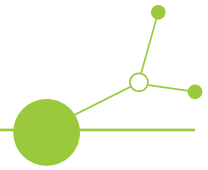


Local Action Plan to monitor and resolve human-nature conflicts in pilot sites

D.3.4.1.



Partner:
Public Institution Kamenjak

Version 1
12 2025





Table of contents

<u>1. Introduction to the Protected Area</u>	3
<u>2. Current state-of-the-art of tourism impacts</u>	5
<u>3. Current mitigation measures</u>	7
<u>4. Monitoring activities' results</u>	8
<u>5. Gaps/weaknesses to address</u>	14
<u>6. Integration into the current tourism impact management strategy</u>	15
<u>7. Linkages to national-regional plans</u>	16
<u>8. Pilot site Action plan</u>	17
<u>9. Zone Plan</u>	24
<u>10. Remarks and Conclusions</u>	28



Introduction

Interreg CE Humanita project and the framework of Action Plans for human-nature interactions in Protected Areas

Within the framework of the Interreg CE Humanita project, involved natural parks and protected areas are required to develop, for each pilot site, the Local Action Plan (D.3.4.1) to monitor and resolve human-nature conflicts in respective sites.

Action plan is the operational plan of the park/protected area's strategy for managing tourism impacts. The Action plan document showcases the actions needed to achieve sustainable management of tourism according to the defined objectives of optimizing human activities with biodiversity and nature protection.

It provides practical guidance on the implementation and monitoring of actions that the organization is committed to achieving upon approval.

The document begins by outlining the context of the park/protected area and displaying the main issues and criticalities that currently threaten the biodiversity and health of the areas' habitats. It describes the current impacts' mitigation measures in place, featuring the main gaps and weaknesses that still exist.

It highlights challenges and potential room for strengthening the strategies in force by combining integrative measures and tools resulting from the monitoring activities performed and knowledge exchange that occurred along the project progress. It illustrates how the action plan will be included into a wider framework of strategies in effect, within which administrative and legislative structures at local, regional and national level will be part, and how it will reinforce them as well.

The action plan includes a Zone plan to designate areas of the parks/protected areas for different recreational use other than their current use.

The document also includes actions specifically aimed at developing new narratives of the park/protected area to foster human responsibility and awareness about environmental values.

The action plan contributes with concrete actions to achieving policy changes and real-world impacts.



1. Introduction to the Protected Area

The Significant Landscape of Lower Kamenjak and the Medulin Archipelago is a protected area within the Municipality of Medulin, characterized by exceptional landscape diversity, including coastal zones, cliffs, cave systems, and numerous natural beaches. The area is highly valuable as a recreational and educational space, as well as a key habitat for the preservation of biological and landscape diversity.

Lower Kamenjak is a peninsula extending into the Adriatic Sea, while the Medulin Archipelago comprises 11 uninhabited islands and islets, each with distinct geomorphological and ecological features. Due to the presence of priority species and habitats of interest to the European Union, the area is included in the Natura 2000 ecological network.

The Lower Kamenjak peninsula is approximately 3,400 meters long, with a width ranging from 50 to 1,600 meters. The area includes a total of 30 coves (such as Podlokva, Dražice, Školjić, Škokovica, Rt Golica, Mali Portić, Portić, Škara, Debeljak, Rt Franina, Sv. Mikula, Velika Kolombarica, Mala Kolombarica, Velike Kršine, Radovica, Toreta, Njive, Plovanije, Polje, and Pinižule) and 11 uninhabited islands and islets: Bodulaš, Ceja, Trumbuja, Fenera, Šekovac, Fenoliga, Levan, Levanić, Premanturski škoj, Pomerski škoj, and Porer.

Accessibility varies across the area: some coves are easily reachable by land, while others can only be accessed by sea. This diversity of access further highlights the need for targeted visitor management, the preservation of natural values, and the protection of sensitive habitats.



Figure 1. Lower Kamenjak (Source: Public Institution of Kamenjak)

The area of Lower Kamenjak and the Medulin Archipelago is one of the most valuable biodiversity hotspots in Istria. The diversity of plant species is particularly notable: 591 plant species have been recorded in the area, including 30 orchid species, two of which are endemic. A total of 37 species are classified as critically endangered, while 63 species are considered endangered, representing 10.6% of the flora of Lower Kamenjak. In addition to rare and endangered species, the area is rich in typical Mediterranean flora,



creating a mosaic landscape composed of forests, shrublands, grasslands, and characteristic geological formations.

The mild Mediterranean climate and diverse habitats contribute to the high level of faunal diversity. A total of 146 bird species have been recorded, 130 of which are considered endangered, along with more than 50 butterfly species, numerous other insects, many invertebrates, and various species of reptiles and mammals. The area also holds significant value in terms of endemism: in 1989, Slovenian biologist Narcis Mršić discovered five specimens of earthworms that were later described as a new endemic species - *Octodrilus istrianus*.

The Lower Kamenjak area and the surrounding islands represent an important migratory route for numerous species of migratory birds. The peninsula and archipelago serve as key nesting grounds and resting sites during spring and autumn migrations.

The grassland areas of Kamenjak were created through forest clearance and are used for grazing livestock (sheep). These habitats are part of the Natura 2000 network and include eumediterranean grasslands of the Thero-Brachypodietea (6220*) and eastern sub-Mediterranean dry grasslands (*Scorzoneretalia villosae*) (62A0)



Figure 2. Natura 2000 sites (source: Natura 2000)

The coastal edge consists of rocks and cliffs of the Mediterranean coastline, covered with endemic *Limonium* spp., alternating with gravel beaches supporting halophytic vegetation (*Euphorbion peplis* association).

The main management challenges involve balancing nature conservation with visitor management. Lower Kamenjak receives around 700,000 visitors arriving by car annually and about 230,000 pedestrians and cyclists, creating significant pressure on the area's infrastructure. The high number of visitors inevitably places pressure on the flora and fauna—particularly protected and endemic species, grasslands, as well as the cleanliness of the environment, beaches, and the sea.



2. Current state-of-the-art of tourism impacts

Visitor monitoring:

Current situation: A large number of visitors during the summer months creates tremendous pressure on the traffic infrastructure, trails, and generally on the quality of stay for visitors in the protected area. Visitor counting is conducted via vehicle counters in 10 parking zones and pedestrian and cyclist counters on the main entrances. The entry of motor vehicles into the protected area in numbers that exceed optimum capacity puts the infrastructure and the protected habitats under pressure. At the peak of the season, there can be traffic jams, crowding and beach overcrowding, which all diminish the quality of experience.

According to the Management plan for protected areas and ecological network areas - Water area of Western Istria, one of the goals of the Public institution of Kamenjak is to preserve flooded and partially flooded sea caves with the aim of limiting visitor activities inside the caves. One of those caves is located at the Velika Kolombarica cove, which belongs to the Natura 2000 ecological network. It is easy to explore by diving into, and a lot of local tourist guides organise excursions by boats or kayaks, which brings tremendous pressure during the summer months.

Main influences:

- Overloading of roads and parking zones
- Dust that harms vegetation
- Illegal parking on sensitive habitats
- Beach and trail overcrowding
- Diminished visitor satisfaction due to crowds and lack of organization
- Increased negative influence on the environment during the peak of the summer season
- Damage to Posidonia meadows due to anchoring



Figure 3. Njive parking

(Source: Public Institution Kamenjak)



Figure 4. Kolombarica parking

(Source: Public Institution Kamenjak)



Vegetation monitoring

Current situation: Grasslands of Lower Kamenjak are degrading due to a lack of traditional grazing, succession into bushes, and visitor trampling. Numerous invasive species are present, which additionally endanger native flora. Flora endangerment is also present due to the local community disposing of their “green” waste in secluded areas of the protected area, thus causing the spread of invasive alien species.

Main influences:

- Fragmentation of habitats due to the expansion of wild trails
- Loss of grasslands due to succession
- Expansion of invasive alien and alien species

Fauna monitoring

Current situation: Kamenjak is a highly valuable habitat to numerous bird species, invertebrates, bats and endemic species like the earthworm species *Octodrilus istrianus*. Pressures come from habitat degradation, noise, and high visitor intensity, which manifests in the creation of wild trails, habitat trampling, etc.

Main influences:

- Loss of insect habitats due to grassland degradation
- Disturbing migratory birds during migrations
- Worsening of soil quality, which impacts soil organisms

Pollution monitoring

Current situation: Shore ecosystems are faced with an increased amount of macroplastics and the damage to the seabed due to anchoring, whilst the land area records an increased presence of microplastics. Also, a large number of cars during the summer season causes the soil to become polluted with heavy metals, from brake fluids, etc.

Main influences:

- Presence of waste on the pilot beaches of Školjić, Polje, and the island of Ceja. Waste accumulated due to sea influence, by accumulating seaborne waste, and visitor influence, by littering
- Microplastics are present in soil near the trails and near the parking zones, and also far from the trails, which shows the influence of the wind
- Waste during peak season is accumulated on the shores and inland

Soil monitoring

Current situation: The soil of Lower Kamenjak is exposed to pollution due to intensive traffic, which influences microbiological communities and ecological balance in total.

Main influences:

- Heightened levels of heavy metals (Zinc, lead, copper, cadmium)
- Soil structure degradation due to trampling and erosion
- Destruction of soil organism habitats



3. Current mitigation measures

Visitor monitoring:

Official trail signs are put up by the expert and ranger service. They are intended to entice visitors to use official trails and prevent them from going through protected grasslands. If wild trails are identified by the expert service and the ranger service, closing is conducted during the winter season. The building of fences is also conducted by the ranger service to prevent further soil degradation of the protected grasslands and habitat fragmentation by visitor trampling.

Also, educational activities are performed all year round to educate the local community and visitors about the significance of the protected area, how to preserve it, how to recognize plant species, and about the area's cultural heritage etc. These include workshops, exhibitions, guided tours, manifestations, etc.

Tracking the number of vehicles is performed all year round, by categorizing and counting them via LPR cameras at the two entrance points (4 categories - Motorcycle, car, camper van, bus).

Fire prevention is also an important aspect of protecting the area, and it is carried out through constant patrolling by the ranger service during the summer season, the installation of water points for fire extinguishing at critical locations and the stationing a fire truck operated by the local voluntary fire brigade near the entrance of Rupine.

Imposing a ban and putting a psychological barrier to anchoring at Debeljak cove has resulted in the conservation of Posidonia meadows detected there, and a ban on anchoring or the building of eco anchoring spots in Portić bay is also being considered.

Pollution monitoring:

Monitoring of heavy metals in soil and vegetation is conducted. Also, seabed cleaning actions by divers are held multiple times per year, and the removal of fishing equipment that is left behind. Seawater quality is also measured multiple times per year by the Istria County Public Health Institute at 4 measurement stations. The workshops about waste disposal and manifestations like World Planet Earth-day are being held to educate the local community and visitors alike about proper waste disposal and the influence of littering and improper garbage disposal on the protected areas and the damage done by pollution on protected plant and animal species. Waste clearance of the protected area is performed by one cleaner during the winter season, and up to three cleaners during the summer season.

Fauna Monitoring:

The monitoring of boar population is conducted in cooperation with the Istrian Botanic Society and the local hunter's guild. Also, yearly monitoring of the earthworm population is conducted. Istrian cattle in the protected area are also contributing to protected grassland restoration by putting them to pasture on the protected grasslands. Furthermore, a programme to preserve noble pen shells is conducted by collecting the young larvae from the shells and helping them reach adult stages, and also monitoring populations of noble pen shells in the coastal area. Bird monitoring is performed yearly, by setting up bird ringing camps to be able to track the bird population more easily and be able to inventory the overall bird species and population of Lower Kamenjak. Monitoring of butterflies is also performed yearly by the expert service in cooperation with external experts. Furthermore, the monitoring of dragonflies (Odonata) on water habitats (ponds), alongside the monitoring of bat population on Lower Kamenjak (which houses one of the largest maternity colonies in Istria) and their habitat in an old Austro-Hungarian ruin is conducted yearly.



Flora Monitoring:

Monitoring of vascular flora by external collaborators is performed every year, alongside the yearly monitoring of fungi species, for which an inventory is made and updated, which is a prerequisite for proper protection and management. The removal of woody vegetation from the protected grasslands is conducted by the ranger service during the winter season, to prevent grassland succession and to restore the habitats. Also, upon identification of alien invasion species, the expert service together with the ranger service removes those species during the winter, spring and fall season. Also, physical barriers are set up before the areas where protected plant species are located to prevent people from trampling and picking them.

4. Monitoring activities' results

Visitor monitoring

The strategic placement of cameras and efficient tracking protocols are needed to maximally use and understand gathered data. Also, regular maintenance and updates of the monitoring system are necessary to make visitor management and parking zone management efficient and on time. To efficiently conduct visitor monitoring, 10 cameras for site monitoring were procured, along with 13 solar power plants, 10 small led panels for parking zones, and a large LED panel that was put up before the main entrance. Parking zones were established, and cameras were set up at the following areas: Pinižule, Dražice, Školjić, Plovanije, Mali Portić, Njive, Portić, Debeljak and Mala Kolombarica. To evaluate visitor activity, a model was developed that integrates Strava Metro data with other available datasets. Also, with the help of the camera counters and LED displays, the occupancy of each parking zone is made visible to the visitors so traffic jams can be avoided and parking zone management is more efficient.

Heritage narrative conservation is being fulfilled through dry stone wall building workshops, promoting awareness of the local population and visitors and educating them about the importance of dry-stone walls as habitats for specific flora and fauna species. The dry-stone walls will also be incorporated into visitor infrastructure.

Monitoring results:

- The counting system has enabled a better understanding of seasonal flows
- Critical spots of overcrowding and illegal parking are identified
- Confirmed diminishment of the quality of experience in periods of the largest occupancy

Priorities:

- Optimization of traffic and parking management
- Development of digital tools to anticipate visitation and manage flows
- Introducing seasonal limitations and regulating movement
- Improving communication and education of visitors
- Actively rerouting visitors to less crowded zones



Figure 5. Big LED parking screen

(Source: Public Institution Kamenjak)



Figure 6. Vehicle counter



Figure 7. Smaller LED parking screen

Vegetation monitoring

Continuous vegetation monitoring is conducted in Lower Kamenjak to track vegetation status and detect threats that could reduce or degrade the habitats of native plant species. In the area of Lower Kamenjak, there have been identified several alien invasive species that present a threat to local biodiversity due to their rapid spreading. Through a citizen science approach that involves citizens in monitoring activities, the iNaturalist app was used to facilitate the detection of these invasive alien species, while leading to an increase in community engagement. Through the app, visitors and the local community independently report invasive alien species location, date/time, quantity, and habitat. Also, to help them identify those species, leaflets in four languages (English, Italian, Croatian and German) are being distributed as well as their digital versions that are made available.

Monitoring results:

- Alien invasive and alien species reported, among which the Tree of heaven (*Ailanthus altissima*) poses the most significant threat
- Increase in engagement of the community in reporting invasive species
- Leaflets about invasive alien species in the Lower Kamenjak area in 4 languages distributed to visitors
- Alien invasive species are being removed upon identification

Priorities:

- Expanding the outreach to more participants
- Providing additional training for participants and promoting ongoing engagement in conservation efforts



HUMANITA

1. Installing iNaturalist on Your Smartphone

You can also access iNaturalist through a web browser: www.inaturalist.org

Searching for Invasive Species

In the app's main menu, select the "Projects" option.

Type "Kamenjak" or species of interest in the search bar.

Filter results by location to focus on the Lower Kamenjak area.

Sharing or Publish Observations

If you notice any invasive species, you can document them:

- Select the "Observe" option.
- Choose the species (you can search for it) or mark it as "unknown" if you're unsure.
- Take a photo of the plant (or animal) and add a description. Add one or more photos as evidence.
- Where you saw it should be added automatically. If this doesn't happen, check app permissions in the Settings app.

Taking Photos and Identifying Plants

Documenting invasive plant species is essential. Add one or more photos as evidence. Use your smartphone to take clear photos along the trails, then identify the species using AI suggestions or your own knowledge for accuracy.

Geotagging Your Observations

Enter the location of your observation. Ensure geotagging is activated on your device to provide location data for your observations. This feature helps map the distribution of invasive species accurately for effective monitoring and research.

Interacting with the Community

Comment and ask questions about observations made by other users. Participate in discussions about invasive species and their impacts on the Lower Kamenjak ecosystem.

Notifications and Education

Follow projects or groups focused on invasive species to receive notifications about new observations and events. Utilize the resources and guides available within the app for additional information on identifying invasive species.

Figure 8. Picture of iNaturalist user instructions (source: www.kamenjak.hr)

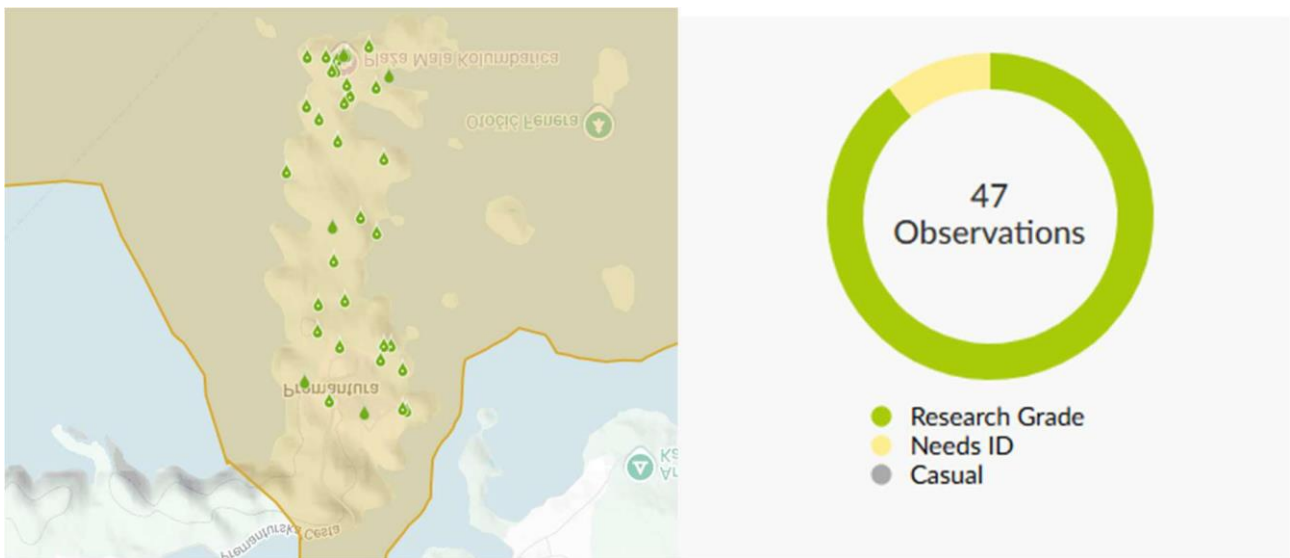


Figure 9. Map of iNaturalist observations (source: Public Institution Kamenjak)

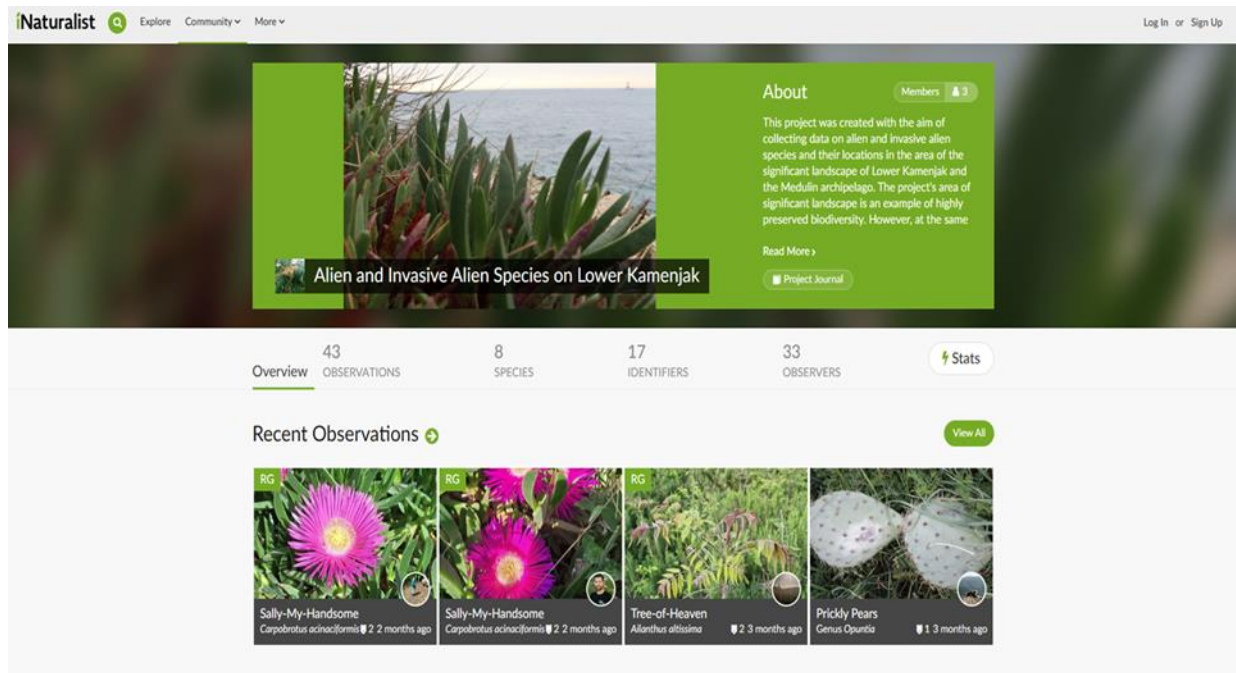


Figure 10. iNaturalist picture of alien invasive species (Source: Public Institution Kamenjak)

Wildlife monitoring

5 species of earthworms have been found, and the most represented are *Octodrilus bretscheri* and *Octodrilus istrianus*. The diversity of earthworm species shows the wealth of biodiversity in the area, but vegetation succession due to changes in soil usage represents a threat to the habitats. The monitoring utilized a combination of soil sampling tools and molecular identification methods. Data was collected through systematic sampling across different habitats at Lower Kamenjak in the spring 2024, from 50 sites, in a total of 150 samples with precise GPS coordinates recorded. For future research, it is essential to expand scientific studies on earthworm populations and their ecological roles to better understand the threats they face and their dynamics. A systematic monitoring programme for soil organisms is crucial for tracking their status and assessing the conservation measures effectiveness. It is also crucial to conduct low-intensity grazing and manage the wild boar population to preserve the earthworm habitats. Also, it would be beneficial to educate the local community and visitors about the importance of soil biodiversity and earthworm roles, through workshops and especially educational signage on the spots of the grasslands where earthworm populations were monitored.

Monitoring results:

- 5 earthworm species identified, including endemic species
- Trends in habitat quality reduction due to succession were identified

Priorities:

- Systematically track populations of earthworms
- Grassland renewal and lowering human influence
- Education of visitors about sensitive species



Pollution monitoring:

Microplastics monitoring - This monitoring assesses soil contamination with microplastics and the impact on the earthworm distribution. Experts from the University of J.J. Strossmayer were engaged to help reveal microplastics pollution and the impact of microplastics on earthworm population distribution. The data collected has shown inconsistencies across locations, most likely because of varying land types, local topography, wind impact, erosion, and seasonal human activities. A total of 150 soil samples were analysed, from 50 different locations, providing crucial insights into the level of microplastic pollution of Kamenjak. The results show a wide array of microplastic concentrations, from 0 to 14,800 particles in a kilo of dry soil, with an average of 2,460 particles. A significant presence like this shows how much pressure the ecosystem of Lower Kamenjak is under. Especially endangered zones are near the popular trails, main roads, and tourist zones, but also isolated areas contain microplastics, which suggest spreading by wind or water. Comparing microplastic levels in Lower Kamenjak to other European regions poses challenges due to a lack of standardized methodologies for extraction and quantification. The monitoring highlighted the need for further research into transport mechanisms and contamination sources. These findings support the development of conservation strategies and education workshops that tackle microplastic pollution in the Kamenjak area. Comparing microplastic levels of Lower Kamenjak to other European regions poses a challenge due to the lack of standardized methodologies for extraction and quantification.

Monitoring results

- Results show that due to many influences, microplastics are spread from trails and main roads to isolated areas, which suggests their spreading by wind and water.
- Range from 0 to 14,800 particles per kg of dry soil, with an average of 2,460 particles

Priorities

- Implement measures to reduce microplastic input into the environment
- Enhance public awareness regarding microplastic pollution
- Traffic reduction and waste disposal education

Macroplastics monitoring - the spread-out litter on the three chosen areas is tracked through all seasons (4 times a year) by the Center for Marine Research Rovinj, Institute of Ruđer Bošković. The methodology is aligned with the framework and guidelines set by the Interreg Med Plastic Busters MPAs project, which measures litter density as the number of items per 100-meter stretch. The weight of litter in each category was recorded, and all collected litter was properly disposed of. Selected groups with more than 20 items per sampling (10 random items per category) were further analyzed for material composition using an Agilent 4500 Series Portable FTIR Spectrometer. Material analysis was conducted on a total of 690 items from the study, divided into individual groups. The most common material found was xylon and olefin fibers, which are commonly used in textile and other industries.

Monitoring results:

- Continued tracking of macroplastics through all seasons, crucial for assessing long-term impacts on local ecosystems
- Most polluted location - Školjić, least polluted location - island of Ceja (low accessibility, lower pollution)
- Key conclusion - accessibility and tourist pressure are key pollution factors

Priorities:

- Systematic cleaning actions



- Establishing a network of waste collection and recycling points
- Ban single-use items



Figure 11. Macroplastic gathering zones

Source: Public institution Kamenjak



Figure 12. Macroplastic, Školjič beach

Source: Public Institution Kamenjak

Erosion monitoring:

The primary objective of this monitoring effort is to identify critical areas of trail formation and soil fragmentation in protected dry grasslands, to prevent new “wild” trail formation and thus further grassland erosion. Key activities included low-altitude UAV surveys combined with a ground-based photogrammetric survey of a forest trail near the main entrance and the transfer of knowledge regarding drone operation and route setup. A total of three surveys were performed, the first two times in cooperation with partners from the University of Parma and University of Žilina, and the last time by the Public institution of Kamenjak independently. One of the results was a complete orthophoto of the entire pilot area, and the other results were in regard to drone surveying, that is, the comparison of data to identify and prevent the formation of new “wild” trails and further protected grassland degradation.

Monitoring results:

- Critical areas of “wild” trail formation identified
- Data for comparison of soil loss collected
- Knowledge about drone operation transferred to PIK operators

Priorities:

- Prevention of new “wild” trails formation
- Expansion of monitoring to other areas of the protected landscape

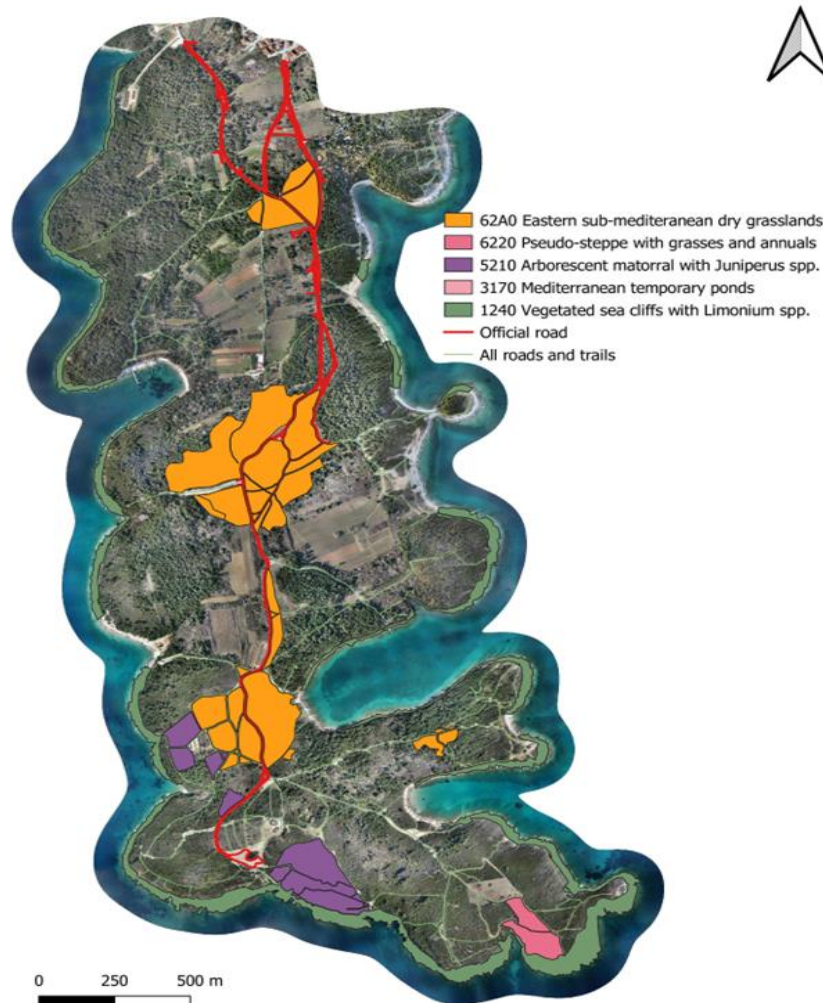


Figure 13. Monitoring zones of protected grasslands (Source: Public Institution Kamenjak)

5. Gaps/weaknesses to address

Despite the existing mitigation measures, several weaknesses present themselves in the Lower Kamenjak protected area. These relate to various aspects of management and present challenges that require action in the short term. According to the strategy for tourism development of the Municipality of Medulin 2021.-2027., a lack of sustainable practices are present in the municipality, so according to the recommendations stated in the plan, better visitor management practices are being implemented in the area of Lower Kamenjak, like prolonging the tourist season, lowering visitor numbers in the peak months and by augmenting the entrance prices (high and low season prices), trying to better distribute visitation frequency, but only making slightly influencing and changing the crowding in the peak summer season months.

Visitor pressure - The weaknesses that are present are the insufficient number of cameras to monitor visitor and vehicle movements. Also, despite the LED information system, visitors still concentrate on certain points (hotspots) and by doing so cause overcrowding and illegal parking and traffic jams. What is also a weakness is that the visitors do not respect the movement regulations, go around the fences set up to protect certain areas and a lack of long-term comparative data on visitor behaviour patterns is also a gap. Systematic monitoring is essential to manage visitors during the peak season (summer), to prevent the creation of wild



trails, destruction of grasslands and habitats, and ultimately avoid traffic jams and reduced visitor satisfaction.

Vegetation monitoring - the visitors and local community's lack of knowledge about identifying invasive species presents a weakness, the lack of visitor's focus on the usage of the iNaturalist app, instead the concentration on recreation and swimming. Also, there is a lack of interpretative and educational infrastructure on the area of Lower Kamenjak.

- Vegetation monitoring is conducted because alien invasive species represent a great threat to biodiversity, and without continuous monitoring and a bigger public involvement their removal is slow, hard, more expensive and less efficient.

Wildlife monitoring - Soil health underpins the entire ecosystem. Soil degradation and loss of its fauna produce long-term negative effects on habitat resilience, especially on already threatened dry grasslands.

Soil erosion monitoring - The lack of visitor awareness causes their contribution to soil erosion by wandering off the designated trails, disregarding the fences, moving on the forbidden areas. By doing so they trample the soil, destroy habitats which all diminishes the biodiversity of the area. What is even worse, motorbikes, quads and similar vehicles drive "off road", on sensitive surfaces and also destroying habitats and protected grasslands. Also, a lack of preventive infrastructure in critical locations causes people to not knowingly destroy or diminish the value of protected areas. The loss of such areas contributes to the disappearance of endangered and endemic species of flora and fauna.

Pollution monitoring - During the peak season there is an increased amount of plastic waste on coastal and inland areas, which is linked to visitors and the local community. There is also the vulnerability to potential large-scale pollution from oil spills, which emphasizes the need for an early warning system (i.e. drone monitoring). Also, the inadequate control of nearby anchored boats leads to them disposing of their waste into the sea and also the damage to Posidonia seagrass meadows due to illegal anchoring. The levels of microplastic which are high in certain areas show that a high number of visitors impact soil health and plant, marine and land organisms.

Among all these weaknesses, it is also important to note that many visitors are unaware that they are inside a protected area, since the level of area protection is a significant landscape (level 4 out of 7 in Croatia). It is also important to highlight the dependence on seasonal tourism when there are extreme pressures in a short period, as the dominance of recreational activities also reduces the attention to the rules of conservation. Another weakness is the local community's lack of interest in nature conservation programs and the absence of themed trails and information panels that educate and encourage responsible visitor behavior. Without such conduct, it is impossible to prevent environmental degradation.

6. Integration into the current tourism impact management strategy

Through the activities carried out through the HUMANITA project, a comprehensive framework has been set up to track the condition of biodiversity, tourism pressures and effectiveness of existing preservation measures. Managing tourist pressures is currently based on traffic and visitor control through the ticket admission system and entry points, and on education and communication with the visitors via information billboards and promotional materials, workshops, exhibitions, etc.

New elements that are resulting from the HUMANITA project additionally strengthen this framework and integrate new methods of tracking, analysis and education.



- **Expansion of the visitor monitoring system**
The vehicle, pedestrian, and cyclist counter system is integrated into existing plans of visitor management and is becoming the basis for dynamic traffic management and the pressure on area capacity. Gathered data enables the creation of more precise models of the seasonal distribution of visitors and planning the optimal capacity of the area.
- **Drone and satellite monitoring of the environment**
Regular tracking of erosion, “wild” trail formation and grassland condition via drone and analysis of water quality through satellite surveillance and sampling in cooperation with HZJZ is integrated in the yearly monitoring plans. By doing so, a continued assessment of tourism effects and climate changes effects on the environment is provided.
- **Tracking of invasive and alien species**
iNaturalist app is becoming a permanent tool within the system of protected area management, and the data gathered used to make operational decisions and direct educational activities.
- **Education and strengthening of employee and stakeholder capacity**
By plan the education of employees of the Public Institution of Kamenjak is predicted in the purpose of training to implement and analyse monitoring actions (i.e. earthworms). By doing so, long-term sustainability and independence in measure implementation is secured. Additionally, there is the aspect of traditional heritage conservation, which is primarily performed through dry stone wall building workshops and the maintenance of dry-stone walls, which also serve as a natural habitat for different flora and fauna.

All of these elements stem from and are supported by the Plan for management of protected areas and ecological network of the Municipality of Medulin for the period 2025-2034 and the Yearly plan for protection, maintenance, promotion and usage of protected areas of the Municipality of Medulin for 2025.

7. Linkages to national-regional plans

1. National level

On the level of the Republic of Croatia, the following regulatory frameworks should be considered:

- Nature protection law (“National newspaper” 80/13, 15/18, 14/19, 127/19, 155/23) - based on that law, nature protection is determined, the categories of protected areas and rights and obligations in nature protection are determined
- The categories of protected areas - according to the Nature protection law, there are 9 categories: Nature reserve, national park, special reserve, nature park, regional park, natural monument, significant landscape, park forest, park architecture monument.
- Directive framework on the EU level which is implemented through national legislation - i.e., Habitats directive, Birds directive
- Forest law (“National newspaper” 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14)
- Hunting law (“National newspaper” 140/05, 75/09, 153/09, 14/14)
- Fishing law (“National newspaper” 81/13, 14/14, 152/14)

2. Regional level

On the regional level the framework is based on:

- The decision on the declaration of protected areas
- The decision on the adoption of spatial plans on special feature areas (PPPPO) of Lower Kamenjak
- On the level of the Region of Istria, public institutions manage protected areas

3. Local level (Pilot-site: Lower Kamenjak)



On the lowest level - specifically, the location of Lower Kamenjak - the action plan must consider the following:

- The decision to establish the public institution for managing protected natural values in the Municipality of Medulin
- The area of Lower Kamenjak is integrated into the ecological network Natura 2000 because of priority habitats and species
- The rules of conduct for visitors of the area are clearly set (i.e. ban on picking protected plant species, ban on introducing alien plant species) - which sets the local implementation of protective measures
- Managing and protecting the area consists of measures like habitat tracking, tourism pressure reduction, and visitor education, which are all in the focus of the HUMANITA project
- The plans that the Public Institution of Kamenjak adheres to and with which the action plan should be synchronized are:
 1. The yearly plan for protection, maintenance, promotion and usage of protected areas of the Municipality of Medulin for 2026.
 2. The plan for management of protected areas and ecological network in the Municipality of Medulin 2025-2034
 3. The Action plan for visitor management of the significant landscape of Lower Kamenjak and the Medulin archipelago
 4. The plan for management for protected areas and ecological network areas of the Western Istria aquatorium 2023.-2032.
 5. The plan for management for areas of ecological network of Šćuza and Medulin bay 2023.-2032.

All in all, the action plan for the Lower Kamenjak area will contain specific measures like: monitoring of tourist activities and their influence on habitats (which is recommended in the Strategic and action plan of nature protection of the Republic of Croatia 2017 - 2025), measures to minimise negative influences, involving local communities and tourists in participative tracking, development of management tools based on facts and evidence.

8. Pilot site Action plan

ACTION 1	
TITLE OF THE ACTION	Monitoring of grassland fragmentation and wild trail formation
DESCRIPTION	Through drone tracking, grassland fragmentation and wild trail formation will be determined within the pilot area, to prevent new wild trail formation and further grassland erosion.
SPECIFIC OBJECTIVES	Prevent the formation of new wild trails and further grassland erosion by assessing the grassland condition and the current existence of wild trails. This allows for timely expert service and ranger interventions.
PROJECT MANAGEMENT TOOLS	HUMANITA database, drone, orthophoto analysis



RESPONSIBLE DEPARTMENT	Head office – Technical service, Expert service, Ranger service
INVOLVED STAKEHOLDERS	External surveys
IMPLEMENTATION STEPS	<ol style="list-style-type: none"> 1. Defining monitoring zones 2. Performing drone surveys before and after the summer season 3. Analyse gathered data 4. Decide on actions based on data analysis
IMPLEMENTATION PERIOD TIMELINE	Before and after the summer season 01.02.-01.05 and 01.09.-30.11.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	EU and national funds, own funds Performed by PIK employees as part of regular activities
EXPECTED RESULTS / MONITORING	<ul style="list-style-type: none"> • Prevented new wild trail formation and further grassland erosion • Regular monitoring campaign conducted and analysed 1-2 times per year (pre and post-season) • Provide reports based on data collected and then determine ranger and expert service actions

ACTION 2	
TITLE OF THE ACTION	Visitor monitoring through visitor counters and parking zones
DESCRIPTION	Visitor monitoring is conducted through parking zones, which determine the number of vehicles in a certain parking zone and inform visitors on space availability, and through pedestrian and cyclist counters on the entrances of the pilot area.
SPECIFIC OBJECTIVES	Better understanding of visitor dynamics, better information about visitors about space availability, and optimization of parking management. Improve visitor experience and satisfaction.
PROJECT MANAGEMENT TOOLS	Internal database, HUMANITA database, Strava metro data database
RESPONSIBLE DEPARTMENT	Head office – Technical service
INVOLVED STAKEHOLDERS	Local community, visitors
IMPLEMENTATION STEPS	Defining parking zones, camera/counter installation, data gathering, data analysis, managing traffic based on data, make seasonal reports



IMPLEMENTATION PERIOD TIMELINE	During the summer season (May- September), every year 01.0.-01.11.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	EU and national funds, own funds Led screen rent - 9.600 €
EXPECTED RESULTS / MONITORING	Illegal parking prevention, and by doing that the prevention of grassland destruction. Prevention of traffic jams, and by doing so, bolstering the satisfaction of visitors and enhancing the image of the protected area. The seasonal visitor flows report is created for each season and used for traffic management decisions.

ACTION 3	
TITLE OF THE ACTION	Earthworm monitoring
DESCRIPTION	Determining earthworm presence in the pilot area through soil sampling and, in turn, determining the ecological health of habitats in the pilot area.
SPECIFIC OBJECTIVES	Determining the ecological health of habitats and the biodiversity of the pilot area.
PROJECT MANAGEMENT TOOLS	Data gathered through soil sampling, QGIS, and laboratory equipment.
RESPONSIBLE DEPARTMENT	Expert service
INVOLVED STAKEHOLDERS	University of J.J. Strossmayer in Osijek
IMPLEMENTATION STEPS	Soil sampling, analysis of soil samples, identification of earthworm species, making reports based on data analysis and using them for education and further monitoring.
IMPLEMENTATION PERIOD TIMELINE	Spring season, once a year 15.03.-01.05.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	EU and national funds, own funds Performed by PIK employees as part of regular activities
EXPECTED RESULTS / MONITORING	<ul style="list-style-type: none"> • Educating the community about the importance for ecological health and the establishment of regular earthworm monitoring in the pilot area • Data gathered used for protected grassland management and conservation • Workshops or presentation held regularly(yearly) about importance of earthworm and results of monitoring



ACTION 4	
Pollution monitoring	
TITLE OF THE ACTION	
DESCRIPTION	By sampling soil from different locations within the pilot area of Lower Kamenjak, the goal was to determine soil pollution and human influence on the environment. Also, an analysis of macroplastic pollution on the beaches of Školjić, Polje, and the island of Ceja was conducted.
SPECIFIC OBJECTIVES	Determining soil pollution with microplastics due to human influence. Determining levels of macroplastic pollution in the pilot beaches and the source of the waste.
PROJECT MANAGEMENT TOOLS	Data gathered through soil sampling and through waste collected from pilot locations
RESPONSIBLE DEPARTMENT	Expert service
INVOLVED STAKEHOLDERS	J.J. Strossmayer University of Osijek, Center for Marine Research Rovinj
IMPLEMENTATION STEPS	Soil sampling and sample analysis, gathering waste on set locations, and then analyzing the waste(macroplastic)
IMPLEMENTATION PERIOD TIMELINE	Once per year, during the spring season (for microplastics) - 15.3.- 01.5. All seasons (for macroplastics) 15.01. - 30.11.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	EU and national funds, own funds 8,000€ (Macroplastic) 10,000€ (Microplastic)
EXPECTED RESULTS / MONITORING	Education of the community and visitors about human influence on the environment and preventing further pollution of the pilot area, determined the source of macroplastic waste and the level of pollution of the pilot beaches. Stopping the pollution, or minimizing the pollution levels related to visitor pressure and the local community. The results of monitoring are used for comparison yearly and used for targeted actions and awareness campaigns



ACTION 5	
TITLE OF THE ACTION	Participative monitoring
DESCRIPTION	Through the iNaturalist application, data is collected on alien and invasive alien species and their location in the Lower Kamenjak area, with a focus on the most common alien species observed in the area by raising awareness among the local community and visitors about the impact of alien invasive species on indigenous plant species. A similar invasive species reporting app is used on the national level called the Invasive species (Invazivne vrste) app.
SPECIFIC OBJECTIVES	Early detection and control of invasive alien species and preventing their further spread through Lower Kamenjak and other protected areas. Increasing local community participation in nature protection and improving response time in invasive alien species removal actions.
PROJECT MANAGEMENT TOOLS	iNaturalist app, Invasive species app (national app)
RESPONSIBLE DEPARTMENT	Expert service
INVOLVED STAKEHOLDERS	Local community, Lower Kamenjak visitors, local fishermen, visiting schools and universities
IMPLEMENTATION STEPS	Gathering data through the iNaturalist app, data analysis, and taking action on foreign invasive species in the pilot area of Lower Kamenjak
IMPLEMENTATION PERIOD TIMELINE	During the whole year, every year 01.1.- 31.12.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	EU and national funds, own funds 0€
EXPECTED RESULTS / MONITORING	Educating the community and visitors about the influence of alien invasive species on the protected area. After identifying invasive alien species, dispose of them according to the regulations of the protected area. Mapping invasive alien species regularly



ACTION 6	
TITLE OF THE ACTION	Visitor and community education through various activities
DESCRIPTION	The education of visitors and the local community about the values of the protected area is conducted through various workshops like “Young rangers”, interpretative walks, traditional manifestations like “Crab fest” and exhibitions connected to dates like “Planet Earth-day”.
SPECIFIC OBJECTIVES	Education of visitors and the local community about the specifics of the Kamenjak protected areas and the importance of nature protection and conservation
PROJECT MANAGEMENT TOOLS	Workshops, educational walks, exhibitions, educational materials
RESPONSIBLE DEPARTMENT	Expert service
INVOLVED STAKEHOLDERS	Visitors, Local community, kindergartens, schools, students
IMPLEMENTATION STEPS	Holding multiple events during the year, collecting feedback from visitors and the local community,
IMPLEMENTATION PERIOD TIMELINE	Every year, multiple times per year 01.02. – 30.11.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	Own funds, National funds, EU funds 10€ per person Performed by PIK employees as part of regular activities
EXPECTED RESULTS / MONITORING	Visitors and the local community are educated about the specific values of the protected areas that the Public Institution of Kamenjak is managing.

ACTION 7	
TITLE OF THE ACTION	Sheep procurement and low-intensity grazing
DESCRIPTION	The rental of sheep is implemented in the protected area as their grazing is beneficial to the maintenance and restoration of the protected grasslands, which are habitats to a diverse spectrum of flora and fauna.
SPECIFIC OBJECTIVES	The restoration and maintenance of protected grasslands. Support traditional land use practices.
PROJECT MANAGEMENT TOOLS	Low-intensity grazing, fencing to prevent trampling of certain habitats, vegetation monitoring



RESPONSIBLE DEPARTMENT	Expert service, Head office
INVOLVED STAKEHOLDERS	Local farmers
IMPLEMENTATION STEPS	<ol style="list-style-type: none"> 1. Determine grasslands for grazing 2. Infrastructure for sheep holding built 3. Sheep procured 4. Sheep grazing conducted 5. Analyse the influence of grazing 6. Adjust grazing to where it is needed the most
IMPLEMENTATION PERIOD TIMELINE	Every year 01.11.-01.05.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	Own funds, national funds and EU funds Sheep rental - 18.000€ Hay for sheep - 1.600€
EXPECTED RESULTS / MONITORING	Through sheep grazing the grasslands should be restored and kept in a satisfying state. Prevention of encroachment of protected grasslands, and grazing adjusted yearly based on the needs of each area of protected grasslands.

ACTION 8	
TITLE OF THE ACTION	Protection and conservation of cultural and traditional heritage through dry stonewall building workshops
DESCRIPTION	The system of dry stonewalls is to be renewed and included in the visitor infrastructure and workshops will be held to raise awareness of the local community and visitors about traditional heritage.
SPECIFIC OBJECTIVES	The restoration and maintenance of dry stonewalls, specific habitat creation, heritage narrative objective fulfillment
PROJECT MANAGEMENT TOOLS	Workshops, maintenance of existing dry stonewalls, exhibitions
RESPONSIBLE DEPARTMENT	Expert service
INVOLVED STAKEHOLDERS	Local community, visitors, dry stonewall experts, kindergartens, schools, NGOs, students
IMPLEMENTATION STEPS	<ol style="list-style-type: none"> 1. Decide where/identify where to hold workshops and restore dry stone walls 2. Workshops for dry stonewall building held 3. Dry stonewalls built 4. Dry stonewalls included in the visitor infrastructure



IMPLEMENTATION PERIOD TIMELINE	Every year 01.03.-01.05.
POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	Own funds, national funds, EU funds Dry stonewall building workshop - 3,000€ Stones for building - 1,500€
EXPECTED RESULTS / MONITORING	Dry stonewalls will provide habitats for specific ecosystems, enhance the image of the protected area, raise awareness of the local community and visitors, and educate them about traditional heritage and specific habitat importance.

9. Zone Plan

There can be no new usage for existing functional zones since the Plan for management of protected areas and ecological network of the Municipality of Medulin was implemented in 2025. and will last until 2034. and functional zone usage is clearly stated in it and declared by the Council of the Municipality of Medulin.

1. **Initial situation and state analysis** - information was extracted from the Plan for management of protected areas and ecological network of the Municipality of Medulin 2025. - 2034.

- **Previous purpose of the area** - i.e., agriculture, grazing, forest, recreation, economic purpose, military purpose
- **Protected values of the area** - habitats, species, relief, landscape, shore, sea and seabed, underground layers
- Through directions for management of the protected area, zoning is conducted considering the level of human activity influence and the need to preserve values
- State of infrastructure and communal systems - traffic, water supply, sewage, electrical grid, accessibility, transportation
- Known problems and conditions - too high visitor numbers during the three to four summer months, while the numbers are a lot lower for the rest of the year

2. **Definition of goals and interest groups**

2.1 Goals

- Preservation and protection of natural values (geological, landscape, biodiversity)
- Activation and valorization of space for new purposes - can be educational, tourist, research, recreational, social, cultural, or ecological
- Integration of local community and economic activities, which are in accordance with the protection of the area
- Long-term sustainable management and financing of the area
- Improvement of infrastructure and accessibility of the area, but without breaking the terms of conservation

2.2 Interested parties

- Local community (inhabitants, land users)



- Protected area manager (Public institution of Kamenjak)
- Competent institutions for nature protection and spatial management
- Economic subjects that would participate in the new purposes
- Environmental experts, planning and infrastructure experts
- Civil society organisations, nature protection organisations, universities/institutes

3. Functional zoning

3.1 Existing functional zones

The categories and titles of zones and subzones are harmonized with the Guidelines for Management Planning of Protected Areas and/or Ecological Network Areas (MINGOR, 2020).

According to the standard zoning framework, three primary management zones are defined: the Strict Protection Zone (Zone I), the Directed Protection Zone (Zone II), and the Use Zone (Zone III).

Given the protection categories of the protected areas within the Municipality of Medulin (park forests and significant landscapes), as well as the absence of ecosystems unaffected by human activity, the zoning system does not include a Strict Protection Zone.

According to the Plan for management of protected areas and ecological network in the Municipality of Medulin 2025-2034, Zone II and Zone III include the following:

Zone II. or the Directed protection zone, encompasses areas of high importance for conservation where significant engagement by the Institution is expected for the purpose of preserving or restoring the natural values of the area.

This zone includes areas which, without the implementation of active conservation and/or revitalization measures, would change their essential characteristics, either through a reduction in biodiversity or a decrease in landscape diversity.

The management objective within this zone is the preservation and/or improvement of the state of biodiversity, geodiversity, cultural heritage, and landscape diversity.

General guidelines for Zone II - Directed Protection:

- The Public Institution conducts scientific research, monitors the condition of natural values, supervises the area, and implements active measures aimed at conserving and improving the condition of ecosystems, geosites, and cultural heritage.
- The introduction and spread of alien and invasive alien species must be prevented.
- Visitation is permitted subject to compliance with the specific regulations of the Public Institution and the corresponding conditions prescribed therein, depending on the protection objectives.
- In order to reduce pressure on natural and cultural values, the establishment of minimal interpretative and educational facilities, as well as access trails that do not require construction works, is permitted, except for activities necessary to maintain visitor safety (fencing, removal of hazardous trees along trails, etc.).
- Interventions in the area are permitted exclusively if they serve the purpose of implementing active measures aimed at conserving and improving the condition of ecosystems, geosites, cultural and



historical sites, and cultural landscapes, as well as installing/maintaining minimal educational and interpretative facilities.

- For all interventions within designated significant landscapes, it is necessary to obtain authorization with nature protection conditions from the competent authority in accordance with the Nature Protection Act.

Zone III. or the Usage zone generally encompasses areas of lower conservation value and/or areas where a certain degree of traditional use has historically been present.

The management objective of this zone is the sustainable use of space, in accordance with the goals of preserving the biological and landscape diversity of the area.

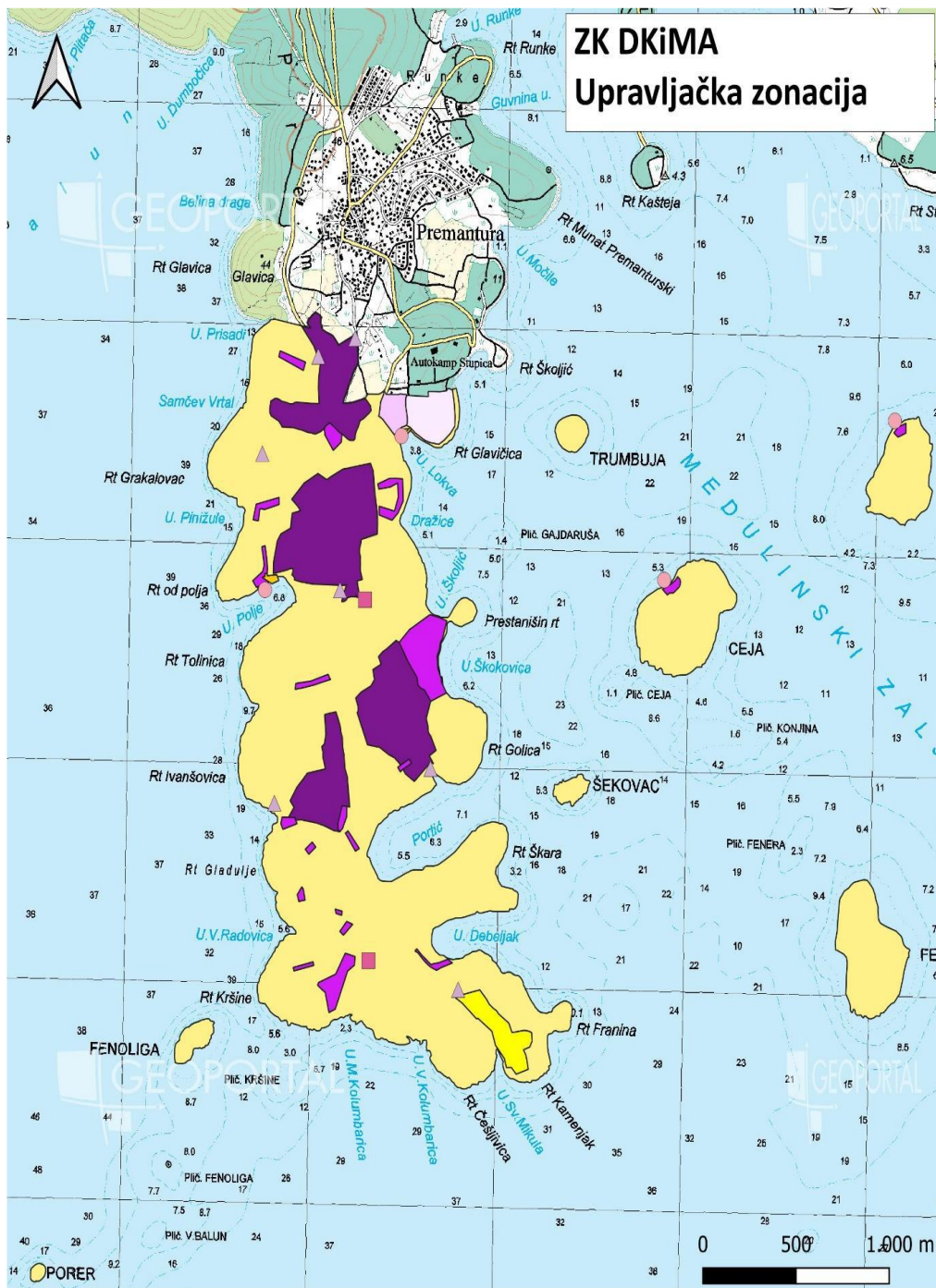
Its use must be consistent with the principles of sustainable development, without compromising the purpose of the protected area or jeopardizing the conservation objectives defined in the management plan.

General guidelines for Zone III - Use Zone:

- Within this zone, it is primarily necessary to ensure compliance with all legal provisions and prescribed nature protection conditions that prevent negative impacts of land use on the features for which the area was designated as protected.
- Agricultural activities may be permitted in this zone, provided they are carried out in accordance with the objectives of conserving the natural and cultural values of the protected area and in compliance with the prescribed conservation measures.
- For all interventions within designated significant landscapes, it is necessary to obtain authorization with nature protection conditions from the competent authority in accordance with the Nature Protection Act.



HUMANITA



- | | |
|--|--|
| Tumač oznaka | IIc Podzona ugostiteljske infrastrukture |
| IIa Podzona očuvanja vrsta i staništa | IIIf Podzona naselja |
| IIb Podzona restauracije staništa | IIIfb Podzona posjetiteljske infrastrukture i rekreacije |
| IIc Podzona nematerijalne kulturne baštine | IIId Podzona objekata različite namjene |
| IIla Podzona poljoprivrednih površina | IIle Podzona luka i pristana |
| IIIfb Podzona posjetiteljske infrastrukture i rekreacije | |

Figure 14. Cartographic presentation of management zones and subzones for the area of Lower Kamenjak and the Medulin archipelago (Source: Plan for managing protected areas and ecological network in the Municipality of Medulin 2025-2034)



10. Remarks and Conclusions

The local action plan for tracking and resolving conflicts between humans and nature in the pilot area of Lower Kamenjak and the Medulin archipelago represents an important step toward sustainable management of this unique landscape. Through the conducted activities of the HUMANITA project, a comprehensive framework has been established for monitoring the state of biodiversity, tourism pressures, and the effectiveness of existing protection measures.

Monitoring results have shown a clear need for a continued and systematic approach - especially in segments of visitor management, waste management and invasive species tracking. The introduction of new technologies (drones, digital counters, and the iNaturalist app) has significantly improved data gathering and management transparency, while the inclusion of the local community and visitors contributes to a sense of collective responsibility to preserve the area.

Planned measures and activities, like zone formation, educational infrastructure development and the integration of new forms of environmental indicators tracking, ensure a long-term harmonization between touristic development and natural values preservation. That all sets the basis for a management model which is sustainable in other protected areas in Croatia and wider.

The key to the success of this plan lies in the continuation of cooperation between all stakeholders - public institutions, local community, scientific organisations, and visitors. Systematic tracking, evaluation of implementation, and adjustment of measures according to new findings will be necessary to achieve wanted protection goals and a sustainable use of the area.

To conclude, tourism in the Lower Kamenjak area and the Medulin archipelago has a significant influence on nature, but at the same time provides a possibility of development of sustainable practices which can become a model for other protected areas in Croatia and also other countries. The goal for a successful and sustainable management of the area is to harmonize tourist activities with nature protection goals.