of human presence of tourists within the caves.

When

- For the summer seasons of 2024 and 2025.

What

- Bat population survey and bat behaviour analysis with regards to human disturbance.
- Human activities in and in front of caves.

Who

- Bükk: wildlife camera and acoustic monitoring, data analysis.
- CEE Web supports the activity.

Where

- Acoustic monitoring in three well-visited caves: Suba-lyuk cave, Kecske-lyuk cave, Búdös-pest cave.
- Wildlife camera in front of two caves (Hór valley pilot site: Suba-lyuk cave, Forrás valley pilot site: Kecske-lyuk cave)

Required resources

- Wildlife cameras
- Acoustic sensors

How?

- Evaluation of acoustic human-nature soundscape.
 - Evaluation of visitor activity with optical data.
- Data will be handled in-house according to GDR regulations.

Bükk NP

Wildlife monitoring

Amphibian monitoring

Why

- Spread of the Batrachochytrium dendrobatidis (BD) infection and Ranavirus infections in amphibian populations.

When

- Summer season 2024-2025.

What

- Monitoring if there is a higher number of amphibian disease near touristic infrastructure vs. remote areas.

Who

- Bükk NP: sampling done by our rangers.
- Sample analysis through external experts.

Where

- Sampling takes place in the Mátra Landscape Protection Area:
 - touristic area: northern side of Kékes.
 - touristic area: Csörgő-valley.
 - three control sites.

Required resources

- Sampling kits
- Laboratory

How?

- Sample collection from two species (yellow-bellied toad, common frog) - planned sample size around 200
- Comparative analysis of samples (touristic areas - control areas) in a lab (external service)

Bükk NP

Pollution monitoring

Mapping of location and trash type

Why

- Monitor the trash type and raise awareness about the problem by involving visitors.

When

- Summer season 2024 /2025

What

- Trash type disposition

Who

- Bükk NP: project implementation and outreach
- CEE Web supports the action
- Citizen Scientists

Where

- Near educational trail in the Hór-valley

Required resources

- Citizen science app
- Info materials and communication

How?

- Use of citizen science app to document trash type disposition and location.

Karawanken-Karavanke UNESCO Global Geopark



Geopark Karawanken

Visitor monitoring

Digital visitor monitoring

Why

- Identify the frequency of hikers and mountain bikers on official and unofficial trails in sensitive natural areas.
- Identify promoted digital trails.

When

- Data from summer seasons of 2024 and 2025 will be analyzed.
- *Recommended to repeat periodically after the tourist seasons.*

What

- Spatial-temporal movement of hikers and mountain bikers.
- Digital trail data on outdoor apps.

Who

- CUAS is responsible for the data collection and evaluation.
- CA partners support in the data collection.

Where

- Data from pilot sites of Petzen/Peca and Hochobir.

Required resources

- GNSS data from various apps.

How?

- Geostatistical analysis of GNSS Data from outdoor apps.

Geopark Karawanken

Visitor monitoring

Automatic visitor counters

Why

- Identify the frequency of hikers and bikers on selected trails.
- Monitor the frequency of cars on selected streets.

When

- Continuous monitoring starting from summer season 2024.

What

- Monitoring of the spatial-temporal distribution of visitors.

Who

- Geopark will install counters.
- CUAS performs geostatistical analysis
- Uni Parma and UNIZA will correlate with erosion monitoring data.

Where

- Counters on selected trails at Petzen/Peca and Hochobir.

Required resources

- Automatic counters.
- Personnel for installation, maintenance, data collection and evaluation.
- Permission of ground owners and trail management organizations.

How?

Counter data will be related to other monitoring activities:

- Correlation with data from outdoor apps (geostatistical analysis).
- Correlation of visitor numbers and erosion.

Geopark Karawanken

Visitor monitoring

Field survey / Questionnaire

Why

- Understand visitor behavior and attitudes towards the environment and awareness about their own environmental impact.
- Understand visitor's use of digital platforms.

When

- From June to October 2023.
- *Recommended to repeat yearly or every two years.*

What

- On-site visitor paper survey.

Who

- Eurac and partners prepare the structure.
- CA partners collect the data.
- Eurac evaluates the data.

Where

- On-site survey at the pilot site of Petzen/Peca.

Required resources

- Personnel for data collection.
- Paper questionnaires.
- Statistical software for data analysis.

How?

- On-site visitor survey.
- Statistical analysis.

Geopark Karawanken

Visitor monitoring

GPS-loggers, indirect data, counter calibration

Why

- Identify the frequency of hikers and mountain bikers on official and unofficial trails in sensitive natural areas.

When

- For the summer seasons of 2024 and 2025.
- Recommended to repeat periodically after the tourist seasons.

What

- Monitoring of the spatial-temporal distribution of hikers and mountain bikers.

Who

- CUAS: GPS Logging, testing and calibration of counters.
- Geopark: Installation of counters and cameras, data collection, indirect data.

Where

- GPS Logging at Petzen/Peca.
- Indirect data from Petzen/Peca and Hochobir.

Required resources

- GPS Loggers.
- Data from Petzen Bergbahnen and Tourist Association Eisenkappel-Vellach.

How?

- Data privatization and geostatistical analysis of visitor flow.
- Analysis of data from cable car and toll road tickets.

Geopark Karawanken

Visitor monitoring

Transboundary Stakeholder Workshop

Why

- Collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.
- Identify important tourist and nature zones.

When

- March 2024.

What

- Transboundary stakeholder workshop.

Who

- CUAS suggests contents, workshop design & evaluates the results.
- Geopark organizes the event.
- Nature conservation and tourist authorities Austria/Slovenian participate.

Where

- Geopark Office.

Required resources

- Meeting room for workshop.
- Moderators for each pilot site.
- Workshop materials (pens, pins, pinboards).
- Print maps of pilot sites.

How?

- Presentation, Group discussions, recorded statements.
- Qualitative content analysis and georeferencing of map points.

Geopark Karawanken

Erosion monitoring

Erosion along bike trails*

Why

- Assess current state of erosion at selected trails. Find a relationships and correlations between erosion grade, number of visitors, soil parameters, terrain, and other variables.

When

- Summer season 2024.
- *planned but not yet fixed, depending on available resources.

What

- Erosion monitoring along bike trails.
- Comparison of different techniques UNIZA vs. Uni Parma.

Who

- UNIZA uses LiDAR UAV and ground-based methods.
- Uni Parma uses photogrammetric UAV and ground-based methods.
- UNIZA and Uni Parma evaluate the soil loss between two or more scans.

Where

- Transects on Petzen/Peca bike trails.

Required resources

- Lidarett scanner.
- 360° camera.
- Drone with photogrammetric sensor.
- Visitor counters.

How?

- UAV-based survey at high and low altitude.
 - Ground-based survey.
 - Evaluation of soil loss.

Geopark Karawanken

Vegetation monitoring

Invasive species monitoring - Citizen science

Why

- Involve visitors in the monitoring to raise their awareness about invasive species.
- Gain information on the location and abundance of invasive plant species along hiking/biking trails.

When

- Implementation of i-Naturalist project in winter/spring 2024.
- Promotion of project start of active vegetation season 2024.
- Evaluation end of seasons 2024 / 2025.

What

- Invasive plant species location and abundance.

Who

- Geopark: project implementation and outreach.
- CUAS support in preparation of info materials and evaluation of data.
- Citizen Scientists.
- Citizen Science Network Austria.

Where

- Focus on Mt. Petzen/Peca and Hochobir.
- Generally possible to use for the whole area of the Geopark.

Required resources

- Account of i-Naturalist.
- Minimum of 50 confirmed observations on the platform.
- Info materials and communication.

How?

- i-Naturalist project establishment and promotion.
- Geostatistical analysis of data of citizen science data.

Geopark Karawanken

Vegetation monitoring

Invasive species monitoring - eDNA

Why

- To understand the contribution to the spread of invasive plants by hikers and mountain bikers.

When

- Test phase in July 2023
- Study phase in July and August 2024 at moist soil conditions.
- Laboratory analysis in 2nd half of 2024

What

- Invasive plant species distribution and transportation on boots and bike tires.

Who

- CUAS: field sampling, amplification of DNA and interpretation of results.
- Trainees for field work and laboratory.
- External laboratory for metabarcoding.

Where

- Mt. Petzen/Peca

Required resources

- eDNA sample kits
- Field workers
- Laboratory research
- Laboratory for amplification of DNA and metabarcoding

How?

- eDNA sampling of soil from boots, bikes and paths .
 - DNA extraction in the laboratory.
 - metabarcoding analysis by external service.
- Data analysis by CUAS using open source software and publicly accessible databases; data interpretation using knowledge of the department and project partners.

Geopark Karawanken

Wildlife monitoring

Presence of wildlife along trails

Why

- Inventory species alongside trails (baseline data)
- Compare differences relative to intensity of trail use; etc.

When

- In the mating season of target species in 2024.

What

- Wildlife alongside trails (*Tetrao urogallus*, *Lyrurus tetrrix*, *Lepus timidus*, *Ursus arctos*)

Who

- Geopark will collect and analyse the data
- CUAS will use a data privatization algorithm on passing people

Where

- Mt. Petzen/Peca and Hochobir

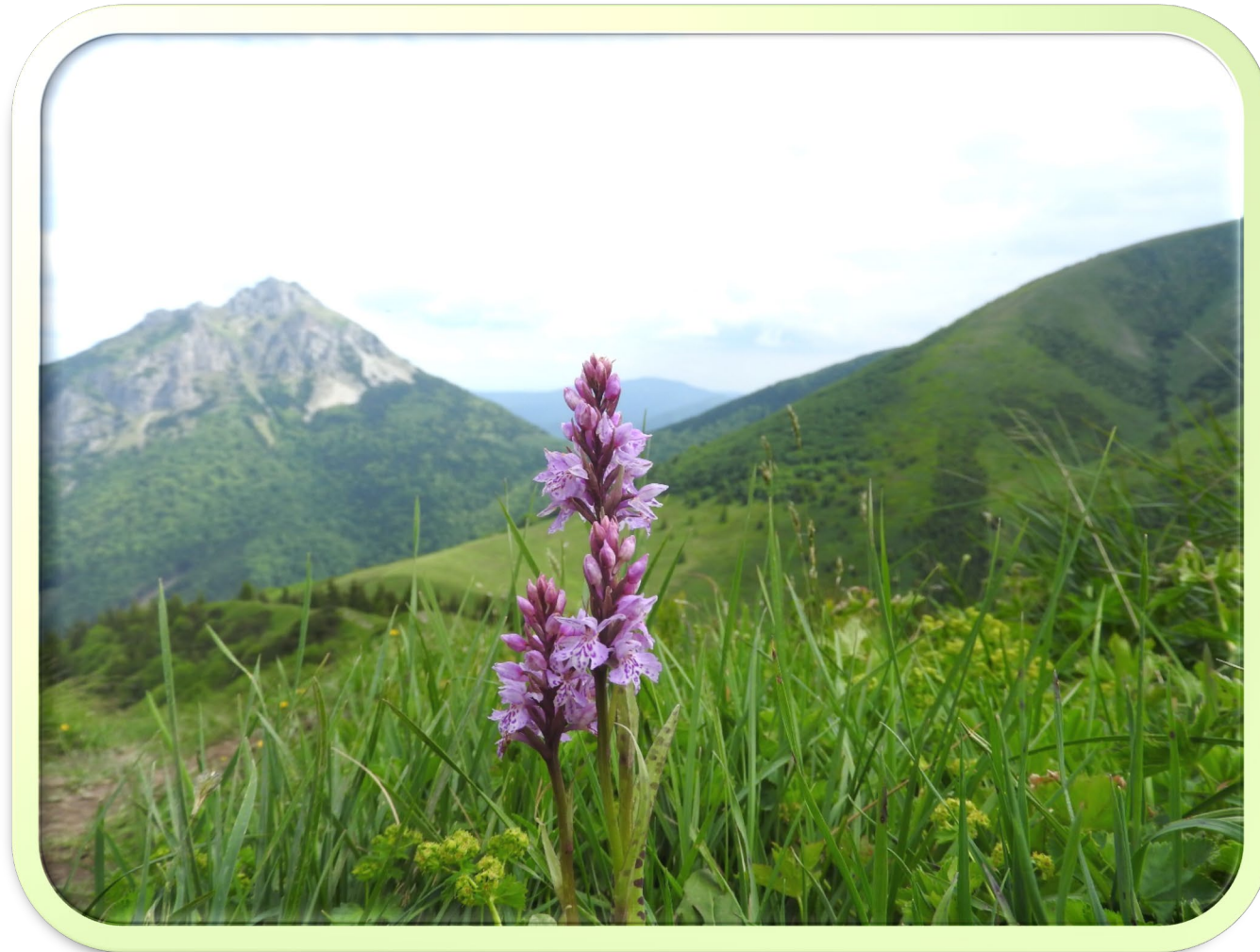
Required resources

- Wildlife cameras
- Server storage capacity
- Object detection and pixelization algorithm

How?

- Video monitoring, semi-automatic classification and algorithmic data privatization.

Malá Fatra National Park



Mala Fatra NP

Visitor monitoring

Digital visitor monitoring

Why

- Identify the frequency of hikers and mountain bikers on official and unofficial trails in sensitive natural areas.
- Identify promoted digital trails.

When

- Data for summer seasons of 2024 and 2025 will be analyzed.
- *Recommended to repeat periodically after the tourist seasons.*

What

- Spatial-temporal movement of hikers and mountain bikers.
- Digital trail data on outdoor apps.

Who

- CUAS is responsible for the data collection and evaluation.
- CA partners support in the data collection.

Where

- Data from Mt. Chleb, Snilovské saddle and Chrapáky pilot site.

Required resources

- GNSS data from various apps.

How?

- Geostatistical analysis of GNSS Data from outdoor apps.

Mala Fatra NP

Visitor monitoring

Automatic visitor counters

Why

- Identify the frequency of hikers and bikers on selected trails.

When

- Continuous monitoring from spring 2024.

What

- Monitoring of the spatial-temporal distribution of visitors.

Who

- Mala Fatra installs counters, collects data and correlates with wildlife activities.
- CUAS performs geostatistical analysis.
- Uni Parma and UNIZA correlate with erosion and trampling monitoring data.

Where

- Near erosion/trampling monitoring sites

Required resources

- Automatic counters
- Personnel for installation, maintenance, data collection and evaluation.
- Permission of ground owners and trail management organizations.

How?

- Counter data will be related to other monitoring activities:
- Correlation with data from outdoor apps (geostatistical analysis).
 - Correlation of visitor numbers and erosion/trampling.
 - Correlation of visitor number with wildlife activities in the area.

Mala Fatra NP

Visitor monitoring

Field survey / Questionnaire

Why

- Understand visitor behavior and attitudes towards the environment and awareness about their own environmental impact.
- Understand visitor's use of digital platforms.

When

- From June to October 2023.
- *Recommended to repeat yearly or every two years.*

What

- On-site visitor paper survey.

Who

- Eurac and partners prepare the structure.
- CA partners collect the data.
- Eurac evaluates the data.

Where

- Mt. Chleb

Required resources

- Personnel for data collection.
- Paper questionnaires.
- Statistical software for data analysis.

How?

On-site visitor survey.
Statistical evaluation.

Mala Fatra NP

Visitor monitoring

Expert interviews

Why

- Collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.
- Collect data on relationship of local stakeholders with tourists, and their mutual interactions.

When

- Continuous but with focus on winter/spring 2023/2024

What

- Interviews with nature conservation, tourist experts, and other stakeholders in region

Who

- Mala Fatra NP own employees
- Uni Zilina
- Interview: nature conservation and tourism experts from the region

Where

- Online or on-site interviews

Required resources

- Personnel for performing interviews.
- Digital hosting platform and/or recording device.
- Protocol for interviews.

How?

Interview guidance and inclusion of results into the report on impacts at pilot sites.

Mala Fatra NP

Erosion monitoring

Erosion along hiking trails

Why

- Assess current state of erosion at selected trails. Find a relationships and correlations between erosion grade, number of visitors, soil parameters, terrain, and other variables.

When

- Twice a year at start of spring season and late autumn, after extreme rainfall

What

- Erosion monitoring along hiking trails.
- Creation of secondary trails.
- Branching of paths.
- Comparison of different techniques UNIZA vs. Uni Parma.

Who

- UNIZA uses LIDAR UAV and ground-based methods.
- UNIZA and Uni Parma evaluate the soil loss between two or more scans.

Where

- At four pilot sites
- Chrapáky pilot site.
 - Snilovské saddle pilot site.
 - Chleb pilot sites.

Required resources

- Lidaretto scanner.
- Drone with photogrammetric sensor.
- Visitor counters.
- Historical data.

How?

- UAV-based survey at high and low altitude.
 - Ground-based survey.
 - Evaluation of soil loss.
- Standard-field methods for terrain character determination.

Mala Fatra NP

Vegetation monitoring

Trampling along hiking trails

Why

- Understand the trampling impact of visitors on trail vegetation on frequented trails.
- Identifying species threatened by trampling at pilot sites

When

- Before and after touristic season (May, October), or according to the life cycle of plants

What

- Plant species number, richness and distribution.
- Formation of wild trails.
- Damage of vegetation.

Who

- UNIZA: UAV and ground-based technology-based methods experts
- Mala Fatra NP: own botanist

Where

- At four pilot sites
- Chrapáky pilot site.
 - Snilovské saddle pilot site.
 - Chleb pilot sites.

Required resources

- Lidaretto scanner
- 360° camera
- Drone with photogrammetric sensor
- Botanist, and technology experts

How?

- UAV and ground-based technology-based methods.
 - Standard field survey.
 - Test semi-automatic detection of wild trails.

Mala Fatra NP

Wildlife monitoring

Soil mites

Why

- Investigation of a suitable indicator to monitor soil health.
- Find suitable species to correlate them with different factors influencing their presence or biodiversity.
- Monitoring studies of soil fauna are scarce.

When

- Twice a year at the start of spring season and in late autumn.

What

- Soil mites abundance and biodiversity

Who

- Uni Zilina: students and employees

Where

- Near erosion/trampling monitoring sites in Mala Fatra, and in another mountaing range for comparision.

Required resources

- Laboratory equipment
- UNIZA Students and employees

How?

- Sampling in a field and lab work

Mala Fatra NP

Wildlife monitoring

Large carnivores

Why

- Gain data on large carnivores and influence of habitat fragmentation, and human presence on their behaviour.
- Compare credibility of results with other wildlife monitoring techniques

When

- Continuously throughout the year

What

- Large carnivores (bears, wolfs, lynx)

Who

- Mala Fatra NP: own personnel

Where

- In the proximity of pilot sites, or other places, where it makes sense.

Required resources

- GPS-collars and wildlife cameras

How?

- Installation of equipment in field, data collection, storage and evaluation.

Mala Fatra NP

Wildlife monitoring

Bird illness

Why

- Provide information on influence of tourists and their activities as potential threats for bird health
- Identifying problematic areas

When

- Once per year (starting 2024)

What

- Pathogenic bacterial species in avifauna droppings

Who

- Uni Zilina employees and students
- Tourists - citizen scientists

Where

- At peaks, mountain chalets, cableway station at Mt. Chleb.

Required resources

- Sample kits
- Field equipment
- Laboratory equipment
- Biologist
- Students

How?

- Expert-based survey on avifauna
 - Field work, Lab work

Mala Fatra NP

Pollution monitoring

Water pollution

Why

- Provide information about the susceptibility of mountain water streams to anthropogenic disturbances
- Identify pollution sources.

When

- Twice a year at the start of the spring season and in late autumn.

What

- Water pollution

Who

- UNIZA students

Where

- Stohový potok and Varínka streams

Required resources

- UNIZA students
- Field equipment to collect samples
- Laboratory equipment

How?

- Sampling and lab work

Significant Landscape Lower Kamenjak and the Medulin Archipelago



Kamenjak

Visitor monitoring

Digital visitor monitoring

Why

- Identify the frequency of hikers and mountain bikers on official and unofficial trails in sensitive natural areas.
- Identify promoted digital trails.

When

- Data for summer seasons of 2024 and 2025 will be analyzed.
- *Recommended to repeat periodically after the tourist seasons.*

What

- Spatial-temporal movement of hikers and mountain bikers.
- Digital trail data on outdoor apps.

Who

- CUAS is responsible for the data collection and evaluation.
- CA partners support in the data collection.

Where

- Data from Lower Kamenjak pilot site.

Required resources

- GNSS data from various apps.

How?

- Geostatistical analysis of GNSS Data from outdoor apps.

Kamenjak

Visitor monitoring

Automatic visitor counters

Why

- Avoid illegal parking next to the road and overcrowded beaches.

When

- Continuous monitoring starting from summer season 2024.

What

- Parking monitoring will be implemented to inform visitors which parking lots are free.

Who

- Kamenjak: external expert will install the counters and evaluate the data.

Where

- 10 parking places at Lower Kamenjak.

Required resources

- Automatic car counters/laser.
- Digital information panel.
- Personnel for installation, maintenance, and evaluation.
- Permission of regional authority.

How?

Laser will count the limit of parking lots and inform visitors about free places on a panel placed at the entrance of Lower Kamenjak.

Kamenjak

Visitor monitoring

Field survey / Questionnaire

Why

- Understand visitor behavior and attitudes towards the environment and awareness about their own environmental impact.
- Understand visitor's use of digital platforms.

When

- From June to October 2023.
- *Recommended to repeat yearly or every two years.*

What

- On-site visitor paper survey.

Who

- Eurac and partners prepare the structure.
- CA partners collect the data.
- Eurac evaluates the data.

Where

- On-site visitor survey at the pilot site of Lower Kamenjak.
- In the House of Nature visitor center (Premantura).

Required resources

- Personnel for data collection.
- Paper questionnaires.
- Statistical software for data analysis.

How?

On-site visitor survey.
Statistical analysis.

Kamenjak

Visitor monitoring

Expert interviews

Why

- Collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.
- Collect data on relationship of local stakeholders with tourists, and their mutual interactions.

When

- Continuous but with focus on winter/spring 2023/2024

What

- Interviews with nature conservation, tourist experts and other experts of the region.

Who

- Public Institution Kamenjak
- Tourist board managers and tourist guides
- Fishing, diving associations, tourist companies
- Public authorities
- Experts from University of Pula

Where

- On-site interviews.

Required resources

- Personnel for performing interviews.
- Protocol of interviews.

How?

Interview guidance and inclusion of results into the report on impacts at pilot sites.

Kamenjak

Erosion monitoring

Erosion along hiking and bike trails

Why

- Assess current state of erosion at selected trails. Find a relationships and correlations between erosion grade, number of visitors, soil parameters, terrain, and other variables.

When

- Significant Landscape Kamenjak: before, during and after touristic season

What

- Erosion monitoring along hiking and bike trails.
- Secondary trails.
- Branching of paths.
- Comparison of different techniques UNIZA vs. Uni Parma

Who

- UNIZA uses LIDAR UAV and ground-based methods.
- Uni Parma uses photogrammetric UAV and ground-based methods.
- UNIZA and Uni Parma evaluate the soil loss between two or more scans.

Where

- For the whole pilot site.
- On protected grassland.
- On one forest trail.

Required resources

- Lidaretto scanner.
- 360° camera.
- Drone with photogrammetric sensor.
- Visitor counters.

How?

- UAV-based survey at high and low altitude.
- Focus is on ground-based survey on the forested trail.
 - Evaluation of soil loss.

Kamenjak

Vegetation monitoring

Trampling along hiking and bike trails

Why

- Monitor the formation of shortcuts and fragmentation of protected grasslands.

When

- 2023 - first monitoring, establishment of survey track
- 2024 - at least 3 times, before, during, after touristic season

What

- Formation of wild trails
- Damage of vegetation

Who

- UNIZA and Uni Parma: UAV and ground-based technology methods
- Kamenjak: start own photogrammetric drone survey in 2024
- Uni Parma will evaluate the data

Where

- For the whole pilot site
- On protected grassland
- On one forest trail.

Required resources

- Lidaretto scanner
- 360° camera
- Drone with photogrammetric sensor
- Visitor counters

How?

- UAV and ground-based technology-based methods.
 - (photogrammetric and LIDAR)
- Test semi-automatic detection of wild trails.

Kamenjak

Vegetation monitoring

Invasive species monitoring - Citizen science

Why

- Involve visitors in the monitoring to raise their awareness about invasive species.
- Gain information on the location and abundance of invasive plant species along hiking/biking trails.

When

- Implementation of project in spring 2024.
- Promotion of project start of active vegetation season.
- Evaluation end of season 2024 / 2025.

What

- Invasive plant species location and abundance.

Who

- Kamenjak: project implementation and outreach.
- CUAS supports CAs in the evaluation of data.
- Citizen Scientists.

Where

- for the whole pilot area of Lower Kamenjak

Required resources

- Account of i-Naturalist.
- Minimum of 50 confirmed observations on the platform.
- Info materials and communication.

How?

- i-Naturalist project establishment and promotion.
 - Geostatistical analysis of data.

Kamenjak

Wildlife monitoring

Distribution of earth worms and microplastic pollution

Why

- Understand pressures and threats of microplastic pollution affecting earthworms and their habitats.

When

- Starting field sampling in mid April until mid May 2024.
- Analysis of earth worms and microplastics in autumn 2024.

What

- Analysis of the distribution and abundance of earth worms (*Oligochaeta: Crassiclitellata*; *Octodrilus istrianus*)
- Analysis of microplastic concentration in soil samples

Who

- Kamenjak: external service of University J.J. Strossmayer of Osijek

Where

- Near parking places on randomly chosen locations.

Required resources

- Sample kits
- External expert

How?

- 150 samples in the field
- Analysis in the laboratory
Field sampling and lab work

Kamenjak

Pollution monitoring

Mapping of location and trash type on beaches

Why

- Understand which kind of pollution is found on individual beaches to determine potential sources of pollution.

When

- 4 times per season starting in spring 2024 until winter 2024/25.

What

- Monitoring of macro litter location and type on different beaches.

Who

- Kamenjak: external expert from the Marine Research Center, Roder Bušković Institute.

Where

- On beaches on West and East side of the Lower Kamenjak peninsula (Polje and Školjić) as well as on the island Ceja.

Required resources

- Protocol of litter type for the field survey.

How?

- 100 m stretch of each beach from the strandline until the back of the beach is monitored.
 - Litter type is documented.

Tuscan-Emilian Apennine National Park



Tuscan-Emilian NP

Visitor monitoring

Digital visitor monitoring

Why

- Identify the frequency of hikers and mountain bikers on official and unofficial trails in sensitive natural areas.
- Identify promoted digital trails.

When

- Data for summer seasons of 2024 and 2025 will be analyzed.
- *Recommended to repeat periodically after the tourist seasons.*

What

- Spatial-temporal movement of hikers and mountain bikers.
- Digital trail data on outdoor apps.

Who

- CUAS is responsible for the data collection and evaluation.
- CA partners support in the data collection.

Where

- Pietra di Bismantova Pilot site
- Sella del Marmagna Pilot site
- Lama Lite Pilot site

Required resources

- GNSS data from various apps.

How?

- Geostatistical analysis of GNSS Data from outdoor apps.

Tuscan-Emilian NP

Visitor monitoring

Automatic visitor counters

Why

- Identify the frequency of hikers and bikers on selected trails.
- Monitor the frequency of cars on selected streets.

When

- Continuous monitoring from summer season 2024.

What

- Monitoring of the spatial-temporal distribution of visitors.

Who

- Tuscan-Emilian NP contracts external expert to install and supervise the counters.
- UNIPR collects, evaluates the data and correlates with erosion processes.
- CUAS performs geostatistical analysis.

Where

- Pietra di Bismantova Pilot site
- Sella del Marmagna Pilot site
- Lama Lite Pilot site

Required resources

- Automatic counters
- Personnel for installation, maintenance, data collection and evaluation.
- Permission of ground owners and trail management organizations.

How?

- Counter data will be related to other monitoring activities:
 - Correlation with data from outdoor apps (geostatistical analysis).
 - Correlation of visitor numbers and erosion/trampling.
 - Correlation of visitor number with wildlife activities in the area.

Tuscan-Emilian NP

Visitor monitoring

Field survey / Questionnaire

Why

- Understand visitor behavior and attitudes towards the environment and awareness about their own environmental impact.
- Understand visitor's use of digital platforms.

When

- From June to October 2023.
- *Recommended to repeat yearly or every two years.*

What

- On-site visitor paper survey.

Who

- Eurac and partners prepare the structure.
- CA partners collect the data.
- Eurac evaluates the data.

Where

- Pietra di Bismantova Pilot site
- Sella del Marmagna Pilot site
- Lama Lite Pilot site

Required resources

- Personnel for data collection.
- Paper questionnaires.
- Statistical software for data analysis.

How?

On-site visitor survey.

Tuscan-Emilian NP

Visitor monitoring

Expert interviews

Why

- Collect local/regional knowledge about the impacts of visitors on the environment at pilot sites.
- Collect data on relationship of local stakeholders with tourists, and their mutual interactions.

When

- Continuous but with focus on winter/spring 2023/2024

What

- Interviews with nature conservation and tourist experts of the regions

Who

- Tuscan-Emilian NP
- Managers of the NP
- Majors of the municipalities of pilot sites
- Tourist office managers
- Mountain guides (associated partners)
- Italian environmental association

Where

- On-site interviews.

Required resources

- Personnel for performing interviews.
- Protocol of interviews.

How?

Interview guidance and inclusion of results into the report on impacts at pilot sites.

Tuscan-Emilian NP

Vegetation monitoring

Tree growth analysis

Why

- Detect indicators of anthropogenic disturbance.
- Understand the influence of ski slopes and trails on tree growth.
- Differentiate between climatic influence, human disturbance and location.

When

- 2023 sampling at Bismantova and Val Parma
- 2024 sampling at Monte Cusna
- September/October 2024 isotopic analysis in the laboratory

What

- Dendroisotopic analysis to analyse the physiological conditions of trees.
- trees along trails in Val Parma and Bismantova.

Who

- Uni Parma, Department of Chemistry, Life Sciences and Environmental Sustainability

Where

- Along trails in
 - Bismantova.
 - Foresta Val Parma.
- Along ski slopes at Monte Cusna.
- Control sites at undisturbed places in the forests.

Required resources

- Temperature and humidity loggers.
- Wood driller (Pressler gimlet) for tree ring sampling
- Laboratory equipment

How?

- Dendroisotopic methods are used to analyze tree ring growth of the past.
- Extract cellulose of each tree ring to determine its isotopic chronology.

Tuscan-Emilian NP

Erosion monitoring

Erosion along hiking and bike trails

Why

- Assess current state of erosion at selected trails. Find a relationships and correlations between erosion grade, number of visitors, soil parameters, terrain, and other variables.
- Root analysis to determine past erosion processes.

When

- Testing methods in 2023.
- Tree root sampling in 2023 at 2 pilot sites.
- Tree root sampling at Mt. Cusna in 2024
- Every two months during main touristic season 2024 / 2025.

What

- Erosion monitoring along hiking and bike trails.
- Branching of paths.
- Dendromorphological tree root analysis (indicator for past soil erosion).

Who

- Uni Parma uses photogrammetric UAV and ground-based methods.
- UNIZA and Uni Parma evaluate the soil loss between two or more scans.

Where

- All three pilot sites
 - Bismantova
 - Monte Cusna
 - Foresta Val Parma

Required resources

- 360° camera.
- Drone with photogrammetric sensor.
- Visitor counters.
- Wood saw to sample tree roots.

How?

- UAV-based and ground-based survey at high and low altitude.
- Root analysis to determine previous percentage of soil erosion.

Tuscan-Emilian NP

Vegetation monitoring

Trampling along hiking trails

Why

- Understand the trampling impact of visitors on trail vegetation on frequented trails.

When

- Before and after the main touristic season 2024 / 2025.

What

- Plant species number, richness and distribution.
- Formation of wild trails (top part of Bismantova, high part of monte cusna side)
- Damage of vegetation

Who

- UNIPR: UAV and ground-based technology methods
- Tuscan-Emilian NP: external expertise (botanist expertise)

Where

- Technology-based methods at all three pilot sites: Bismantova, Monte Cusna, Foresta Val Parma
- Standard field survey at two sites: Bismantova, Monte Cusna

Required resources

- Lidareto scanner
- Drone with photogrammetric sensor
- 360° camera
- Botanist

How?

- UAV and ground-based technology methods.
 - Standard field survey.
- Test semi-automatic detection of wild trails.

Tuscan-Emilian NP

Wildlife monitoring

Animal species presence and activity

Why

- Collect data on animal species and activity and to correlate this with the human noise impact.
- To regulate the traffic in the pilot site.

When

- two times each year from May to August.
- On days with low/high visitor frequencies
- 3-times 20 minute sessions per day

What

- Number of avifauna and amphibia species and species activity.

Who

- Tuscan Emilian NP: external service from University of Pavia.

Where

- Foresta Val Parma (dirt road open to the public)
- At transect of a dirt road, near and far from the road

Required resources

- Acoustic sensors.

How?

- Expert-based survey on avifauna and amphibia species
 - Bioacoustic methods

Tuscan-Emilian NP

Water monitoring

Water demand

Why

- the purpose of this monitoring activity is to evaluate the impact of the increase in visitors on some springs of high naturalistic value in the pilot area of Monte Cusna, captured for drinking use for the small villages below

When

- continuously from June 2024 to the end of the project

What

- Increase of water demand in different periods of the year, Hidrogeological monitoring, physico-chemical analyses, isotopic analyses, geological and geomorphological data, pipeline buildings blocks, diagram and patterns during the 4 seasons

Who

- external expert in collaboration with the Geological Service of Emilia Romagna Region (associated partner)

Where

- the monitoring activity will take place in a group of 10 springs in the northern-eastern side of Monte Cusna.

Required resources

- the equipment is provided for free by the Geological Service of Emilia Romagna Region (associated partner). The amount of 11.700€ is foreseen in Humanita budget as external assistance

How?

- the monitoring activity will be carried out using portable multiparameteres, Flow tracker handheld, acoustic Doppler velocimeter for wading discharge measurement, mass spectrometer

Collaboration and Responsibilities in the Monitoring Strategy

The monitoring strategy serves as our guiding compass, directing our efforts toward key objectives. In the HUMANITA project, our focus is on addressing specific issues of tourism impacts identified within CAs, recognizing the regional, country-specific, and user group-specific nuances. Notably, distinctions arise, such as those between a national park and a UNESCO Global Geopark, each presenting unique monitoring obligations and management objectives.

Our selected methods are specifically designed to achieve the diverse objectives outlined, and we are proactively exploring opportunities for cross-border collaborations. While the overarching structure of the project naturally encourages collaboration between scientific and practical partners from each country, there is a distinct emphasis on fostering joint transnational collaboration in our monitoring endeavors, a prospect that holds considerable interest for all partners. The ensuing section articulates the clearly defined responsibilities of all partners within the HUMANITA project for the implementation of the monitoring strategy at pilot sites.

Carinthia University of Applied Sciences

- Investigation of visitor flow in the Karawanken-Karavanke Geopark using visitor counters, GPS loggers and digital data from outdoor apps;
- Digital visitor monitoring using data from outdoor apps for all pilot regions;
- Preparation of contents for the transboundary stakeholder workshop in the Karawanken-Karavanke Geopark;
- Environmental DNA soil sampling and genetic analysis to investigate the spread of invasive alien species caused by hikers and mountain bikers in the Bike Park Petzen;
- Assisting the Karawanken-Karavanke Geopark in the implementation of the citizen science project, monitoring invasive alien species with the iNaturalist app;
- Anonymization of camera footage from wildlife cameras of the Karawanken-Karavanke Geopark.

Karawanken-Karavanke UNESCO Global Geopark

- Support in the data collection of digital visitor monitoring data;
- Installation and data collection of visitor counter data;
- Organisation of a transboundary stakeholder workshop with public authorities, local stakeholders and tourists.
- Administration of questionnaires to visitors of pilot sites;
- Supporting UNIZA and Uni Parma in the monitoring of soil erosion at the Bike Park Petzen;
- Development of a citizen science project using the iNaturalist app to monitor invasive alien species;
- Assisting other pilot sites in the implementation of the citizen science project with the iNaturalist app;

University of Parma

- Assessment of soil erosion in all pilot sites of Tuscan-Emilian Apennine National Park (Pietra di Bismantova, Lama Lite Pass, Lago Santo - Marmagna Saddle) by employing UAV-based and ground-based photogrammetry;

- Conduction of dendrogeomorphological and dendroisotopic analyses on tree ring samples and roots collected in the Tuscan-Emilian Apennine National Park pilot sites;
- UAV-based low-altitude photogrammetric survey of five different areas of interest (dry grasslands) previously identified in Nature Park Kamenjak to investigate trampling, erosion and land transformation;
- Ground-based photogrammetric survey of an educational path near the entrance of Nature Park Kamenjak to evaluate the trail conditions over time;
- Data recording and erosion determination with UAV and ground based photogrammetric methods in the Bike Park Petzen;
- Provision of a common database for monitoring data and visualization platform of results of the monitoring activities.

Tuscan-Emilian Apennine National Park

- Installation and collection of data of automatic counters to monitor visitors in the Pietra di Bismantova, Sella del Marmagna and Lama Lite Pilot sites.
- Support in the data collection of digital visitor monitoring data;
- Administration of questionnaires to visitors of pilot sites;
- Conduction of expert interviews with nature conservation and tourist experts of the region;
- Standard vegetation field survey at Mt. Bismantova and Mt. Cusna;
- Bioacoustic monitoring of avifauna and amphibia species at a transect along a dirt road in the Foresta Val Parma;
- Analysis of water demand at 10 springs on the north-eastern side of Monte Cusna.

Eurac research

- Processing, administration, and analysis of questionnaires aimed at investigating tourists' attitudes towards the natural environmental impacts in pilot areas;
- Comparison with key project stakeholders on questionnaire results;
- Organization and monitoring of participatory processes to disseminate project activities in pilot areas;
- Development of a strategy to mitigate human-nature conflicts in pilot areas;
- Formulation of recommendations capable of summarizing the entire project work to be directed towards institutions and managers of pilot areas;
- Preparation of a sensitization and education process through the Online Green Academy, using citizen science-oriented approaches.

University of Zilina

- Conduction of expert interviews with nature conservation and tourist experts of the region;
- Assessment of soil erosion in all pilot sites of Malá Fatra National Park with UAV-based photogrammetry and LiDAR;
- Recording and erosion determination with a Lidareto Scanner in the Bike Park Petzen;
- UAV survey of an educational path near the entrance of Nature Park Kamenjak to evaluate the trail conditions over time;

- Study of the impact of tourism on the diversity of soil mite species (Acarina) - a group of small arthropods, important decomposers, and determinants of ecosystem health changes in the soil;
- Detecting pathogenic bacterial species in avifauna droppings collected in areas with a high frequency of tourists, especially at mountain peaks and surroundings of mountain chalets or cableway stations;
- Assisting the Administration of Malá Fatra NP with all monitoring activities;
- Assessment of water quality in two mountain streams Stohový potok and Varínka in Malá Fatra NP.
- Evaluation of the spatial and environmental characteristics of trails at pilot sites.

Malá Fatra National Park

- Installation and data collection of automatic visitor counters at pilot sites;
- Administration of questionnaires to visitors of pilot sites;
- Support in the data collection of digital visitor monitoring data;
- Conduction of expert interviews with nature conservation and tourist experts of the region;
- Standard field survey trampling vegetation at the pilot sites;
- Monitoring of large carnivores using telemetry collars and photo traps;

CEE Web

- Administration and analysis of questionnaires from visitors of Bükk National Park pilot sites;
- Organisation of interviews and workshops with public authorities, local stakeholders and tourists together with Bükk National Park;
- Assisting Bükk National Park in all activities, such as monitoring of the influence of humans on bat populations, analysing data, reporting;
- Dissemination of results, collaboration with sister projects, networking.

Bükk National Park

- Administration of questionnaires to visitors of pilot sites;
- Support in the data collection of digital visitor monitoring data;
- Installation of visitor counters on the Hór Valley pilot site;
- Organisation of interviews and workshops with public authorities, local stakeholders and tourists;
- Development of a citizen science project to monitor pollution alongside the new educational trail in Hór valley;
- Detecting pathogenic species within amphibian populations;
- Field survey on vegetation trampling at the pilot sites, including monitoring of invasive alien species;
- Using acoustic detectors for monitoring tourism impact on bat populations;
- Developing an interactive educational trail.

Public Institution Kamenjak

- Administration of questionnaires to visitors of pilot sites;
- Support in the data collection of digital visitor monitoring data;

- Organization of interviews with nature conservation, tourist experts and other experts of the region;
- Monitoring of macro-litter pollution in coastal areas;
- Monitoring of microplastics pollution in the soil;
- Monitoring of influence of microplastics on the concentration of earthworms;
- Monitoring of the creation of “wild” paths and grassland fragmentation with a help of drone;
- Implementation of innovative parking system;
- Application of citizen science approach by using the iNaturalist app to observe invasive alien species.

Notitia

- Support for communication activities at the local level and project level;
- Preparation of communication and dissemination materials;
- Managing relationships with project stakeholders and associated partners;
- Organization and monitoring of participatory processes to disseminate project activities in pilot areas.

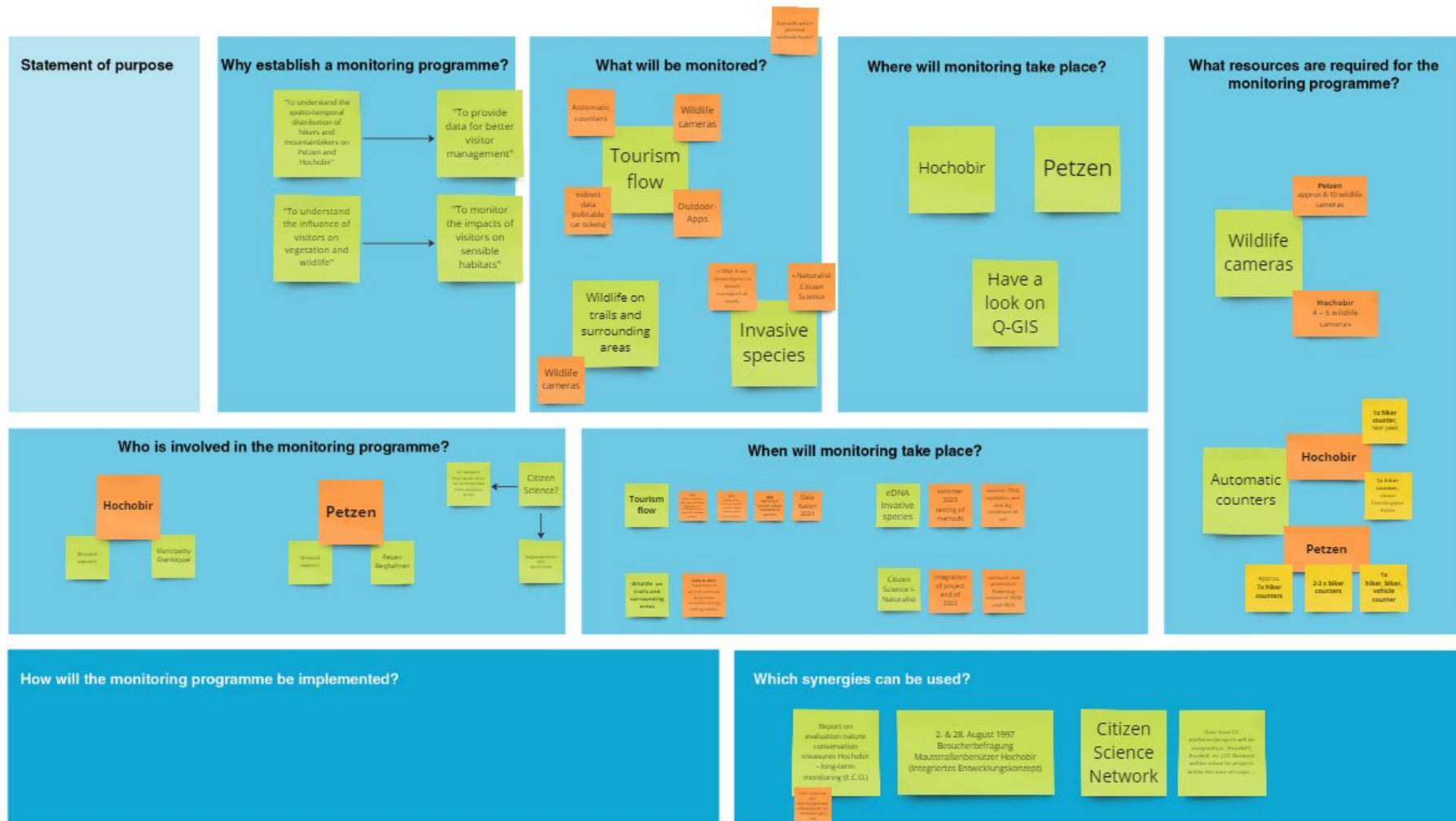
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Annex

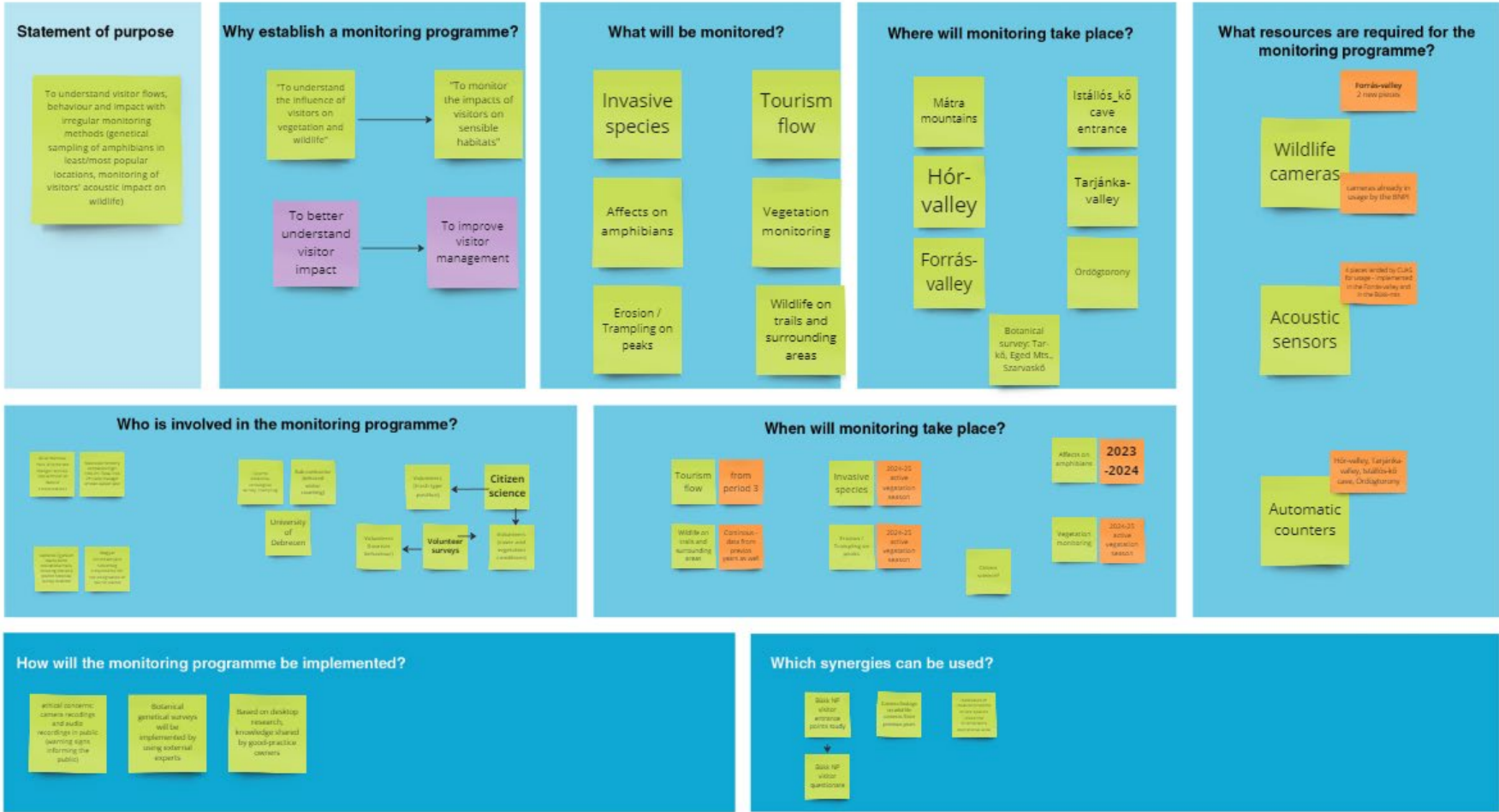
In the Annex, the monitoring concept worksheets can be found, that have been elaborated at the kick-off workshop of the HUMANITA project. They were further elaborated in the online collaborative tool MIRO by CA and scientific partners and were the starting for the production of the transnational monitoring strategy.

Karawanken-Karavanke UNESCO Global Geopark

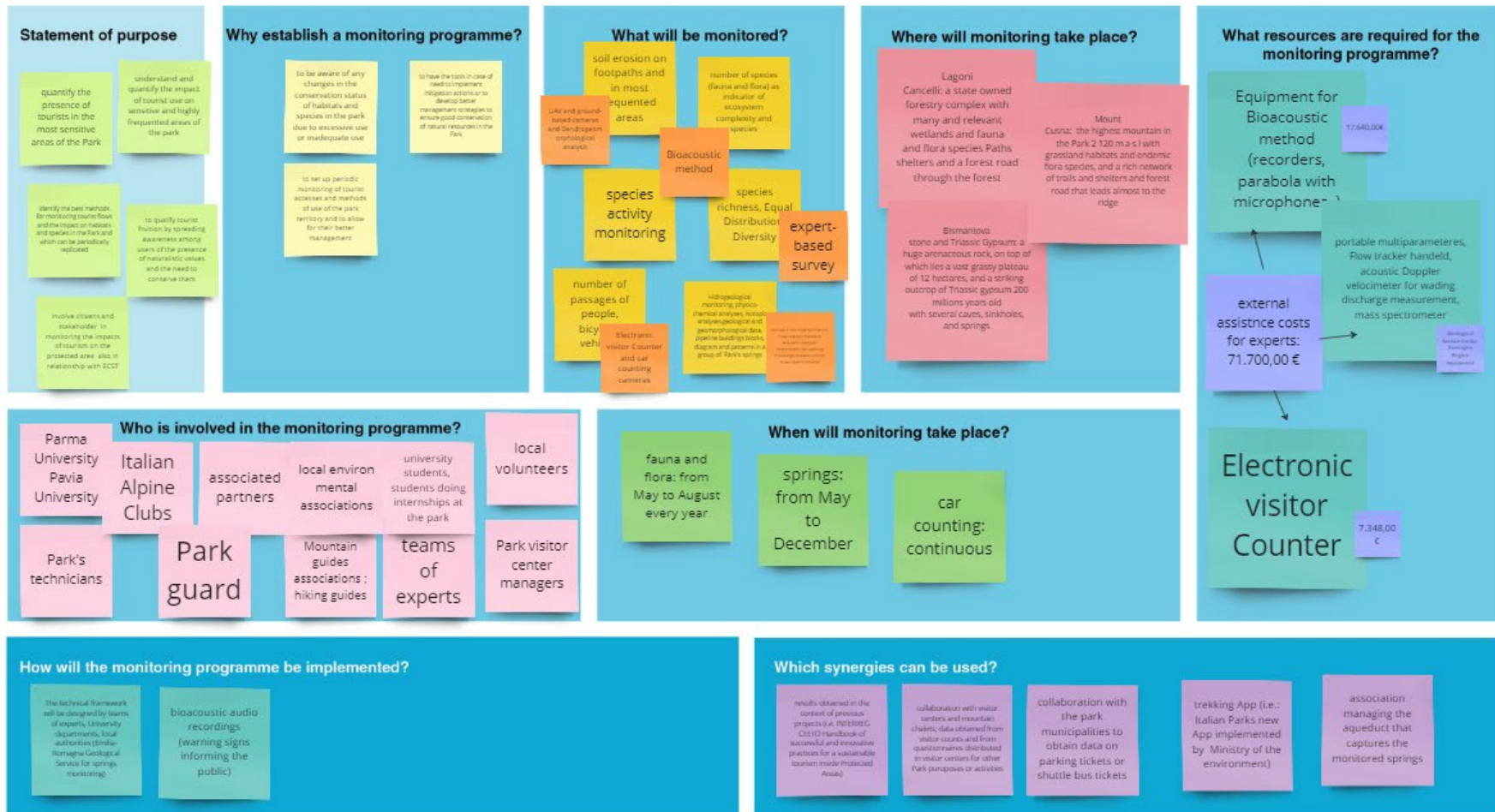


Bükk national park

Project start: 2023



Tuscan-Emilian Apennine national park



Mala Fatra national park

