



# Capo Carbonara Marine Protected Area

## Municipality of Villasimius

### Sardinia – Italy

Identification and assessment of the main coastal  
tourism-related issues concerning climate change

#### The Consortium:



Project Information	
Project Acronym	NaTour4CChange
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Version	Date	Contributors



## Project Overview

The Mediterranean region is one of the most vulnerable hotspots in the current biodiversity and climate crises, warming 20% faster than the global average and being the second biodiversity hotspot in the world. The increase of severe climate events is also likely to influence the choice of destinations and time to travel for its over 510 million inhabitants. The effects of climate change will put additional pressure on already strained ecosystems and vulnerable economies and societies, with Tourism being one of the most affected economic sectors.

The recent Transition Pathway for Tourism and the Glasgow Declaration are building a global momentum for Climate Action in Tourism, but policymakers and destinations need support to better develop efficient climate mitigation and adaptation policies using ecosystem-based approaches and improved multi-level governance structures, including robust planning and ensure the long-term engagement of the private sector and citizens. Indeed, ecosystem-based management is considered a good practice to effectively deal with these threats as it considers the different stakeholders and factors affecting ecosystems and the mechanisms involved, in order to find solutions.

NaTour4CChange builds on and capitalises on successful experiences at the Mediterranean and global level to test solutions for increasing the resilience of coastal destinations in the Mediterranean. The project will aim to set common methods to allow participating regions to assess their tourism-related climate adaptation and mitigation priorities, and take climate action via plans and strategies, supported by cooperative governance.

In coastal destinations, cross-sector teams will deliver specific tourism climate Action Plans, focusing on climate adaptation, where Nature-based Solutions (NbS) will be tested to ensure their feasibility. At the same time, innovative destination marketing and communication approaches will engage private stakeholders, visitors, and residents in climate action.

The project will also ensure cross-fertilisation among participating regions and destinations, to achieve common methods and to compare the different tested plans and solutions, leading to lessons, best practices, and policy.



## Glossary

Climate Change Adaptation (CCA) means anticipating the adverse effects of climate change and taking appropriate measures to prevent or minimise the damage they may cause, or to take advantage of the opportunities that may arise.

Climate Change Mitigation (CCM) means making the impacts of climate change less severe by reducing the sources of emission of greenhouse gases (GHG) into the atmosphere or by improving the storage of these gases.

Ecosystem Services (ES) are the benefits that an ecosystem brings to society and that improve people's health, economy, and quality of life.

Ecosystem-based Approaches (EbA) focus on managing biodiversity and ecological systems in a holistic way to maintain and enhance ecosystem services benefits and functions.

Nature-based Solutions (NbS) encompasses all actions that rely on ecosystems and the services they provide to respond to various societal challenges such as climate change, food security, resource management, or disaster risk.



## 1. INTRODUCTION:

### 1.1 LOCAL CONTEXT AND SPECIFICITIES

Tourism is one of the main economic sectors in Sardinia, driving growth and employment for the island while contributing to economic and social development and integration. Regional policy aims to maintain Sardinia as a leading tourist destination through a new strategy and action plan focused on three key objectives: enhancing the sector's competitiveness, promoting sustainable tourism development, and strengthening the island's image as a high-quality destination. This involves building greater resilience in the industry, promoting more environmentally friendly tourism, and implementing legislative initiatives related to environmental protection and climate neutrality. Therefore, climate change mitigation and adaptation measures should always be integrated into sustainable tourism strategies at national, regional, and local levels. In this context, the municipality of Villasimius is one of the most sought-after destinations for tourists, especially during the summer months. Villasimius is the managing authority of the Capo Carbonara Marine Protected Area (AMPCC), which covers approximately 5,800 hectares (58 km<sup>2</sup>) and includes a coastal strip of about 40 kilometers, encompassing several islands. Located in southeastern Sardinia, Villasimius has around 3,700 residents, but during peak tourist months (July and August), the population can reach an average of 50,000 per day, totaling approximately 1,000,000 visitors between June and September. One of the greatest strengths of both the region and the municipality of Villasimius is its exceptional environmental value: numerous beaches and coastal areas are internationally renowned for their scenic beauty and high-water quality. Over the past twenty years, the municipality of Villasimius has promoted and implemented concrete initiatives for sustainable local development, recognizing that the continuity of tourism depends on the protection and enhancement of natural resources. The establishment of the Capo Carbonara Marine Protected Area is one of the most significant achievements of this commitment and a fundamental tool for building a culture of sustainability while promoting durable and responsible tourism development models. In addition to the presence of the Capo Carbonara Marine Protected Area, examples of good practices include:

- A modern wastewater treatment plant used also for the reuse of wastewater;
- Effective waste management;
- Thanks to the "Acqua Nostra" Project for the Enhancement of Public Water (PO-FESR 2007-2013), the potabilization of water from local springs channeled into three public fountains and drinking water dispensers located at the municipality offices, the Capo Carbonara Marine Protected Area, the Environmental Education and Sustainability Center (CEAS), and at schools (preschool and elementary);



- Implementation of projects for the protection of the territory and marine-coastal environments.

Despite the municipality's commitment to preserving and enhancing the area's high environmental value, the heavy influx of tourists presents considerable challenges. The high anthropogenic pressure, primarily concentrated in the summer months, can negatively impact marine-coastal biodiversity, especially due to tourism activities that are not always sustainable.

There is a kind of conflict: while tourism is essential for economic growth, it can also affect natural areas.

Paradoxically, an area with a strong natural vocation, certified by the presence of the Marine Protected Area (AMP) and the Site of Community Importance (SIC), which have enabled significant ecosystem conservation projects, remains subject to intense anthropogenic pressure.

The intense use of natural resources results in significant environmental impacts, making the Villasimius area vulnerable, especially during certain times of the year. The main challenges include the loss or alteration of biodiversity, excessive water consumption, overcrowding beyond the carrying capacity of coastal areas, potential beach degradation, increased waste production, and higher traffic levels.

### CAPO CARBONARA MARINE PROTECTED AREA (CCMPA)

The Capo Carbonara Marine Protected Area, managed by the municipality of Villasimius, was initially established by the Ministerial Decree of September 15, 1998. Later, on August 3, 1999, a new decree was issued, which fully replaced the previous one, absorbing all its effects up to that point.

In addition to being considered a prestigious area to protect at the national level, it was also recognized as a Specially Protected Area of Mediterranean Importance (ASPIM) within the framework of the Barcelona Convention (Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean - ASP/DB Protocol).

Located in the southeastern part of Sardinia, the Marine Protected Area covers approximately 14,360 hectares and includes about 40 km of coastline, of which 7 km are sandy beaches and 2 km are rocky beaches. Overall, Villasimius has 22 beaches. The marine area spans 8,598 hectares and extends from Capo Boi to the west, in the western sector, to Punta Is Proceddus to the northeast, the Secca di Libeccio to the south, and also includes the coastline of the two main islands, Cavoli and Serpentara, several rocky islets, and submerged cliffs scattered along the coast and the main islands (Figure 1).

Inside the area, there are priority habitats included in the Natura 2000 Network, such as the meadows of *Posidonia oceanica* (posidonia meadows) and the coastal dunes with junipers. These habitats host high biodiversity and are essential elements of the coastal system, influencing the balance of the beaches. Their physical and biotic components determine the morphodynamic



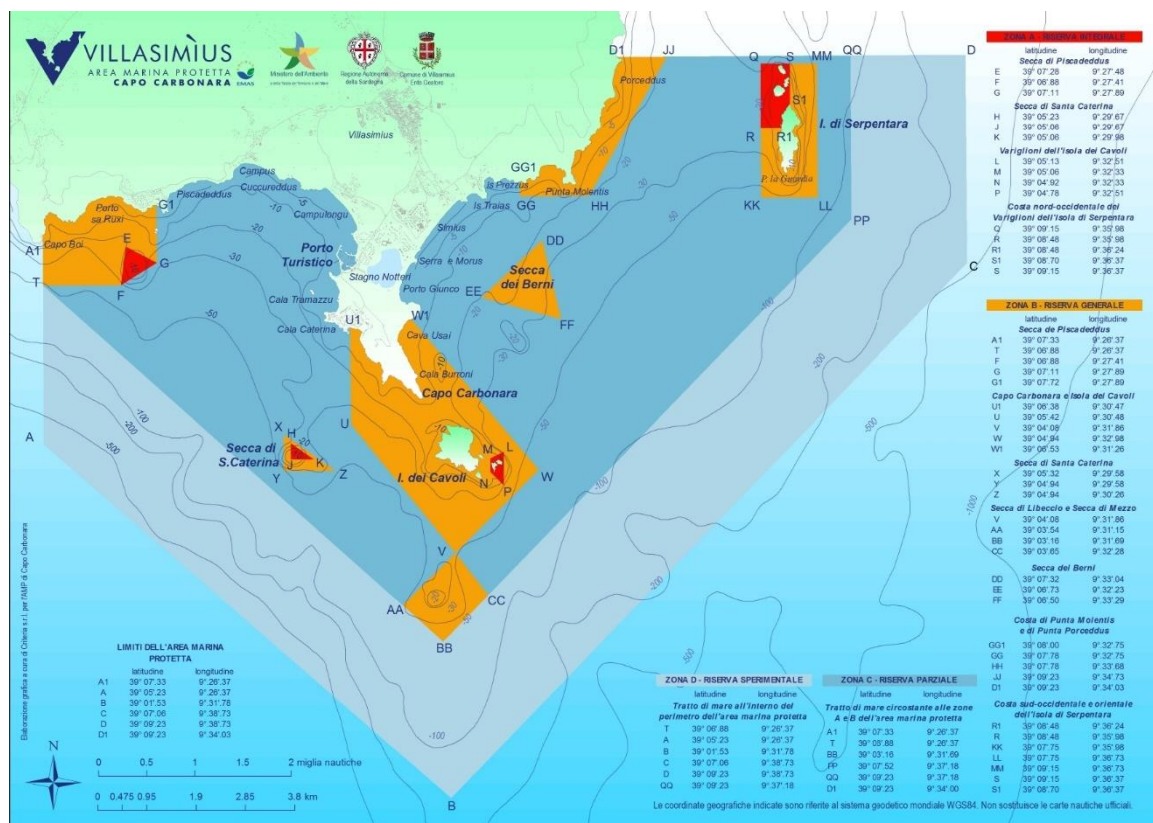


FIGURE 1. MAP OF THE ZONING OF THE CAPO CARBONARA MARINE PROTECTED AREA.

equilibrium, which regulates the evolution and stability of coastal environments.

These habitats are particularly fragile and vulnerable to disturbance caused by human activities, especially tourism-related ones, such as anchoring in *Posidonia oceanica* meadows or trampling on sandy dunes. In the past, due to anthropogenic pressure, the dune system has suffered significant degradation, almost disappearing in some areas.

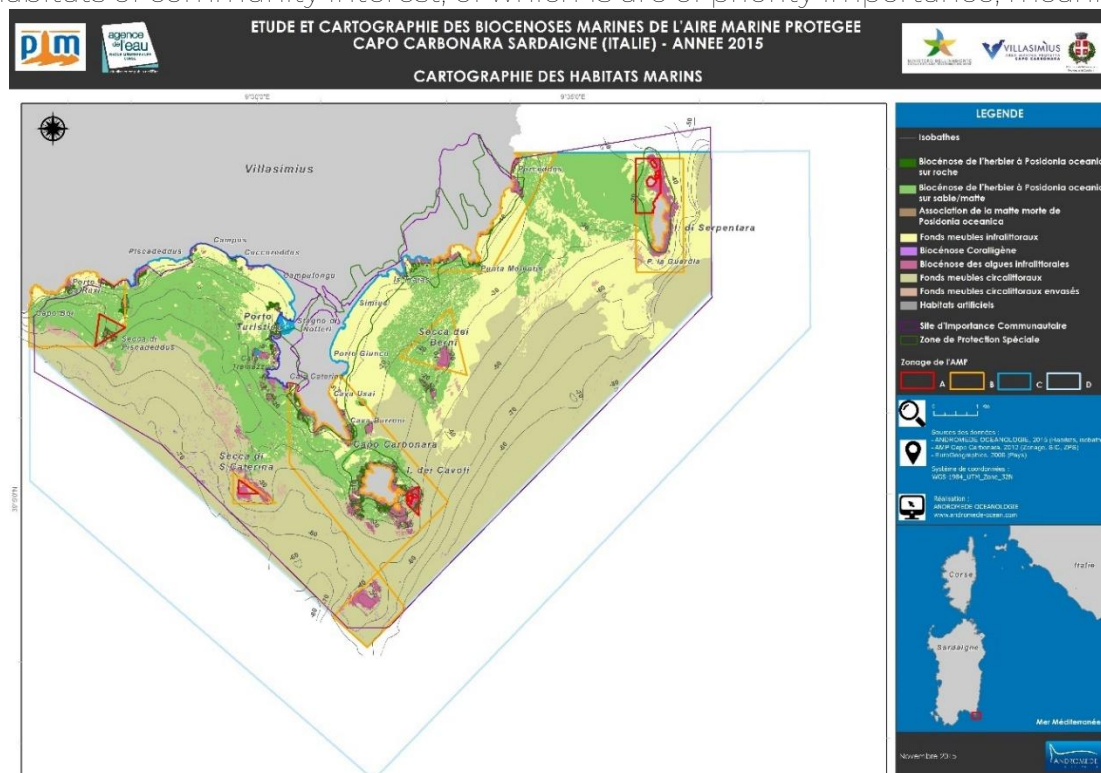
The *Posidonia oceanica* meadows cover about 2,500 hectares and colonize the seabed from a few meters to 40 meters deep (in green in Figure 2). In general, they are in good health, with a compact and continuous structure, except in some more frequently visited areas where signs of degradation and discontinuity are observed.

Regarding marine fauna, the AMPCC is home to species typical of the seas of Sardinia, both in rocky seabeds, which predominate in the area, and in sandier ones. To name just a few: the octopus (*Octopus vulgaris*), the gastropod mollusk *Dendropoma* (*Dendropoma petraeum*), the sea urchin (*Paracentrotus lividus*), the lobster (*Palinurus elephas*), the red gorgonian (*Paramuricea clavata*), and the yellow gorgonian (*Eunicella cavolini*). Among fish species, there are the gilt-head bream (*Oblada melanura*), dentex (*Dentex dentex*), amberjack (*Seriola dumerili*), common grouper (*Chelidonichthys lucerna*), moray eel (*Muraena helena*), flathead mullet (*Mugil cephalus*), gilthead bream (*Sparus aurata*), common corvina (*Sciaena umbra*), various species of groupers (*Epinephelus marginatus*, *Epinephelus costae*, *Mycteroperca rubra*), and some species of

spiards (*Diplodus spp.*). Among mammals, in addition to the frequent presence of bottlenose dolphins (*Tursiops truncatus*), it is possible to spot striped dolphins (*Stenella coeruleoalba*), sperm whales (*Physeter macrocephalus*), and Risso's dolphins (*Grampus griseus*). The presence of these habitats and species confirms the quality of the marine waters and the absolute need to enhance their protection.

## NATURA 2000 NETWORK: SCI AND SPA IN THE MUNICIPALITY OF VILLASIMIUS

The Natura 2000 Network in Sardinia currently consists of 32 Special Protection Areas (SPAs) and 93 Sites of Community Importance (SCI), and it includes 52 habitats of community interest, of which 13 are of priority importance, meaning



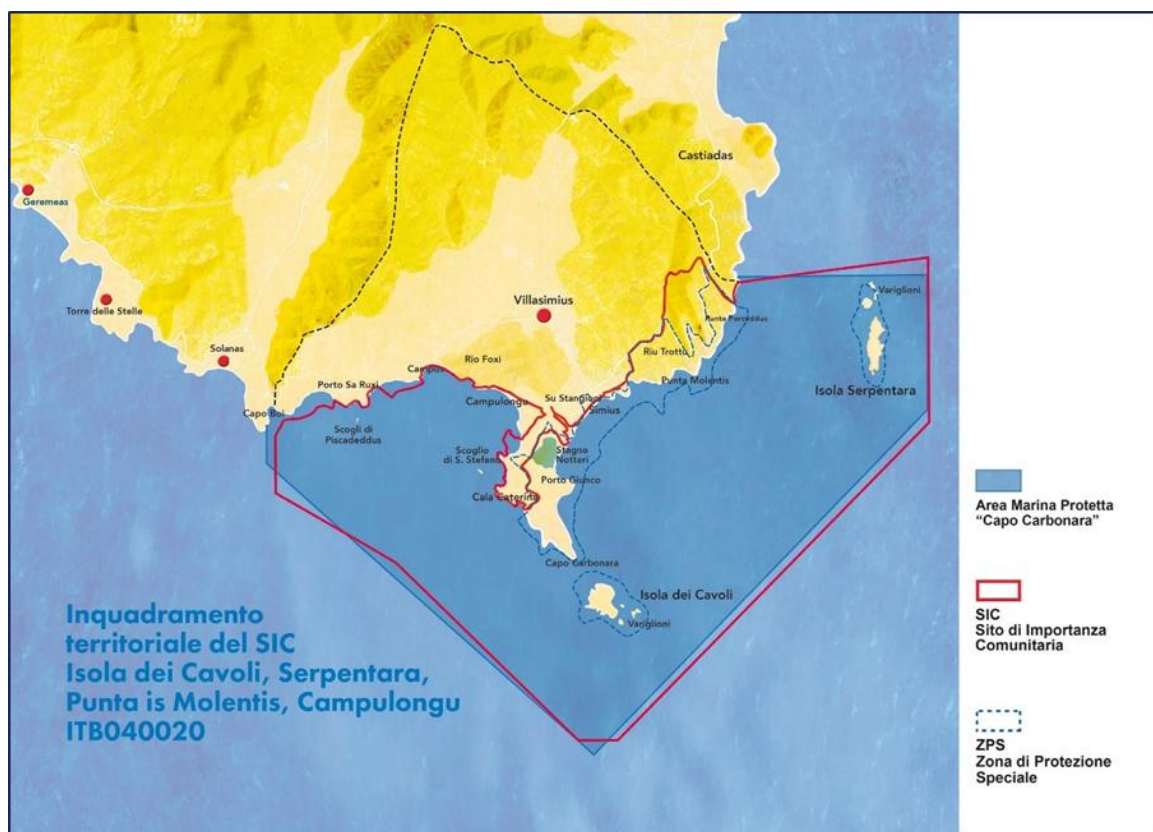
**FIGURE 2. MAP OF THE BIOTIC COMMUNITIES WITHIN THE CAPO CARBONARA MARINE PROTECTED AREA.**

they are at high risk of disappearing.

Within the territory of the Municipality of Villasimius, there are two Sites of Community Importance and three Special Protection Areas.

The perimeter of the MPA almost entirely coincides with the Site of Community Importance "Isola dei Cavoli, Serpentara, Punta Molentis, and Campulungu" (ITB040020), which covers 15,183 hectares, 95% of which represents the marine area (Figure 3).

The SCI protects one of the most important marine-coastal sites in the Natura 2000 Network of Sardinia and includes 22 habitats of community interest (19 on land and 3 in the sea), 5 of which are priority habitats.



**FIGURE 3. SCI OF CAVOLI AND SERPENTARA ISLANDS, PUNTA MOLENTIS AND CAMPULONGU.**

It includes the islands of Cavoli and Serpentara, the Notteri Lagoon, and the coastal area stretching from Campulongu to Punta Molentis and up to Punta Is Porceddus. The Island of Cavoli is located at the extension of the Capo Carbonara promontory, about 700 meters from it, while the Island of Serpentara is situated north of Punta Molentis, at the northernmost tip of the site, a little over 3 km from the coast.

The three Special Protection Areas are incorporated within the SCI ITB040020 and are: Island of Serpentara (ITB043026), Island of Cavoli (ITB043027), and the coastal/wetland area "Capo Carbonara, Notteri Lagoon, and Punta Molentis," covering 876 hectares (ITB043028).

The SCI "Costa di Cagliari" (ITB040021) includes the territory of Villasimius only in part, in its western portion.



Directive	Nature 2000 CODE	Area (ha)	Sea %	Protected species	Protected habitats
SCI	ITB040020	15183.00	95	26	22
SCI	ITB040021	1.010	4	19	13
SPA	ITB043026	134	72	10	5
SPA	ITB043027	173	72	10	6
SPA	ITB043028	867	45	21	19

**TABLE 1. NATURA 2000 PROTECTED AREAS WITHIN THE TERRITORY OF VILLASIMIUS.**

<https://eunis.eea.europa.eu/sites>

### Marine habitats

Within the CCMPA/SCI - ITB040020, two important marine environments are present, which the Habitat Directive identifies as worthy of protection and conservation: the "Posidonia meadows" and the "reefs."

Posidonia meadows - Priority Habitat 1120\* "Posidonia meadows (*Posidonia oceanica*)" - extend from the surface to about 40 meters in depth, both on sandy and rocky bottoms. Characterized by high biodiversity, they are essential for oxygen production, the stability of the seabed, and for damping wave action, limiting coastal erosion. It is the largest habitat, occupying 22% of the total area of the SCI.

Habitat 1170 "Reefs": this habitat consists of a complex of plant and animal communities that colonize hard, compact substrates. They host a rich variety of plant and animal communities of particular significance to the typical Mediterranean biodiversity. Included in this category are the coralligenous bottoms, characterized by the growth of calcareous algae that form complex, three-dimensional structures. This ecosystem, which develops between 30 and 120 meters in depth, plays a fundamental role in marine biodiversity by providing shelter and breeding grounds for numerous fish species, crustaceans, mollusks, and other invertebrates. Moreover, the coralligenous habitat significantly contributes to carbon fixation and the stability of the seabed, combating erosion and promoting the maintenance of marine ecosystem productivity. However, it is a fragile habitat threatened by human activities such as trawling, pollution, and climate change, making its conservation through protective measures and sustainable management essential.

### Marine Habitats critical issues

Among the critical issues that have emerged in recent years the most concerning is the issue of anchorage, which can lead to the alteration and fragmentation of habitats, particularly those on *Posidonia oceanica*, but also on rocky substrates. In areas most frequented by recreational boaters, clear signs of mechanical abrasion are observed.





Another critical issue that could develop into a significant problem over time is the presence of invasive alien species. Specifically, in relation to the *Posidonia oceanica* meadows, the invasive species *Caulerpa racemosa* var. *cylindracea* and *Caulerpa prolifera* have been detected in certain areas. If these species become widespread, they could pose a threat to local biodiversity. Finally, another form of anthropogenic disturbance comes from abandoned fishing gear, particularly fishing lines and pots, which have been found in several areas of the marine area.

### Terrestrial habitats located on the coast and Cavoli e Serpentara Islands

The coastal environment is characterized by long quartz beaches separated by rocky promontories and granite cliffs. Near Porto Giunco beach lies the Stagno di Notteri (SPA), a 34-hectare wetland area behind the dunes. The coastal environments, islands, and islets are important for the nesting of at least 10 species of marine and aquatic birds, as well as a strategic location within the migratory routes of 40 species. Additionally, they are the habitat for 11 species of reptiles and 2 species of amphibians, all of which are important biological indicators of the conservation status of the SCI.

Among the many habitats found in this area, some of the typical coastal zone habitats include:

- Cakileto (Habitat 1210 – "Annual vegetation of marine deposit lines"), distinguished by the presence of pioneering plant species.
- Halophilic habitats, such as *Ruppieto* (priority habitat 1150 – "Coastal lagoons") or *Agropireto* (Habitat 2110 – "Embryonic shifting dunes"), which are typical of maritime dune environments.

The high-natural-value plants that comprise the SCI's flora include more than 20 endemic species, which are mostly found on the islands. The Island of Cavoli alone is host to one of Sardinia's most significant wild cabbage populations, *Brassica insularis* species, the only plant in the SCI listed in Annex II of the Habitats Directive (92/43/EEC). On Serpentara Island, there are two endemic species: *Ferula arrigonii*, a Sardinian-Corsican endemic, and *Silene valsecchiae*, endemic to eastern Sardinia. Other notable species include *Scrophularia trifoliata*, the Tyrrhenian birthwort (*Aristolochia tyrrhena*), the three-lobed toadflax (*Cymbalaria aequitriloba* ssp. *aequitriloba*), and the clustered-flower thistle (*Carduus fasciculiflorus*). Meanwhile, the dead horse arum (*Helicodiceros muscivorus*), the Sardinian-Corsican bryony (*Bryonia marmorata*), and the Sardinian mullein (*Verbascum conocarpum* ssp. *conocarpum*) are found on both islands. Another endemic species, *Limonium retirameum*, is distributed along the whole coastal strip.

Among the numerous bird species present in the area, the avifauna includes 10 nesting species, 14 species of aquatic birds in wetland areas, and 40 migratory species. Among the species that nest on cliffs, there are the peregrine falcon (*Falco peregrinus*), Scopoli's shearwater (*Calonectris diomedea*), Yelkouan shearwater (*Puffinus yelkouan*), and the European shag (*Phalacrocorax aristotelis*). In the wetland areas, the species observed include the common



kingfisher (*Alcedo atthis*), the purple swamphen (*Porphyrio porphyrio*), the black-winged stilt (*Himantopus himantopus*), and the Kentish plover (*Charadrius alexandrinus*).

Regarding amphibians and reptiles, Villasimius is home to 13 species, including the Italian green toad (*Bufo balearicus*) and the Sardinian tree frog (*Hyla sarda*), both endemic to the Tyrrhenian region. Among the 11 reptile species found along the coast, on the islands of Serpentara, Cavoli, and other islets, three notable endemics are present: Fitzinger's algyroides (*Algyroides fitzingeri*), one of the smallest living lizards in the world; the European leaf-toed gecko (*Euleptes europaea*); and the Tyrrhenian wall lizard (*Podarcis tiliguerta*), endemic to Sardinia and Corsica.

### Terrestrial Habitats critical issues

In the specific territory of Villasimius, some of the main critical issues, particularly related to past decisions, include the destruction and subsequent loss of dune environments. Urbanization, intensive use of coastal areas for tourism and recreational purposes, and the construction of the "Marina di Villasimius" harbor have been among the main causes of the reduction of many of these zones, which were widely developed until the 1950s and are now extremely at risk. Furthermore, activities such as trampling, which causes uprooting or weakening of the existing flora, shell and sand collection, and soil compaction lead to direct damage to this type of ecosystem. The presence of alien and invasive species significantly contributes to creating ecological imbalances in plant and animal communities. These species, often lacking natural predators, compete with local species for resources, reducing biodiversity and altering the structure of ecosystems.

### CEAS AMP CAPO CARBONARA, THE ENVIRONMENTAL EDUCATION AND SUSTAINABILITY CENTER (EESC)

The Environmental Education and Sustainability Center (EESC) operates within the territory, supporting the Marine Protected Area of Capo Carbonara (CCMPA). It is part of the Regional Network of Environmental Education Centers of Sardinia (INFEAS Network). Environmental Education and Sustainability (EES) are crucial tools for raising awareness among citizens of all ages and communities, fostering greater responsibility and attention toward environmental issues and good governance. The center's mission is to encourage behavioral and lifestyle changes through conscious and environmentally respectful choices. The EESC plays a key role in the region by promoting knowledge about the coastal marine environment, advocating for sustainable and responsible environmental behaviors, and raising awareness of the importance of the Marine Protected Area (MPA). Since its founding in 2000, the EESC has been implementing Environmental Awareness and Sustainability (EAS) initiatives that address a wide range of environmental issues, including biodiversity conservation and protection, care for common goods, active global



citizenship, sustainable environmental practices, climate change and adaptation, coastal erosion, dune system degradation, and the threat of invasive alien species.

## VILLASIMIUS: CONNECTIONS, SERVICES, AND TOURISM INFRASTRUCTURE

Villasimius is located about fifty kilometers from Cagliari, the capital of Sardinia, and is connected by a scenic coastal road, SP17, or via a faster road, SS125var. Additionally, to reach Villasimius from the center of Cagliari, you can take the ARST bus: the route runs more frequently during the summer season (line 135, from June 16 to September 15) and less frequently during the rest of the year (line 101, from September 16 to June 15). For those arriving in Cagliari by ferry, the port is conveniently located in the city center, offering easy access to the necessary services. Alternatively, those arriving by plane can reach the center of Cagliari from the airport by train (with frequent service), by renting a car, or by using a private shuttle or taxi.

During the summer season, a paid shuttle service is available for transportation between the town and the beaches as well as the "Marina di Villasimius" port. The shuttle operates daily with hourly departures. Most of the beaches have paid parking. The beaches of Villasimius are partly free to access, while others are managed by beach establishments that offer paid services, such as umbrella and sunbed rentals, as well as food and beverage sales. There are also two bike lanes that connect the town to the main beaches.

The accommodation facilities in the municipal territory include 30 guesthouses, 45 hotels, 8 residential hotels, 22 bed and breakfasts, a campsite, and a designated area for camper parking. In total, there are 16,333 beds, of which 7,775 are in hotels, 8,431 in non-hotel establishments, and 127 in B&Bs. Additionally, many homeowners offer alternative lodging services in their properties, such as short-term rentals and Airbnb.

In addition to the tourists staying at local accommodations, Villasimius also experiences the impact of many day-trippers who arrive by car from Cagliari and nearby towns.

A few kilometers from the center of Villasimius, within the Capo Carbonara Marine Protected Area, is the "Marina di Villasimius" tourist port. This port spans 72,000 square meters of water, with a maximum depth of 6.5 meters. It is equipped with 17 docks, 2 piers, and 840 boat slips. It can accommodate vessels up to 60 meters in length and is fully serviced, including a shopping center and a boatyard. Furthermore, the port offers various recreational and leisure services authorized by the AMP Capo Carbonara, such as rental of inflatable boats, boats offering tours within the AMP, diving centers, sailing schools, and fishing tourism.

Some areas located further inland (within the municipal territory but not specifically coastal) are dedicated to agro-pastoral activities and agricultural production, including cheese and wine production.



## Local climate

The regional climate is typically Mediterranean. During the winter season, frequent depressions moving from the Atlantic inland, towards the east, cause variable, mild, and humid weather with high rainfall. In the summer, weak and infrequent depressions from the Atlantic move to the north or south of the Mediterranean, resulting in hot and dry summers with many months of drought and maximum solar radiation. The annual precipitation regime is generally between 500 and 900 mm of rain, mostly concentrated from October to April. The dry period varies depending on the area but is always prolonged. Winters are mild, with average temperatures in the coldest month typically ranging from 5 to 15°C, and only rarely do temperatures drop below zero. In summer, average temperatures are normally high, and during July and August, the daytime air temperature can exceed 30°C, with the ground temperature at points of highest solar exposure becoming very elevated. As a result of the temperature patterns, evapotranspiration values are low in the winter season and high in the summer season, in contrast with the precipitation trends. This condition leads to a water imbalance, with a surplus of water during the wettest period and an accentuated deficit during the hot period. Other factors influencing the climate include solar radiation, heliophany (clear skies and few clouds in the summer season), and wind, which, particularly in insular areas such as Sardinia, significantly affects the climate.

### 1.2 THE MAIN IMPACTS OF TOURISM ON THE LOCAL ENVIRONMENT

Coastal beach tourism, despite being the main source of income for most Sardinian localities, can also become, without sustainable and conscious management, one of the main factors of environmental pressure and impact. Its development can have significant effects on various ecological components. The main visible impacts can be analyzed in relation to biodiversity, soil, water, air, and climate. Specifically, it can affect:

- **Loss of Biodiversity Due to Coastal Ecosystem Degradation**

The increase in tourism activities along the coasts puts significant pressure on coastal ecosystems. The growing demand for tourism has led to the construction of new infrastructure, tourist facilities, and residential buildings, which can alter the natural balance of the shoreline and accelerate erosion. This phenomenon is exacerbated by the reduction of protective dune vegetation, increasing the coastline's vulnerability to extreme weather events. Coastal dunes, which are crucial for shoreline protection and biodiversity conservation, are particularly exposed to urbanization and trampling. Marine ecosystems also suffer from these pressures, especially Posidonia seagrass meadows, which play a vital role in coastal protection and water quality. Unregulated anchoring of boats in these areas causes irreversible damage to this essential habitat, which supports marine biodiversity and stabilizes coastal currents.





- Increase in Water Consumption

Tourism leads to a significant increase in water demand, especially during the summer season. Hotels, restaurants, and tourist infrastructure require intensive use of water resources, which can result in a depletion of local drinking water reserves. In many tourist destinations, water resource management becomes critical, particularly during peak season when the tourist population increases exponentially.

- Land Use

Overtourism and overcrowding of beaches during peak seasonal months, particularly in July and August, lead to excessive pressure on coastal areas. This results in habitat loss, soil compaction, and a reduction in the natural regeneration capacity of ecosystems. Infrastructure developed to accommodate tourists, such as parking lots and accommodations, further contributes to the loss of natural land and habitat fragmentation.

- Increase in Pollution

Tourism-related pollution manifests in multiple forms, negatively impacting the environment and local ecosystems. Air pollution from vehicle traffic and the intensive use of transport to reach tourist destinations leads to increased greenhouse gas emissions and air pollutants, contributing to global warming and deteriorating air quality, with repercussions on both human health and the environment.

At the same time, the influx of tourists leads to a significant increase in waste production. If waste management is ineffective during peak season, the risk of plastic and other pollutants being abandoned on beaches increases, severely harming the marine ecosystem. Marine litter poses a direct threat to wildlife, such as seabirds and sea turtles, and contributes to water contamination.

Noise and light pollution are also significant issues in coastal areas. The increase in recreational and tourist activities can disturb local animal species, while light pollution from tourist facilities can disrupt the natural behaviors of sensitive species, such as sea turtles, which rely on natural light for orientation.

- Climate Change

The rise in tourism activity indirectly contributes to climate change, primarily through the use of fossil fuels for long-distance travel. As a result, tourism can intensify greenhouse gas emissions and contribute to global warming, with potentially devastating effects on coastal ecosystems, such as rising sea levels and changing weather patterns.



## 1.3 STRATEGIC AND REGULATORY FRAMEWORK FOR REGIONAL AND LOCAL POLICIES RELATED TO CLIMATE ACTION AND TOURISM

### REGIONAL LEVEL

The Sardinian Regional Strategy for Sustainable Development (SRSvS), the Regional Climate Change Adaptation Strategy (SRACC), and the Regional Strategic Tourism Plan 2023-2025 (RSTP) serve as the key strategic and regulatory frameworks guiding regional, local, and sectoral policies related to climate action and tourism.

#### Regional Strategy for Sustainable Development – Sardinia 2030 (SRSvS)

Adopted in 2021 by the Sardinia Region, the SRSvS represents the territorial implementation of Italy's National Strategy for Sustainable Development (SNSvS) and aligns with the United Nations 2030 Agenda. It is integrated with the Regional Development Program and, most importantly, with the Regional Climate Change Adaptation Strategy (SRACC), a decision primarily based on climate projections for Sardinia.

The Mediterranean is recognized as one of the world's climate change hotspots, meaning it is among the geographic areas most affected by climate variations. Due to its insular nature and geographical location at the center of this hotspot, Sardinia is increasingly experiencing significant climate impacts across all sectors, with profound environmental, economic, and social consequences.

In this context, according to Sardinia 2030, climate adaptation measures can significantly improve the quality of life for affected communities. The climate crisis, along with a growing awareness of its effects, presents an opportunity to rethink economic and social models from a sustainability perspective. This includes adapting and modifying existing infrastructure, such as transport systems, and designing new green and social infrastructures tailored to climate change and evolving socio-economic conditions.

#### Tourism within the Sardinia 2030 Strategy

Tourism is a key sector in Sardinia 2030 due to its cross-cutting role in sustainability. The strategy integrates environmental and ecotourism principles with social and inclusion aspects, recognizing tourism as a vital tool for territorial enhancement and the development of new professional opportunities.

Specifically, tourism is at the core of Strategic Theme "SARDEGNA + VERDE" (Greener Sardinia), Objective 7: Develop sustainable tourism for socio-economic growth and the protection of culture and biodiversity.

This includes:

- Creating a sustainable and ecotourism-based tourism offer across the island, particularly in environmentally valuable areas.
- Developing sustainable tourism products to strengthen, diversify, and extend the tourist season in Sardinia.



- Implementing both material and intangible initiatives to promote responsible and conscious tourism.
- Ensuring effective governance of the tourism sector.
- Promoting Sardinia as a sustainable and ecotourism destination in both national and international markets.

### Regional Climate Change Adaptation Strategy

The Regional Climate Change Adaptation Strategy is the tool through which the Region of Sardinia has structured its approach to implementing adaptation policies. It was first adopted in 2019 and updated in 2024. It enables various regional stakeholders to integrate these policies into sectoral and territorial strategies.

### Regional Strategic Tourism Plan 2023-2025 (RSTP)

The Regional Strategic Tourism Plan (RSTP) 2023-2025 serves as a reference framework for future strategic tourism policies and is closely aligned with the Sardinia 2030 Regional Strategy. The plan highlights the strong connection between tourism activities and the Regional Climate Change Adaptation Strategy (SRACC), recognizing the impact of climate change on tourism dynamics.

The plan considers both opportunities and threats arising from ongoing climate change. On the one hand, warmer and milder temperatures could extend the tourist season, reducing seasonality and creating new possibilities for sustainable tourism development. Additionally, some vulnerable areas could be transformed into naturalistic zones, enhancing conservation efforts while diversifying tourism offerings. Another potential advantage is the redistribution of tourist flows, which could help ease pressure on destinations most affected by overtourism.

At the same time, the plan acknowledges the challenges posed by climate change. Coastal erosion threatens the stability of key tourist areas, while recreational sites are increasingly exposed to risks such as wildfires and flooding. The overuse of water resources for tourism, particularly during drought periods, raises concerns about sustainability, as does the high energy consumption associated with tourism infrastructure. Addressing these issues is crucial to ensuring a more resilient and environmentally conscious tourism model for Sardinia.

## LOCAL LEVEL

The activities related to the enjoyment of the coastal marine environment are regulated by the legislation concerning the Capo Carbonara Marine Protected Area, the Natura 2000 Network sites, and the Coastal Use Plan (in Italian: Piano di Utilizzo del Litorale – PUL).

Capo Carbonara Marine Protected Area Regulations



On February 7, 2012, with Ministerial Decree No. 60, the "Regulations on the Activities Permitted in the Different Zones of the Capo Carbonara Marine Protected Area" were adopted. This decree updated the management of the MPA, establishing the activities allowed in the various zones of the protected area. On May 12, 2017, the REO (Regulation for the Execution and Organization of the Capo Carbonara Marine Protected Area) was approved and published in the Official Gazette No. 124 on May 30, 2017. The activities carried out within the AMPCC are currently governed by this regulation and its supplementary guidelines, which are modified and updated annually. The management of the MPA has been entrusted to the municipal administration of Villasimius.

#### Natura 2000 Sites: Management Plan for SCI ITB040020

The Management Plan for the Site of Community Importance (SCI) ITB040020, named "Isola dei Cavoli, Serpentara, and Punta Molentis," was approved by Regional Decree No. 28 on February 28, 2008. This plan outlines the conservation measures necessary to protect and enhance the habitats and species present in the site, in accordance with European directives on biodiversity.

Collaboration among local authorities, environmental associations, and other stakeholders is essential to ensure the effectiveness of the conservation measures outlined in the plan, contributing to the preservation and enhancement of the natural heritage of the SIC ITB040020.

#### Municipality of Villasimius, Coastal Use Plan (in Italian: Piano di Utilizzo del Litorale – PUL)

The Coastal Use Plan (PUL) of the Municipality of Villasimius is a territorial planning tool designed to regulate the use of coastal areas, ensuring the conservation of the environment and the enhancement of natural resources. The PUL was adopted by Municipal Council Resolution No. 16 on May 21, 2013, and its goals include environmental conservation and enhancement, through the protection of the physical and patrimonial integrity of maritime public property, as well as promoting public use and economic activities. The plan seeks to balance the needs of public enjoyment with economic activities, fostering the sustainable development of public coastal areas.

#### Climate Change Adaptation Strategy

Currently, there is no local climate mitigation and adaptation plan in place, but this project will initiate the development of the first adaptation plan at the pilot site level. It is important to highlight that the Capo Carbonara Marine Protected Area (CCMPA), even in the absence of a formal climate adaptation plan, has been implementing marine and coastal environmental protection and conservation projects for over a decade.

Within the frameworks of the LIFE Providune (2010-2014), LIFE Res Maris (2014-2020), and FESR O.P. (2014-2020, Line 6.5.1 *"Integrated intervention for the restoration of ecosystem services and reduction of habitat fragmentation in*



the coastal marine environment of the Municipality of Villasimius - SCI ITB040020 Isola dei Cavoli, Serpentara, Punta Molentis, and Campulongu") programs, various actions have been carried out to preserve and protect beach-dune systems through nature-based solutions (NbS). These interventions included:

- Fencing to protect dunes from human interference, alongside the installation of appropriate signage to highlight the ban and explain the reasoning.
- The installation of walkways to regulate and facilitate access to the beach.
- The placement of windbreaks and geogrids to retain sand on the dunes. Over time, these have helped restore some previously existing dune structures.
- The eradication of invasive alien plant species, planting of native species in the dune systems (after collecting native germplasm).
- The restoration of the *Posidonia oceanica* meadow in the area in front of the beaches of Campulongu and Campus, identified as the zone most impacted by anchoring.
- The installation of mooring buoys in areas of high tourist interest, primarily for use by authorized operators working within the CCMPA.
- Communication actions at the local level (citizenship/schools, tourists, visitors, stakeholders) and on social media.

The actions undertaken have proven effective and, in most cases, have led to the restoration of the natural dynamics of the dune-beach systems, where human interference has been addressed and contained. The placement of windbreaks also fulfilled its intended role, promoting sand deposition.

The POSBEMED2 Project - *Governance and Management of Posidonia Beach-Dune Systems across the Mediterranean* (2019-2022) aimed to implement sustainable management actions for the *Posidonia* beach-debris on Mediterranean beaches and develop management strategies that enhance the value of these coastal ecosystems. The project tested various methods to reduce the damage these systems suffer and capitalized on other strategic coastal initiatives at the local and regional level across the Mediterranean.



## 2. COLLECTION AND ANALYSIS OF HISTORICAL CLIMATE DATA

### 2.1 DESCRIPTION OF DATA COLLECTION METHODS

The analysis of Sardinia climatic data recorded by weather stations managed by the Regional Environmental Protection Agency (ARPAS), for the reference period 1981-2010 was carried out for the main meteorological parameters. Quality control of temperature and precipitation data series was undertaken. For the climatic analysis relating to the Capo Carbonara Protected Marine Area, data from the meteorological stations located in Villasimius and Muravera were considered. The work consisted of the following stages:

- Definition of the daily series database, quality control and homogeneity analysis;
- Elaboration of the climatology of the main meteorological parameters and indexes based on weather station available data;
- Calculation of climatic mean values;
- Interpolation on a regular grid of the climatologies of the processed meteorological parameters;
- Bias correction of reanalysis of climatic data and indicators interpolated in a regular grid with observed climatic data and correction of systematic errors in future temperature and precipitation scenarios.

#### Climate risks in terms of regional vulnerability

Local climate variability and the evaluation of future anomalies linked to climate change were derived from the study of the climate situation in Sardinia for the thirty-year reference period 1981-2010. Climate projections have highlighted that the region will experience a general increase in temperature, a reduction in total annual precipitation, a rise in average sea levels, and a general increase in average sea temperatures. Extreme climatic events, both in terms of temperature and precipitation, are expected to increase in intensity and frequency, particularly resulting in heavy precipitation, storms, floods, river flooding, droughts, and heatwaves. Impacts are also expected in coastal erosion, saline intrusion, and watershed salinization, with consequences for biodiversity loss and reduced crop production.



## Local climatic data

Some key statistical data for the construction of adaptive capacity indicators are difficult to find and not always available. With reference to the touristic sector, in coastal areas sea level rise and wave force data are not available because of lack of survey systems. This critical issue has an impact on coastal erosion monitoring, which is currently analyzed essentially on site-specific case studies (in the next section: Action Framework Plan for CCMPA, 2021 and IAS-CNR Report, 2023). Furthermore, specific studies on the effects of climate change on the region's socio-economic and sectoral system have to be developed. With regard to the climatic analysis of the Capo Carbonara Marine Protected Area, data from the meteorological station located in Villasimius for precipitation and Muravera for temperature data were considered. The data for the thirty-year period 1981-2010 were sufficiently complete, although for some parameters (rainfall in particular) some daily data were missing, and years with less than 90% of available data were not considered, according to the guidelines of the World Meteorological Organization. The data (Annex 1, Figures 1-4) show that, until 2010, heat waves and extreme events had a relatively stable trend, with peaks in specific years. Meanwhile, precipitation (annual average rainfall) tended to decrease, while tropical nights increased.

The need to obtain data updated to the last 15 years is a priority for the CCMPA. In the marine environment, thanks to collaboration with Greenpeace and DISTAV, it has joined the MARE CALDO (Warm sea) project, whose main objective is to monitor temperature changes along the water column and assess the effects of global warming on coastal marine habitats. Through this project, eight sensors have been installed to record temperature at different depths (every 5 meters, from 5 to 40 meters deep), following the T-Med Net protocol, in a selected area of the CCMPA near Cavoli Island.

Additionally, the University of Cagliari has recently developed three prototype smart moored buoys suitable for environmental monitoring (Majumder A., et al., 2024). These buoys were deployed within the MPACC and equipped with temperature, salinity, and pH sensors to monitor and collect meteorological data. This project is highly innovative, and no dataset is currently available.

## Impacts of climate changes on Capo Carbonara MPA habitats

As part of the monitoring carried out by MPACC, the following impacts related to climate change have been identified.

In relation to the increase in sea temperature, a study on the rocky reef habitat was considered, comparing data collected in 2000 with data collected at the same locations 20 years later. The first characterization of the benthic communities of the rocky reef was carried out by Bianchi and Morri (2001) as part of a plan promoted by the Municipality of Villasimius for the ENVIRE Community Interest Program, aimed at designing management tools for a marine protected area. In this study, a high biodiversity was observed in the rocky reef habitat, attributed to the heterogeneity of the seabed and the



biocenotic complexity. During the monitoring, over 100 plant and animal species were recorded with a limited sampling effort (only 3 sites, rapid surveys, considering only the “conspicuous species”). Finally, the study area was found to be rich in habitats and species of high naturalistic value, of conservation interest, or considered worthy of protection under international agreements (e.g., the Bern Convention, the Barcelona Convention, the Washington Convention) (Montefalcone and Azzola, 2020). The Capo Carbonara MPA deemed it important to repeat this study to assess the current ecological status of the rocky reefs on the seabed of the marine area and the temporal changes in the structure of the rocky benthic communities over the past 20 years. The study revealed that, over the last 20 years, the Capo Carbonara MPA rocky reefs have been subjected to multiple factors linked to climate change and local human pressures. Consistent with global trends, sea surface temperature (SST) in this area increased by 0.32°C from 2000 to 2020. Maximum SST values showed the greatest increasing trend, with recurrent marine heatwaves recorded in the same years when major thermal anomalies and mortality events were reported for the north-western Mediterranean. Minimum SST values also showed an increasing trend. Higher winter temperatures and the decrease in the frequency of cold winter events (which can lead to physiological damage and mortality) are believed to favor the establishment of both alien species, typically of tropical or subtropical origin, and native thermophilic species. In fact, within the Capo Carbonara MPA, thermophilic species have been identified, along with signs of necrosis and mass mortality of some species (such as the mass mortality of gorgonians at a specific site, likely caused by heat-waves that occurred in the summer of 2019). The presence of thermophilic species, mass mortality events, the presence of mucilage, and the changes observed over the past 20 years are all clear indicators of how the effects of global warming and thermal anomalies are impacting protected areas as well (Azzola A. *et al.*, 2022).

Regarding erosion, thanks to the involvement of the Capo Carbonara MPA as a pilot site in the Interreg POSBEMED2 project - Governance and Management of Posidonia Beach-Dune Systems across the Mediterranean (2019-2022), which focused on creating an Action Plan for managing beached *Posidonia oceanica* leaf accumulations, two specific beaches in the marine area with this situation were thoroughly inspected: Campulungu and Is Traias. The monitoring carried out also provided data on the possible retreat of the coastline, with the aim of assessing whether the two beach systems were facing coastal erosion problems. The monitoring showed that Campulungu beach, at certain points, exhibits clear erosion problems, while other areas of the beach, due to the periodic sediment supply, show zones of both retreat and seasonal advancement. Is Traias beach, on the other hand, does not appear to have erosion issues and demonstrates a greater capacity for resilience, with variations in width mainly due to seasonal and annual changes (Action Framework Plan for CCMPA, 2021). To further investigate other beaches within





the territory of Villasimius, the same type of monitoring was carried out in 2023 on the beaches of Punta Molentis and Sa Ruxi: the two beaches appear to show moderate retreat in certain areas (IAS-CNR Report, 2023).

## 2.2 ANALYSIS OF PAST EXTREME WEATHER EVENTS

Statistical data analysis for the territory of MPA of Capo Carbonara for the reference period 1981-2010 have shown a significant positive trend both in maximum and minimum temperature values. In particular, extreme temperature indicators (heat waves and extreme temperature) show a positive trend in the considered 30 year period, following the same pattern of similar areas along Sardinia. Also, minimum temperature values have decreased in the last decades, as the Tropical Nights Index (TR, figure 2) shows for Muravera weather station. Regarding precipitation, the total mean annual rainfall amount shows a negative trend in the reference period, while the number of intensive events (at least 20 mm/day) have decreased in the 1981-2010. Precipitation data analysis (fig. 3 and 4) is always very difficult and sometimes misleading, due to the very erratic behavior of rainfall events. The south east sub-region of Sardinia is generally characterized by convective rainfall that can lead to intensive rainfall events and floods. Heat Waves and shortage of water resources will affect the characteristics of the tourist season resulting in increased energy requirements for cooling buildings and tourist facilities affecting also public health on one hand, while water resources shortage could affect tourist, agricultural and civil needs during summer period.

Extreme weather events such as droughts, long periods of heat waves, increased wave energy, storm surges and coastal erosion have been observed locally in the past. Climate projections for the future have shown for the area:

- increased temperatures;
- reduction in the amount of precipitation;
- high intensity and frequency of extreme weather events;
- hydrogeological instability;
- rise in mean sea level;
- changes in the action of prevailing winds;
- increased wave energy;
- coastal erosion;
- loss of ecosystem services;
- increase in average sea temperature. These phenomena produce effects on natural and human systems. In particular, on water resources and ecosystems.

Impacts of climate events on ecosystems, infrastructure and communities



Changes in the water cycle pose an increasing risk of significant variations in water availability and quality, with a reduction in the water supply during summer months and alterations in the chemical-physical, biological, and ecological parameters of aquatic ecosystems. These changes, already observable in various areas of Sardinia, are also manifesting in the Villasimius area, where water resource management could become an increasingly critical issue. Currently, the presence of a wastewater treatment plant helps mitigate some of these impacts by reusing regenerated water for the irrigation of gardens and green areas. However, this measure may not be sufficient considering forecasts indicating further increases in temperatures and reductions in precipitation, which will intensify the pressure on water resources. The local community has been experiencing the consequences of extreme weather events for several years, including prolonged heat waves and periods of drought, which lead to an increase in energy demand for cooling buildings and tourist facilities. The rise in energy costs directly impacts local economic activities, with a significant effect on the tourism sector, the region's main economic driver. This vicious cycle creates growing pressure on infrastructure and service networks, putting the economic and social sustainability of the area at risk.

Coastal erosion, exacerbated by changes in local currents and the increase in wave energy, is leading to the retreat of the coastline. These events not only result in the loss of significant portions of shoreline but also compromise the ability of beaches to perform their ecological and economic functions. Beaches are, in fact, extreme environments, characterized by selective conditions for the survival of plants and animals. Species inhabiting these habitats have developed specific adaptation strategies to survive in a constantly changing context. However, the acceleration of erosive processes and the increasing human pressure could exceed their resilience capacity, leading to the progressive loss of biodiversity and the fragmentation of dune habitats.

From an ecological perspective, the repercussions extend to biogeochemical cycles and marine and coastal biodiversity, with cascading effects on the functionality of ecosystems. The potential reduction of *Posidonia oceanica* meadows, crucial for sediment stabilization and coastal protection, would exacerbate the erosion process and the loss of habitats essential for numerous fish species. Moreover, the alteration of the distribution ranges of many marine and terrestrial species could disrupt existing ecological balances, leading to a reduction in ecosystem productivity and compromising the supply of essential ecosystem services, such as climate regulation, flood protection, and natural water purification.

As a result, economic activities related to tourism will also face significant impacts. Coastal structures and infrastructure, such as beach resorts, walkways, parking areas, and recreational zones, will be increasingly exposed to the risk of structural damage due to storm surges and the rise in intense weather phenomena. The reduction in beach surface area and landscape degradation could undermine the tourist appeal of the destination, with direct



consequences on the hospitality and restaurant sectors. In the long term, a decline in tourism competitiveness may lead to reduced employment and a local economic crisis.

Finally, over time, the combination of these factors could affect the quality of life of the resident population. Prolonged heat waves and rising humidity could impact public health, while the increased risk of hydrogeological hazards, flooding, and wildfires would make the territory more vulnerable. The management of climate and environmental emergencies may require an enhancement of infrastructure and civil protection systems, with increasing costs for local administrations and the community.

### Types of stakeholders involved by pilot site

With the intention of addressing and deepening the themes of tourism, sustainability, and climate change, in order to then plan adaptation actions, the main stakeholders of Villasimius, both public and private, were involved. In particular: representatives from the municipal administration, the municipal police, and the Forest Corps – Villasimius Station, the managers of the municipality's in-house company that runs the Municipal Tourist Office, directors and managers of accommodation facilities, managers of beach establishments, diving centers, the cooperative of local professional fishermen, the cooperative offering environmental education/ecotourism services and managing the educational services of the CEAS, and local volunteer associations.

### Perception of impacts by different stakeholders

The perception of climate change threats is particularly strong during extreme weather events that cause direct damage. However, among both the local population and tourists, general awareness of the territory's vulnerability and the need to adopt prevention and adaptation measures still seems limited.

In Villasimius, an exception is represented by the school population, especially primary and lower secondary school students, who receive information and training on these topics both through the school curriculum, which includes the study of climate issues, and through educational pathways offered by the CEAS projects.

Greater awareness is observed among local stakeholders, such as the owners of beach resorts and businesses with coastal concessions. These operators, who experience the coastal environment and beaches on a daily basis due to their work, are more attuned to the ongoing climate changes, noticing increasing instability in weather conditions during recent summer seasons.

Climate uncertainty has a significant impact on beaches and, consequently, on the economic activities related to their use. Specifically, during a meeting organized to assess the perception of local operators regarding climate change, it emerged that the seasons are undergoing changes: May is perceived as colder and characterized by greater meteorological instability compared to the



past, while October features higher temperatures, similar to those typically seen in summer.

Phenomena such as prolonged droughts and increasingly intense heat waves are changing the habits of both tourists and residents, reducing beach attendance during the hottest hours and resulting in a decrease in the number of customers at beach resorts.

Another critical issue is the change in dominant winds, which has led to an increase in the frequency and intensity of storms. These events have a direct impact on the beaches and coastal ecosystems, accelerating erosion processes and reducing the space available for beach resorts.

Diving center owners and professional fishermen also report the impact of climate change, particularly the tropicalization of the Mediterranean Sea. The spread of invasive alien species is disrupting marine ecosystem balances, with potential repercussions both on biodiversity and on economic activities related to fishing and underwater tourism.

### Population sector(s) most at risk

Regarding the territory of Villasimius, the population groups most at risk from the impacts of climate change are primarily the elderly and vulnerable individuals, followed closely by children.

Both the elderly and children are particularly vulnerable to the effects of drought, rising temperatures, and heat waves due to their more fragile health and greater dependence on others for care and protection. In elderly individuals, the reduced perception of thirst and the presence of chronic conditions can exacerbate the effects of high temperatures. In children, the immaturity of thermoregulation systems and their lesser ability to express discomfort increase the risk of heat strokes and dehydration.

People with chronic diseases, such as cardiovascular, respiratory, or renal conditions, are particularly vulnerable, as heat and dehydration can worsen their conditions. Moreover, drought and rising temperatures can affect air quality, worsening pre-existing respiratory problems. Terminally ill and chronic patients, as well as those with mental health disorders and their caregivers, often under significant physical and emotional stress, are also among the most exposed. This stress can be amplified by extreme climatic conditions.

Women are also considered at risk, particularly regarding the effects of drought and heatwaves. Certain life stages, such as menopause, can enhance sensitivity to high temperatures due to hormonal changes, making women more exposed to discomfort related to heat and lack of water resources, especially in older age. Finally, populations with fewer economic resources, such as the unemployed, socially marginalized individuals, and those with lower incomes, are among the groups most vulnerable to climate change impacts. Their lower ability to cope with emergencies, difficulty accessing adequate cooling systems, and greater exposure to substandard housing conditions contribute to increasing the risk for these categories.



## 3. IDENTIFICATION OF VULNERABILITIES

### 3.1 EXPOSURE OF TOURISM TO CLIMATE HAZARDS

The sectors related to tourism in a coastal location like Villasimius are particularly vulnerable to climate change and its associated risks, which can compromise both the quality of the tourist experience and the economic sustainability of local activities. These sectors include:

- Coastal Tourism and Hospitality Sector (Hotels, Beach Resorts, Restaurants)  
Climate Risks: Coastal erosion, changes in local currents, heatwaves, storms, and heavy waves.  
Impact: The loss of beaches due to erosion and sea encroachment can reduce tourist attraction and threaten beachfront structures, compromising service delivery. Heatwaves can discourage visitors, affecting hotel occupancy rates and restaurant revenues.
- Water Resources and Tourist Services  
Climate Risks: Drought, heatwaves, and reduced rainfall.  
Impact: Increased competition for water usage between tourism, agriculture, and residents, especially during peak seasons. Water scarcity can limit the operation of hotels, restaurants, and recreational activities, increasing management costs and reducing service quality.
- Nautical Tourism (Pleasure Boating, Diving Centers, Boat Tours)  
Climate Risks: Ocean warming and acidification, biodiversity loss, extreme weather events.  
Impact: Rising sea temperatures and acidification can damage marine ecosystems, reducing biodiversity, promoting unusual algal blooms, and the spread of invasive species that compete with native ones. This makes activities like diving and snorkeling less attractive. More frequent storms and waves can damage port infrastructure and hinder sea excursions.
- Fishing, both Professional and Recreational  
Climate Risks: Ocean warming and acidification, biodiversity loss, extreme weather events.  
Impact: Decrease in fish stock productivity, affecting both commercial and recreational fishing activities.
- Waste Management and Urban Infrastructure  
Climate Risks: Rising temperatures and seasonal overloads.  
Impact: Waste production increases significantly during the summer months, while high temperatures accelerate decomposition, creating challenges in waste collection and disposal, with potential hygiene and urban aesthetic issues.
- Transport and Accessibility



Climate Risks: Heatwaves, extreme weather events (floods, wildfires).

Impact: Increased pressure on public transport during the high season, with supply often insufficient in relation to demand. Extreme events, in addition to being highly dangerous, can damage roads and infrastructure, blocking access to the area and reducing the efficiency of public transport, exacerbating discomfort for residents and tourists, and increasing pressure on local resources.

- Agriculture and Local Food Production

Climate Risks: Drought, rising temperatures, soil degradation.

Impact: Reduced agricultural productivity and shifting cultivation areas can affect the availability of local products, impacting the restaurant and food and wine sector, which are important parts of the tourist experience.

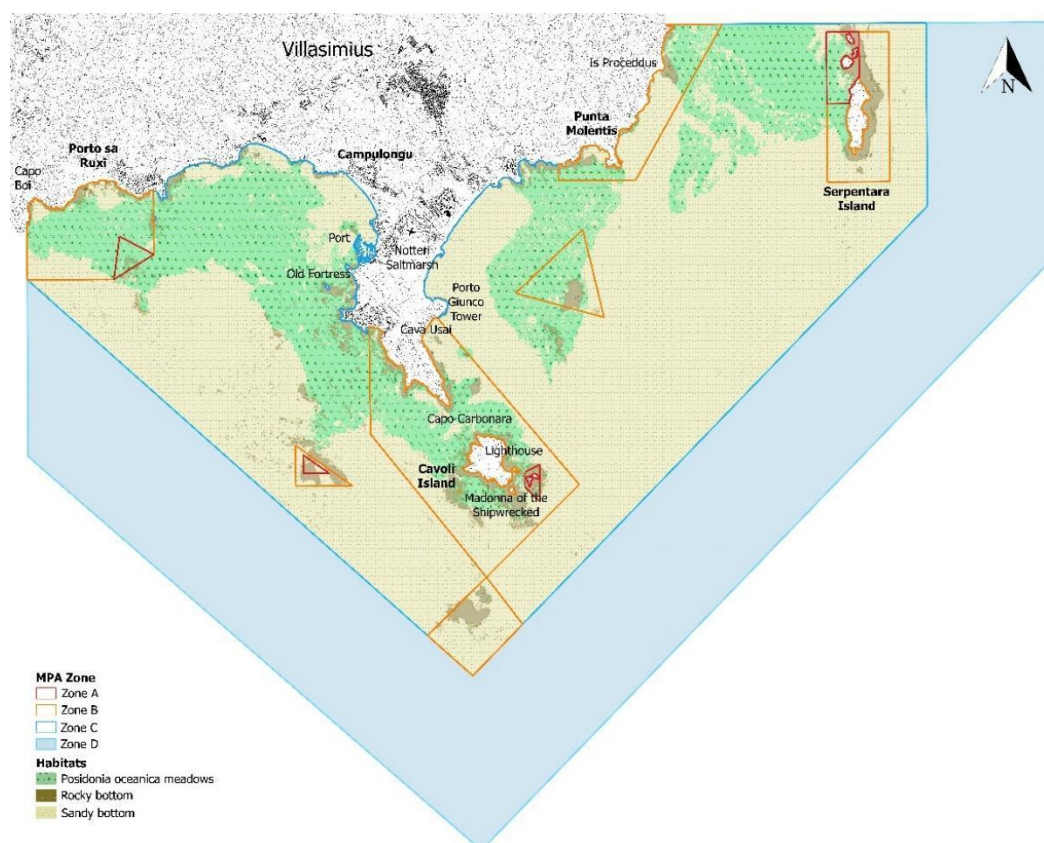
Based on the sectors listed above and the currently available data on the Villasimius area, we can identify four main issues related to climate change and 26 different tourism assets, listed in Table 2:

Main possible issues related to climate change	Tourism assets Natural assets, in green Cultural and historical, in blue Economic activities, in purple
<ul style="list-style-type: none"> <li>Average annual temperature rise</li> <li>Change in total precipitation (decrease)_Drought</li> <li>Coastal erosion</li> <li>Biodiversity loss</li> </ul>	Punta Molentis Beach
	Porto Sa Ruxi Beach
	Campulongu Beach
	Notteri Saltmarsh
	Centennial Juniper of Porto Sa Ruxi
	Centennial Juniper of Cava Usai
	Rio Foxi (creek)
	Dune system
	Walking trails
	Natural sandy, pebble and rocky beaches
	Posidonia meadows
	Mediterranean maquis
	Diving sites
	Quarry of Cava Usai
	Madonna of the Shipwrecked
	Fortezza vecchia - Old Fortress
	Lighthouse of Cavoli Island
	Porto Giunco Tower
	Beach establishments

	Seafront accommodation and private residences
	Marina di Villasimius - Port of Villasimius
	Accommodations (hotel, B&B, resort, etc)
	Camping
	Diving (stakeholders)
	Professional and recreational fishing
	Rental and leasing of nautical boats

**TABLE 2. THE TOURISM ASSETS AND POSSIBLE ISSUES RELATED TO CLIMATE CHANGE IN VILLASIMIUS.**

The map below shows some of the tourism assets in the list:



**FIGURE 4. CAPO CARBONARA MPA AND POINTS OF INTEREST.**

## 3.2 ASSESSMENT OF CURRENT IMPACTS ON TOURISM

### Current impacts of climate change on tourism activities

Currently, due to the lack of sufficient data and studies on climate change in the Villasimius area, it is only possible to make projections based on trends observed at the regional, national, and Mediterranean levels. Based on this, it is possible to hypothesize that, on tourism, there may be a shift in tourist seasonality patterns, influencing the choice of destinations and the timing of travel. We might see a geographical shift in tourist flows towards higher latitudes, as traditionally warm destinations may become less attractive in the summer months due to excessive temperatures. As a result, Mediterranean locations like Villasimius could face increasing competition from northern





destinations that will benefit from milder summers and more favourable climatic conditions. Moreover, travellers from countries with more temperate climates may choose to spend more time in their home countries, reducing the need to travel to traditionally warm destinations. This phenomenon could lead to a reduction in summer tourist demand in Mediterranean destinations. Excessive heat during peak months (July and August) has already led to increased tourist inflows, especially from Northern Europe, during shoulder months (May, June, September, and October). However, the continuous rise in temperatures could drive a growing number of tourists to prefer alternatives, opting for even cooler periods like March, April, and November, when air and water temperatures are more comfortable for them. This shift could represent an opportunity to deseasonalize tourism and better distribute tourist flows throughout the year. However, the extension of the tourist season, while offering potential economic benefits, will require adjustments in infrastructure and services, such as more sustainable management of water and energy resources, and a rethinking of labour organization in the tourism sector (<https://climadat.isprambiente.it/conoscere-i-cambiamenti-climatici/impatti-vulnerabilita-adattamenti/turismo/>). An additional impact emerging in the territory is the modification and retreat of the coastline. Beyond the reduction in available beach area for tourists, an increasingly relevant issue concerns the system of maritime state concessions. Beach concession holders are beginning to recognize the effects of climate change, observing a progressive loss of usable space for their activities, resulting in a reduction of the originally granted area and an increasing risk to the economic sustainability of their structures. As a result, this could lead to a rise in requests for modifications to the concessions, including applications for the retreat of structures or adjustments to the assigned areas. However, this raises several issues, including: a complex administrative management in an Italian context already characterized by long and intricate bureaucratic procedures; conflicts between operators and local authorities, who must balance the needs of beach operators with environmental protection and public access to the beaches, making it difficult to find shared solutions; and potential adaptation costs that operators would need to face to address the growing problem.

### Impact on local economy (direct and indirect economic costs)

The local economy of a coastal tourist destination like Villasimius, considering the emerging issues related to climate change, could face repercussions both in terms of direct and indirect economic costs. It may need to contend with direct costs for:

- Infrastructure upgrades and adaptation investments, as the progressive tourism season extension will require a rethinking of tourist facilities and services. Investment will be needed in accommodations suitable for a longer season, with energy and water-saving systems to support demand during less traditional periods. Additionally, the retreat of the





coastline will force beach concessionaires to modify their structures, relocating them further inland or investing in coastal protection works, which come with high costs and no guarantee of long-term effectiveness.

- Increased administrative and bureaucratic costs for requests to modify beach concessions, complicating the administrative management and generating additional costs for both operators and local authorities.
- Potential economic losses for the tourism sector if tourism in the summer months were to decrease due to high temperatures. Some activities, such as beach establishments, restaurants, and hotels, could experience a decline in revenue during peak periods. Moreover, competition from destinations at higher latitudes could reduce the market share of Mediterranean locations.

Indirect economic costs could arise from a reduction in tourist demand during peak months and its shift towards the off-season, which could create imbalances in the local labour market. This would lead to increased difficulty in recruiting seasonal workers and potentially negative impacts on activities that rely on peak tourist traffic, such as transportation, retail, and catering. Additionally, changes in tourist flows could affect the costs of public services, such as waste management and transportation infrastructure, which would need to adapt to a tourism pattern less concentrated in the summer months. Over time, this could also result in a decline in the destination's attractiveness, with long-term repercussions on the entire local tourism sector.

### Adaptation of businesses and local communities to change

Unfortunately, at the moment, there are no real adaptive actions being implemented by businesses and local communities. What is emerging instead is the need and urgency for regional governance to guide policies at the local level. Specifically, regional governance should support the off-season tourism of tourism with clear guidelines and policies that, on the one hand, promote the expansion of transportation services to Sardinia beyond the summer months, and, on the other hand, extend the duration of beach concessions, which are currently limited to the summer period.

## 3.3 FUTURE PROJECTIONS AND ANTICIPATED RISKS

The climate scenarios adopted to show the trend to 2050 of the main climate parameters and the resulting climate indicators are those provided by the COSMO-CLM regional climate model of the CMCC Foundation - EuroMediterranean Centre for Climate Change. The RCP 4.5 scenario was selected, considering that mitigation policies have already been and will be implemented in order to reduce GHG emissions. Heat waves and extreme high temperatures will become more intense and frequent in respect of the reference period, and also more consecutive dry days (CDD) will occur. The exacerbation of climatic extreme conditions will lead to more intense



precipitation events, while the total amount of mean annual rainfall will not change significantly.

Currently, measures to mitigate the risks associated with climate change in Sardinian coastal tourist destinations, such as Villasimius, are limited. Despite the urgency of intervention, there are no concrete and widespread adaptation plans at the local level. However, some needs have been highlighted, such as the adoption of regional policies to support the off-season tourism, including improvements in transportation during the low season and extending beach concessions beyond the summer months. Although there is a lack of overall coordination and a long-term strategic plan, some preventive coastal protection actions have been tested in certain areas of the Villasimius territory, primarily related to the protection and management of beach-dune systems. Among the main initiatives are the installation of fences to protect the dunes, preventing tourist access, along with signage explaining the ban and its reasons; the positioning of walkways to regulate beach access, allowing controlled entry and reducing human impact; the installation of windbreaks and geogrids to facilitate sedimentation and restore dunes; and the eradication of invasive alien species, followed by planting native species in the dune systems to improve local biodiversity. To intensify the protection of the beach-dune system, the focus has also been on the restoration and protection of *Posidonia oceanica* meadows, restoring areas more affected by boat anchoring and installing mooring buoys in areas of greater tourist interest. These actions have proven effective in containing damage and encouraging the recovery of natural dynamics, ensuring greater ecological sustainability and helping preserve the natural resources that are vital for coastal tourism. In any case, there is a growing awareness of the need to address the issue through regional governance that provides guidelines and incentives for climate change adaptation.



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### Link

- Regulation for the Execution and Organization of the Capo Carbonara Marine Protected Area, 2017

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[extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ampcapocarbonara.it/uploads/pdf/2017\\_Regolamento%20di%20Esecuzione%20ed%20Organizzazione.pdf](https://www.ampcapocarbonara.it/uploads/pdf/2017_Regolamento%20di%20Esecuzione%20ed%20Organizzazione.pdf)

- RES Maris Project  
<https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE13-NAT-IT-000433/life-res-maris-recovering-endangered-habitats-in-the-capo-carbonara-marine-area-sardinia>
- Management plan ITB040021 – Costa di Cagliari  
[https://download.mase.gov.it/Natura2000/Materiale%20Designazione%20ZSC/Sardegna/04\\_Misure%20di%20Conservazione/Elaborati%20di%20Piano/ITB040021/01\\_Elaborati%20Testuali/Piano%20di%20Gestione.pdf](https://download.mase.gov.it/Natura2000/Materiale%20Designazione%20ZSC/Sardegna/04_Misure%20di%20Conservazione/Elaborati%20di%20Piano/ITB040021/01_Elaborati%20Testuali/Piano%20di%20Gestione.pdf)
- RES Maris best practice toolkit



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- European Environment Agency  
<https://eunis.eea.europa.eu/index.jsp>
- National Platform Climate Change Adaptation  
<https://climadat.isprambiente.it/conoscere-i-cambiamenti-climatici/impatti-vulnerabilita-adattamenti/turismo/>

## ANNEXES

### Annex 1\_Climate change graphics

Figure 1 – Heat waves for MPA of Capo Carbonara for the reference period 1981-2010

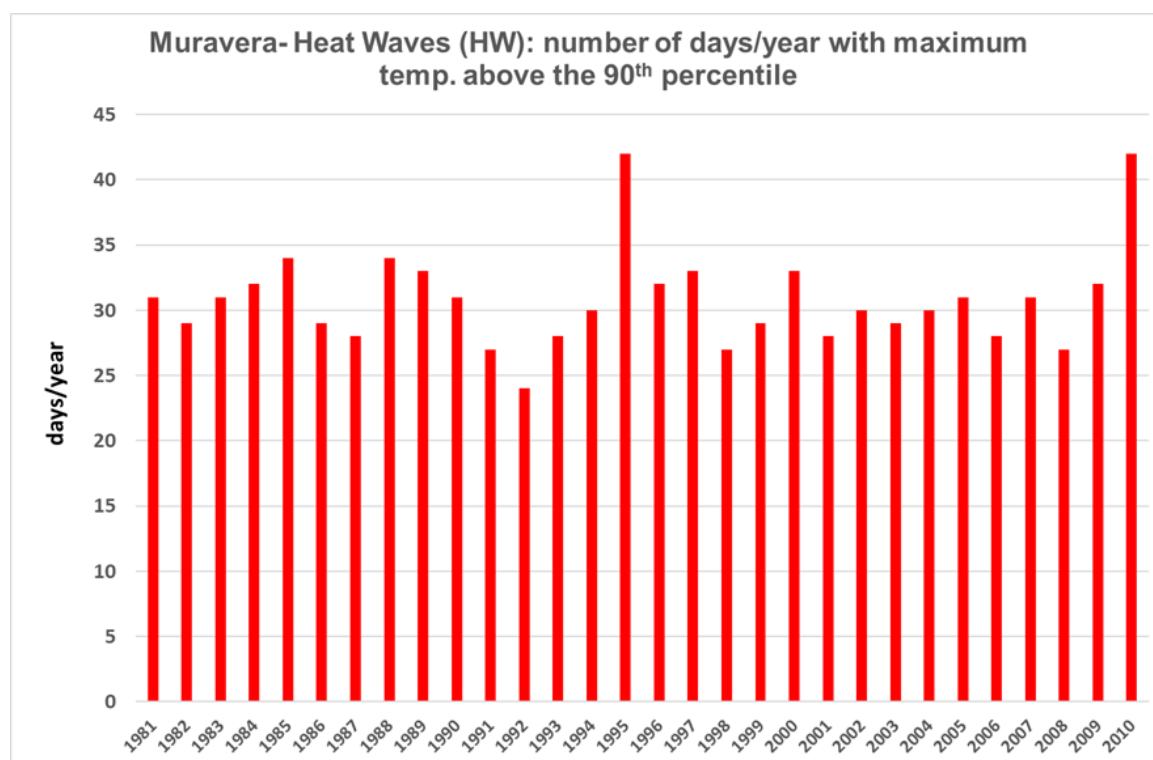


Figure 2 – Tropical nights in MPA of Capo Carbonara

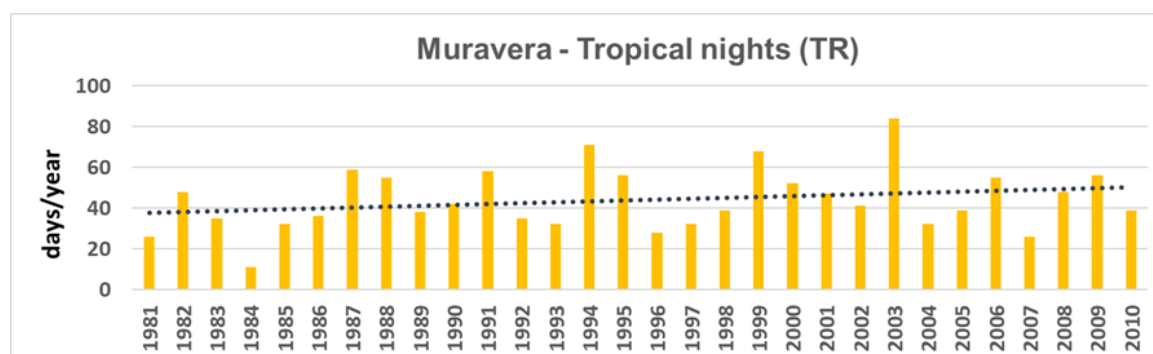




Figure 3 – Mean annual rainfall amount in MPA of Capo Carbonara

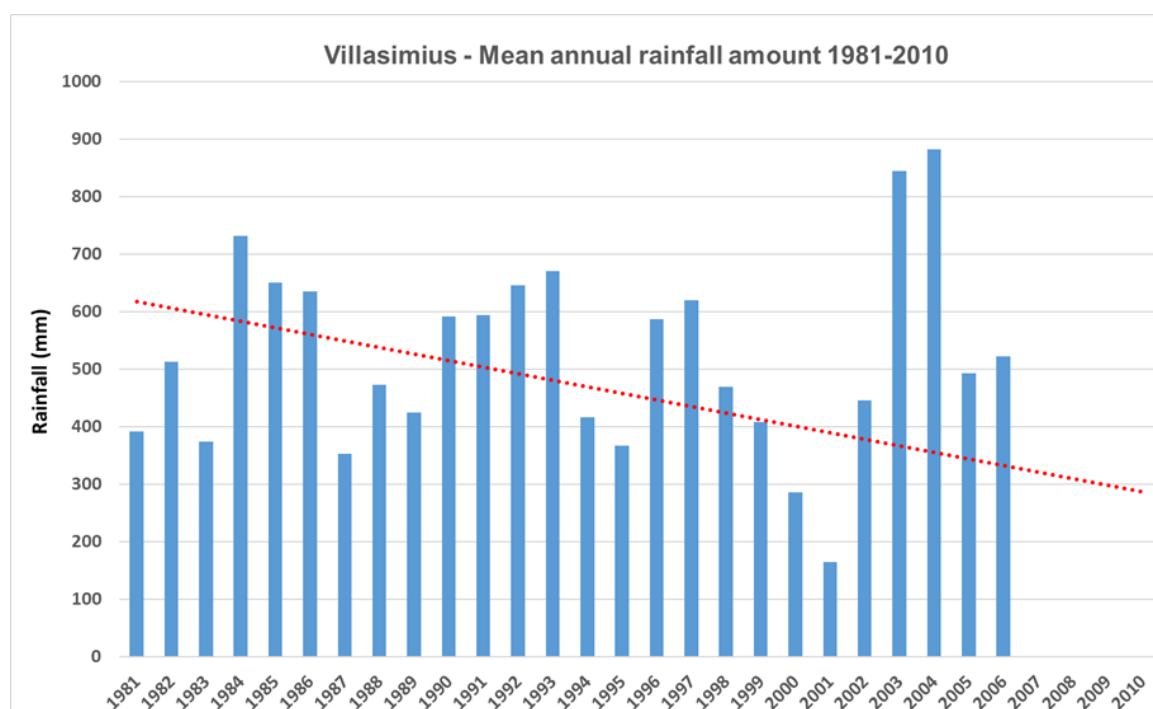


Figure 4 – Number of events of intensive events in MPA of Capo Carbonara

