



# *Autonomous Region of Sardinia Identification and assessment of the main coastal tourism-related issues concerning climate change mitigation and adaptation*

## The Consortium:



CPMR  
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Natura Jadera  
PUBLIC INSTITUTION FOR MANAGEMENT OF PROTECTED  
AREAS IN JADAR COUNTY



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REGIONE AUTONOMA  
DELLA SARDEGNA



ΠΕΡΙΦΕΡΕΙΑ ΚΡΗΤΗΣ  
REGION OF CRETE



Hellenic Society  
for the Protection  
of Nature



Ministarstvo poljoprivrede,  
šumarstva i vodoprivrede HNŽ



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Version	Date	Contributors
1	14.03.2025	Luisa Mulas, Emanuela Manca, Loredana Poddie, Giampiero Piredda, Andrea Motroni, Mario Deriu. Susanna Diliberto, Tiziano Onnis
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## 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 are 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.



## 2. TOURISM AND SUSTAINABILITY IN SARDINIA

### 1.1 REGIONAL CONTEXT AND SPECIFICITIES

Sardinia is the second-largest island in the Mediterranean Sea (after Sicily and before Cyprus) with an area of 24,100 KMq.

The coast of Sardinia is 1,849 km (1,149 mi) long. It is generally high and rocky, with long, relatively straight stretches, outstanding headlands, wide, deep bays, rias and inlets with various smaller islands.

The resident population in Sardinia, based on ISTAT data as of December 31, 2022, amounts to 1,578,146 residents, a decrease compared to 2021 (-9,267 individuals; -0.6%). More than half of the population lives in the provinces of Cagliari and Sassari. Women make up 50.9% of the resident population, surpassing men by over 29,000 units, mainly due to greater female longevity. The demographic data show a resident population with relatively high aging indices compared to Italy and a growing trend. This is coupled with a very low birth rate, which was 4.9 in 2022 and is continuously declining (-32% in the last decade). The foreign population in Sardinia, as of December 31, 2022, amounts to 50,211 people, approximately 3.2% of the resident population. 50.1% of the 377 Sardinian municipalities have a population between 1,001 and 5,000 inhabitants, and more than a quarter of the population (26.8%) resides there, while 17.1% of the population lives in the two municipalities with over 100,000 inhabitants, not exceeding a total of 300,000 units. Most Sardinian municipalities are in hilly or mountainous areas, with only a quarter being plain countries.

### 1.2 TOURISM IN SARDINIA

Sardinia is a destination of consolidated fame on the national and international tourism scene thanks to the existence of considerable resources of exceptional artistic, historical and archaeological value, alongside the inestimable environmental and landscape riches, mainly known for the great variety of enchanting beaches, which extend over 1851 km of coastline and are distinguished by the presence of crystal-clear waters and sands of high quality.

Tourism undoubtedly plays a fundamental role in the socio-economic framework of the Island and its evolution dates back to the 1960s-1970s, when, with the Costa Smeralda's entry into the international markets, Sardinia's image was established as a seaside and luxury destination, favoured by tourists from northern Europe.

This fact then contributed to the affirmation of a development model based mainly on coastal tourism, although over the years new formulas of enjoyment have been encouraged, based on the enhancement of other identity elements, the lengthening of the season and greater attention to environmental sustainability.





It should be pointed out that coastal tourism is developed through beach tourism and nautical tourism.

Beach tourism has as its main attraction the enjoyment of beaches and related recreational activities, e.g. bathing establishments, water sports such as windsurfing and kitesurfing, and others. The coastal areas that on average attract the most tourists are located in the north of the island, followed by the east coast, some locations in southern Sardinia and the west coast. This form of tourism is very widespread in areas characterised by sandy beaches and crystal-clear waters, and requires constant updating of the offer in terms of attention to environmental impacts and also in terms of differentiating the activities that can be practised on the coasts, so as to be able to counteract the effects of seasonality and excessive crowding in the summer months, especially in renowned localities.

Nautical tourism, on the other hand, focuses on the use of the sea for recreational and leisure activities, such as sailing, cruising and yachting. The latter is particularly developed and concerns the use of private boats (yachts, sailboats, speedboats and dinghies) to explore the coasts, islands and inland waters. From an economic point of view, this activity is also associated with a considerable induced activity with economic activities focused on various sectors, e.g. beyond shipbuilding, those of clothing and nautical equipment, but also events and food supplies. Sardinia has a potential catchment area of 4.5 million people, and not only the number of registrations and nautical licences are growing, but also the number of foreigners who choose to practice this tourist activity in the region. As for the port system, this extends along the entire coastline of the island and consists of 54 equipped marinas and 56 roadsteads.

Returning to the development model based on coastal tourism, it should be noted that the formula continues, years later, to be preponderant, as shown by the most recent trend data.

In 2023, Sardinia consolidated its position as one of the most sought-after destinations at national and international level, recording a significant increase in tourist demand: admissions (number of nights) totalled 16.58 million (+ 2.4% over 2022) and arrivals reached 3.9 million, up 4.40% year-on-year, with an average stay of 4.25 nights. Attendances were equally distributed between Italians and foreigners, with a slight decrease on the part of Italians, who recorded a negative percentage variation of 2.34% in Sardinia compared to 2022 (Source: Regional Tourism Observatory).

### Overnight stays in Sardinia - 2023 Total: 16.585.664

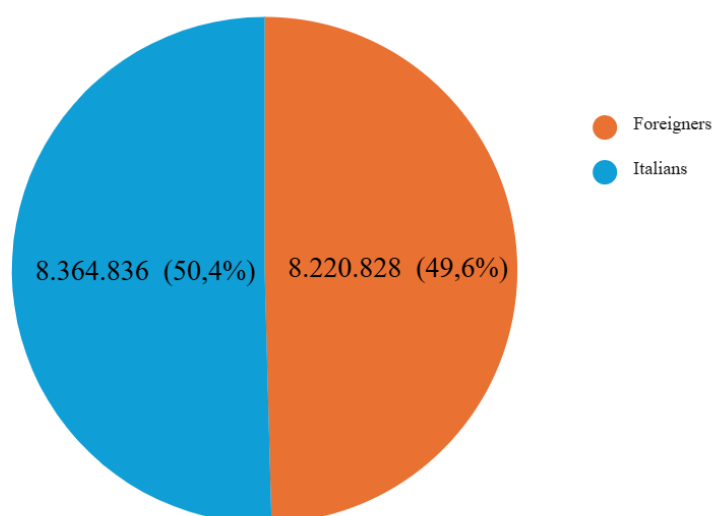


Figure 1: Overnight stays in Sardinia. Source Regional Tourism Observatory 2023

The foreign tourists who most appreciate Sardinia come from European countries and are in order Germany (2.2 Mln), France (1.1 Mln) and Switzerland (0.87 Mln).

Among the non-European countries, the United States is growing steadily, with 0.22 Mln overnight stays recording a growth of 29% compared to 2022 (Source: Regional Tourism Observatory).

### Overnight stays in Sardinia of foreign tourists by origin (in millions) - 2023

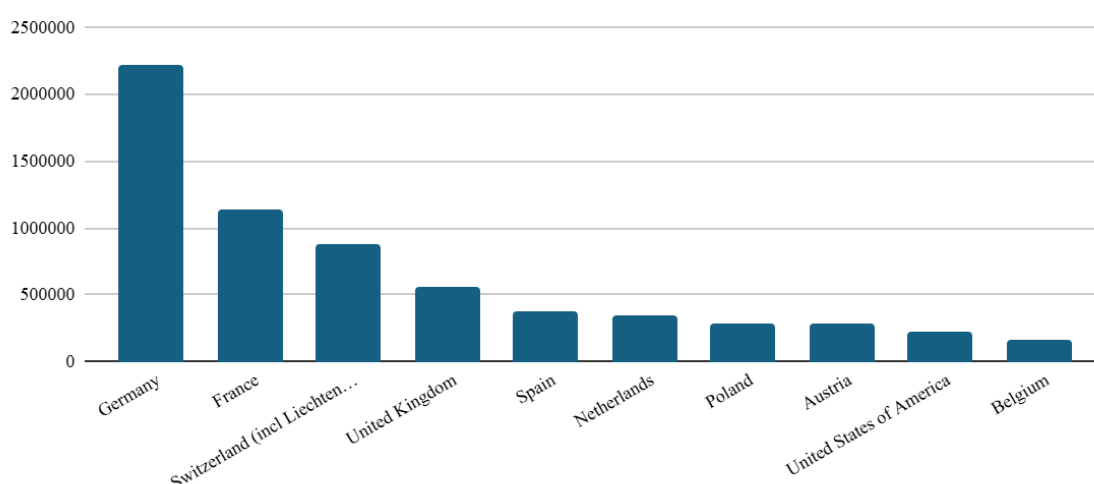


Figure 2: Foreign tourist overnight stays in Sardinia. Source Regional Tourism Observatory 2023

The distribution of overnight stays over the year shows a strong preference for sea-bathing tourism concentrated in the summer months, although in the so-called shoulder months steady growth has been consolidated due to favourable climatic conditions, a more accessible pricing policy, and the development of initiatives to promote alternative forms of tourism (e.g. active tourism), as shown in the graphs below:

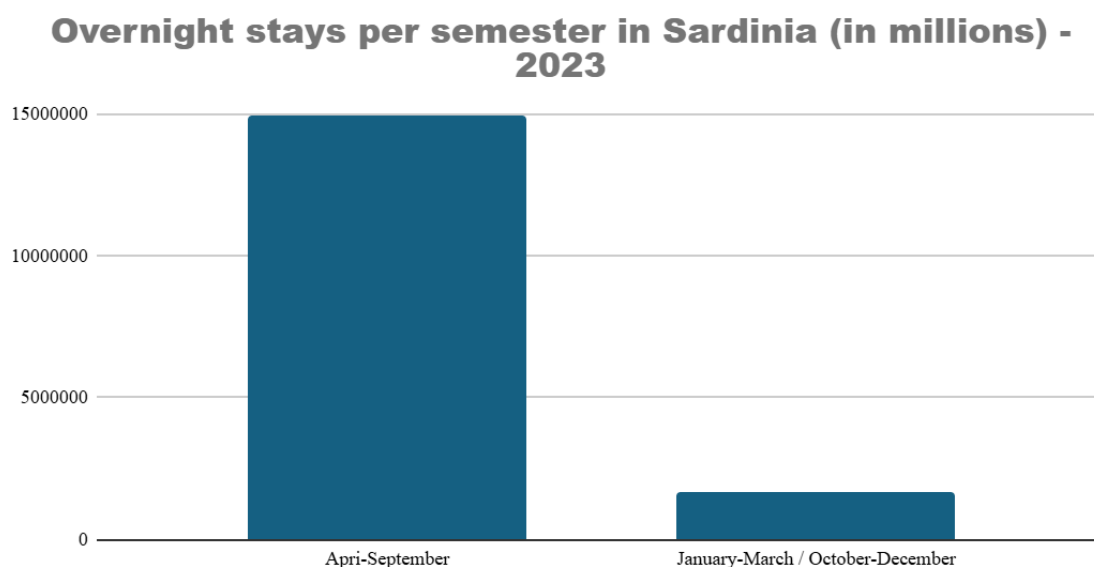


Figure 2: Foreign tourists overnight stays in Sardinia. Source Regional Tourism Observatory 2023

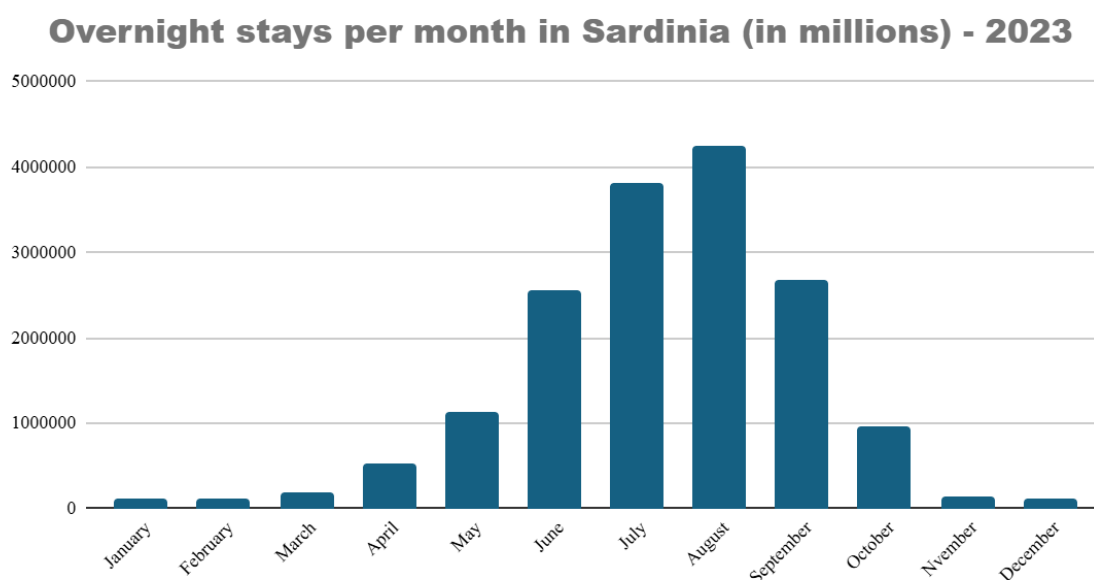
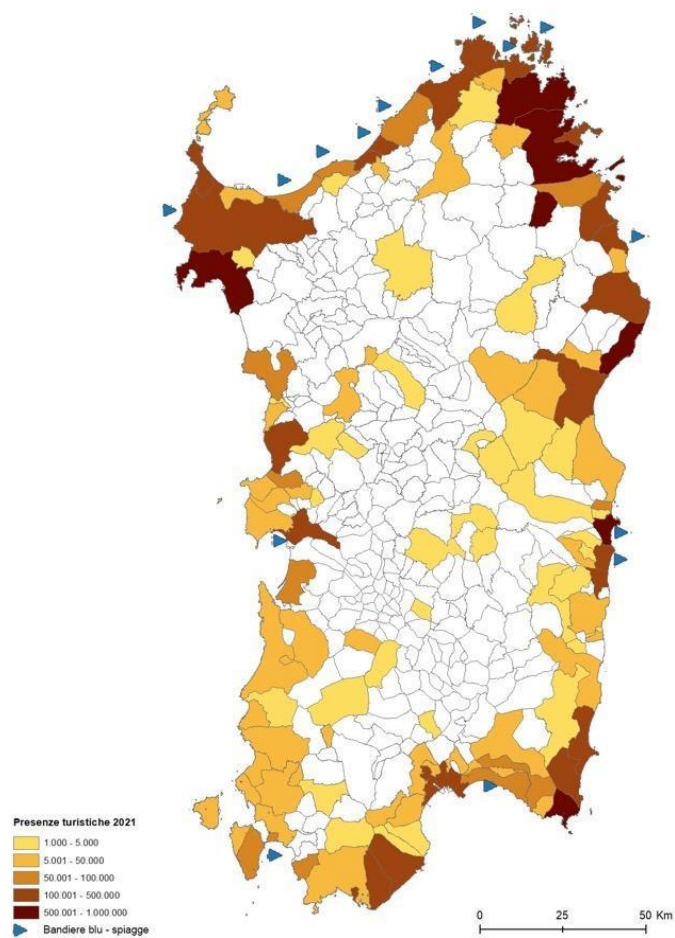


Figure 3: Overnight stays per month in Sardinia. Source Regional Tourism Observatory 2023

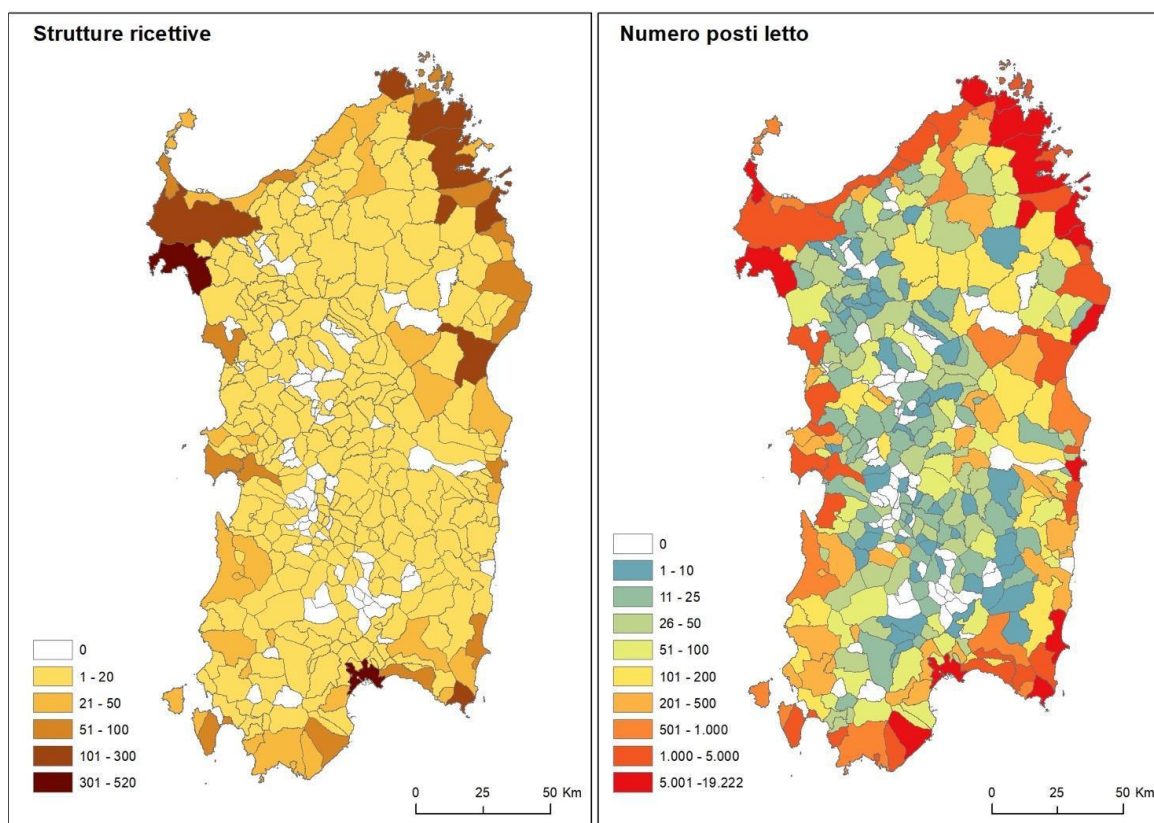


To sum up, even in 2023, despite the efforts made by policy makers to lengthen the tourist season, enhance the attractions of the innermost areas, and optimise the effects of the advent of low-cost airlines and digital advances in holiday planning, the tourism sector in Sardinia continues to be characterised by a very pronounced seasonality and a consequent concentration of tourists (overnight stays) in coastal areas, leading to situations of anthropic load and strong impact on the environment concerned.

According to the Sardinia Enterprise Report (Tourism Focus 2022), by the end of 2022, the tourism supply chain in the strict sense (which includes accommodation, restaurant services, travel agency services and tour operators) comprises 14,140 active businesses and 65,347 employees. Over the past five years, the Island has recorded a steady growth in active businesses. The presence of this sector in the Sardinian economy represents about 10% of the overall entrepreneurial fabric. This contribution is higher than the national average, which stands at 8%, placing Sardinia fourth among Italian regions for the incidence of the sector. In the restaurant field, which constitutes about 80% of tourism businesses, there has been a slight decrease in the number of companies. Fortunately, this negative trend has been offset by a 6.2% increase in the number of employees compared to 2021. The other two main sectors, however, are showing robust growth. Accommodation-related activities are rapidly approaching 2,000 businesses and employ over 13,000 people, recording an increase of 2,300 employees compared to the previous year. Tourist services, on the other hand, are experiencing growth in entrepreneurial initiatives and an increase in the number of employees exceeding 4%.



Map 1\_ Distribution of overnight stays in 2021. Source Regional Tourism Observatory



Map 2: Spatial distribution of tourist accommodation. Source Regional Tourism Observatory

Map 3: Distribution of tourist accommodations by number of beds. Source Regional Tourism Observatory

We do not have data specifically related to the incoming movement of tourists. We have data regarding passenger traffic that has passed through the main ports and airports of Sardinia. According to the 'SardegnaMobilità' portal: using our 5 ports, in 2024, 2,621,074 people arrived in Sardinia, representing an increase of 4.5% compared to the previous year. Meanwhile, using one of our 3 airports, 5,109,416 people arrived in Sardinia. The following graph shows the monthly distribution of total passengers (arrivals and departures) for the year 2024. It clearly highlights the concentration during the summer months. We also recorded 684,061 cruise passengers in transit, an increase of 57.50% compared to 2023 (source: Port System Authority of the Sea of Sardinia).

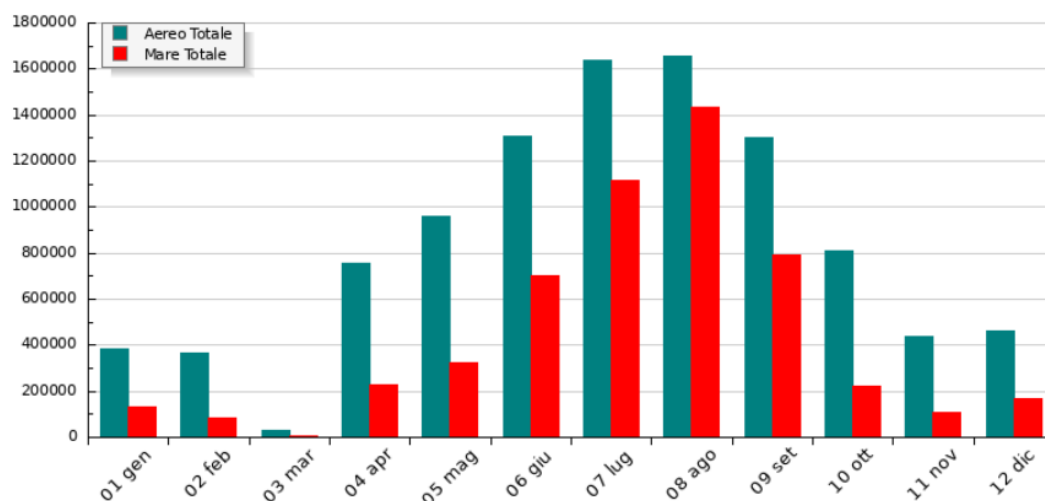


Figure 4 : Monthly distribution of total passengers (arrivals and departures) for the year 2024, source SardegnaMobilità

To sum up, the model of coastal tourism development, declined in its seaside and nautical components and extended also to the territories further inland and close to the coastal resorts themselves, determines a strong pressure, compromises sustainability and exposes the viability of the whole sector to environmental risks. The increasing intensification of the anthropogenic load therefore makes a change of course indispensable and requires the adoption of strategic policies and plans aimed not only at protecting the coastal environment, but also at responding to the challenges arising from climate change. An integrated approach that considers risks and promotes effective mitigation measures is essential to ensure a sustainable tourism future that preserves natural resources and, at the same time, promotes economic development without compromising its integrity. Protecting our coasts is, therefore, not only an ecological imperative, but also a necessity for the very survival and competitiveness of coastal tourism in the decades to come.

Tourism is one of Sardinia's largest economic sectors, acting as a significant generator of growth and employment in the island, while contributing to development and economic and social integration.

Sardinia policy aims to maintain Sardinia's status as a leading tourism destination, setting out a new strategy and action plan based on stimulating competitiveness in the sector, promoting the development of sustainable tourism and consolidating Sardinia's image as a high-quality destination.

It means promoting resilience and making tourism more environmentally friendly and implementing several ongoing legislative initiatives relating to environmental protection and climate neutrality.





### 1.3 Tourism and environmental impact

Coastal seaside tourism is considered to be one of the main vectors of significant environmental pressures and impacts. The potential adverse effects of tourism development can be subsumed under numerous different impacts, but the reverse is also true: the tourism sector is being significantly affected by climate change.

The impact of tourism on Sardinia's environment is a multifaceted phenomenon, exhibiting both positive and negative aspects. The island, renowned for its striking landscapes, pristine waters, profound history and distinctive culture, draws millions of visitors annually. While tourism brings economic benefits, it also creates several environmental challenges such as:

The issue of **overcrowding and habitat destruction** is a pressing concern for popular tourist destinations, particularly those situated in coastal areas and the island's natural parks, which experience overcrowding during peak seasons. This phenomenon has the potential to result in the degradation of sensitive ecosystems, including dune systems, beaches, and marine environments. The construction of hotels, resorts, and infrastructure (such as roads) to accommodate tourists often encroaches on natural habitats, posing a threat to native plant and animal species.

The tourism industry produces a considerable amount of **waste**, including plastics, food waste, and litter, particularly during the peak season. This waste has the potential to pollute both terrestrial and marine environments, thereby causing harm to wildlife and ecosystems. This problem is further exacerbated in regions where inadequate waste management systems are in place, resulting in environmental contamination.

The rising volume of **traffic and transport** for tourists (cars, buses and boats) contributes to air pollution and carbon emissions. The presence of boats in Sardinia's pristine waters, particularly in popular areas such as the Maddalena Archipelago, poses a considerable threat to marine life and water quality in the Mediterranean.

There is a direct correlation between the increase in **water** demand (a vital resource) and the increase in tourist numbers. The excessive utilisation of water for hotels, restaurants, and leisure activities can exert pressure on local water supplies, particularly during the dry summer months. The demand for fresh water for irrigation in tourist-heavy areas also exerts a significant impact on the region's agricultural water systems.

**Overfishing** represents a further key concern, with tourism, particularly in coastal areas, often resulting in a rise in demand for seafood, thereby exerting pressure on local fish populations. The disruption of marine ecosystems resulting from overfishing can have a detrimental effect on biodiversity.





### Biodiversity loss

Habitats, ecosystems and species are threatened by anthropogenic pressure. This is mainly represented by the construction sector, which aims to build tourist accommodation, infrastructure and facilities.

Although underestimated, tourists can also pose a threat by their own presence, causing disturbance to wildlife, including nesting sites for marine species such as sea turtles, e.g. nesting activities of *Caretta caretta*.

Human activities are also dangerous for the introduction of invasive species, and overexploitation of marine resources, such as overfishing and damage to marine life from diving tourism.

### Soil: land degradation

Soil degradation in the region of Sardinia is an issue of considerable environmental concern. Despite low consumption compared to the national average, Sardinia suffers from a high risk of desertification, making land use even more critical.

The main causes of soil degradation in Sardinia have been identified as deforestation, overgrazing and poorly managed agricultural practices. These activities have resulted in a number of negative impacts, including soil erosion, loss of organic matter and reduced soil fertility.

According to the ISPRA-SNPA 2024 report, between 2022 and 2023, 462 hectares of soil were consumed in Sardinia, mainly due to infrastructure and industrial activities. Soil consumption occurs mainly through the conversion of natural or agricultural areas into artificial surfaces, often sealed with cement or asphalt. Although Sardinia has a low population density, this phenomenon is increasing and is monitored by ARPAS, the Regional Agency for Environmental Protection<sup>1</sup>.

One of the most evident effects of degradation is the loss of green areas: all over the island there is an increase in concrete at the expense of biodiversity and soil quality. For example, the municipality of Uta has seen an increase of 106 hectares of soil consumed in a single year, followed by Porto Torres (+36 hectares) and Olbia (+31 hectares). Sardinia is also the region with the largest degraded surface area in absolute terms, with 641,000 hectares of soil that have lost productivity, economic value and biodiversity, increasing vulnerability to hydrological phenomena.

Although Sardinia is one of the regions with the lowest population density in Italy (about 68 inhabitants per km<sup>2</sup>, compared to a national average of about 200), it has experienced an increase in land consumption in coastal and urban areas. Sardinia has a lower consumption than the northern Italian regions, but higher than other less urbanised southern regions.

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<sup>1</sup>Source: <https://www.sardeгнаambiente.it/>

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The consumption rate is lower than the national average, but still increasing, particularly in the provinces of Cagliari, Sassari and Olbia-Tempio.

The coasts and urban areas are the most affected due to the expansion of tourism and the construction of new infrastructure.

Moreover, Sardinia has been experiencing a decline in green areas due to deforestation, wildfires, and land-use changes. The island has seen a notable loss of tree cover over the years, with key drivers including agricultural expansion, urbanization, and climate change-related factors such as prolonged droughts and heat waves<sup>2</sup>.

Sardinia has a high (around 19% of terrestrial and marine area) percentage of protected areas and Natura 2000 which limits urban expansion compared to other Italian regions. Infact, the Natura 2000 network - which is a European Union initiative for biodiversity conservation - consists of a large number of protected areas. Specifically, the region has a total of 128 sites designated under this network. These include 31 Special Protection Areas (SPAs), which are focused on protecting birds, and 89 Special Areas of Conservation (SAC), which aim to preserve critical habitats. Additionally, there are 8 Sites of Community Interest (SCI) awaiting final approval<sup>3</sup>.

Furthermore, a significant proportion of the island of Sardinia is covered by Natura 2000 areas. A considerable number of these areas also overlap with other forms of protected areas, including national and regional parks, as well as nature reserves and marine protected areas. These latter areas also represent an important spotlight in terms of sustainable tourism experiences.

#### Water pollution and scarcity

Increased demand for freshwater resources, leading to depletion of local aquifers. Pollution from untreated sewage, chemicals and plastic waste affecting coastal ecosystems. Eutrophication from agricultural and tourism run-off leading to algal blooms.

#### Air pollution

Greenhouse gas emissions from increased transport, including air travel, cruise ships and vehicles. Increased energy consumption in resorts and tourism facilities, often dependent on fossil fuels. Air quality degradation from increased vehicle emissions and construction dust.

#### Coastal and marine degradation

Damage to marine ecosystems from boating, anchoring and underwater recreational activities. Beach erosion caused by poor land-use planning and unregulated development. Waste generated by tourists, particularly plastic and non-biodegradable materials.

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<sup>2</sup> Source: <https://www.globalforestwatch.org/dashboards/country/ITA/14/>

<sup>3</sup> Source: <https://portal.sardegna.it/rete-natura-2000-dati-ambientali>, <https://natura2000.eea.europa.eu/>



## 1.4 Main plans and strategies framework

The Autonomous Region of Sardinia approved the **Regional Strategy for Climate Change Adaptation**<sup>4</sup> (SRACC) in 2019, with a subsequent update and expansion of the strategy in 2024. Moreover, in 2023, the **Regional Strategic Tourism Plan**<sup>5</sup> (STP) was adopted, which sets out a strategic framework document for the period 2023-2025. Consequently, the documents form the baseline and the conceptual and methodological framework within which this plan is situated. This paper sets out the intention to proceed with the identification of integrated lines of implementation specifically aimed at the adaptation of coastal tourism to climate change, starting from the above-mentioned documents.

As will be better seen in Chapter 2, the Regional Strategy for Adaptation to Climate Change (SRACC) provides a wealth of information on the climate profile of Sardinia over the period 1981-2010, as well as studies on climate scenarios. Furthermore, it offers methodologies and instruments for identifying climate change adaptation objectives across diverse sectors.

At the strategic level, the Regional Strategy for Sustainable Development Sardegna2030<sup>6</sup> (RSSD) is another pertinent reference document. The RSSD constitutes the regional reference framework for environmental and territorial planning, programming and evaluation processes. The Strategy, which localizes the 2030 Agenda to the regional level, identifies objectives, lines of intervention, actions and targets for a sustainable development pathway that includes energy transition actions for the decarbonisation of the economy and towards a model of economy, protection of biodiversity and strengthening the resilience of ecosystems; interventions to strengthen the culture of sustainability and responsible consumption, to name but a few. Within this Strategy, Objective 7 aims to 'Achieve sustainable tourism for socio-economic development and the protection of culture and biodiversity', which is therefore capable of integrating the various dimensions of sustainability, integrating the environmental and ecotourism aspects with the social and inclusion aspects, since the sector is considered an important lever for territorial enhancement, economic growth and territorial cohesion.

Sardegna2030 incorporates adaptation to climate change as a fundamental, cross-cutting principle, which is operationalised throughout:

- integration of climate change considerations into multi-level programming and planning;

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<sup>4</sup> See SRAAC document at this link chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/<https://portal.sardegnaasira.it/documents/21213/201290/SRACC2024.pdf/88c09cce-a7fa-407a-8edb-aeb310f6a6a1>

<sup>5</sup> See STP document here chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/<https://delibere.regione.sardegna.it/protected/68798/0/def/ref/DBR68454/>

<sup>6</sup> See Sardegna2030 <https://delibere.regione.sardegna.it/protected/57126/0/def/ref/DBR57095/>



- enhancement of surveillance and warning systems;
- management of the effects of climate change in diverse policy domains;
- augmentation of the adaptive capacity of the regional system.

From a regulatory and political aspect, the main reference document for the development of tourism in Sardinia is the Regional Strategic Tourism Plan 2023-2025 (approved by DGR n. 47/2 of 29.12.2023), which serves as a reference point for strategic guidelines for the sector. Given that one of the region's primary attractions is its environmental and natural heritage, the Plan was formulated in accordance with the Regional Strategy for Sustainable Development - Sardinia 2030.

The document aims to develop an integrated tourism development strategy and to establish an ad hoc digital platform to create a sophisticated land monitoring system. Aspects of environmental sustainability constitute the so-called 'transversal axis of sustainability', in which many environmental issues are considered, although further clarification and evaluation is required regarding climate considerations. The plan was developed through the collaboration of 14 thematic tables, dedicated to collecting stakeholder needs and proposals from the public and private sectors. This included a specific table focused on "coastal-swimming and nautical tourism". We believe that this table can be a useful reference for the stakeholder involvement process for the purposes of the Tourism and Climate action plan for Sardinia.

The Regional Strategic Tourism Plan 2023-2025 identifies the 'Sardinia Tourist Platform' and the 'Sardinia Tourism Index' as one of the solutions deriving from the technological context. This tool collects data and indicators concerning various aspects of tourism (e.g. environmental impact, natural resource management) and allows for an objective assessment of the sustainability of the destination. This will help policy makers, operators and local communities to make informed decisions to improve tourism management in a way that is sustainable in the long term.

The 'Sardinia e-tourism index' was developed from the results of the research obtained with the creation of the SMAS protocol (©DUMAS-UNISS). If the index is parameterised to measure climate resilience, it could be used to assess how a destination is adapting to climate change.

At the planning level, reference documents include the Regional Landscape Plan, the Hydrogeological Structure Plan and its implementation rules, the Regional Plan of the Tourist Port Network (currently undergoing SEA - Strategic Environmental Assessment), and the Water Protection Plan. These documents are all highly relevant for the purposes of this Plan, but the integration of climate considerations is still in its infancy. In the implementation of the SRACC, dedicated working tables are being established to address this specific objective.

The region does not have coastal planning but only cognitive tools such as the Coastal Action Programme (PAC), dated 2013, which gives a description of the Sardinian coastline, identifying low, medium and high criticality stretches. This tool is used as a reference for planning coastal defence interventions.



Within the framework of the Interreg Euro Med project '[POSBEMED2](#)', coordinated by Sardinia Region, it has been elaborated **a manual for conserving Mediterranean beaches with posidonia oceanica and assessing progress of management actions**<sup>7</sup>.

Considering the important ecological role of posidonia meadows for the marine ecosystem and of posidonia banquette in terms of barrier to coastal erosion, the project and the manual contribute to the dissemination of good shoreline management practices. In particular, it enables a long-term, balanced perspective of coastal management including climate change issues and the use of nature-based approaches, and promotes public understanding of Posidonia coastal areas and proposed management approaches with consultation and participation of stakeholders.

It is important to note here that the project involved the regional administration and two protected areas (Penisola del Sinis - Isola di Mal di Ventre MPA and Capo Carbonara MPA).

Sardinia recognises, with its own law, the deposits of beached posidonia on the coasts as a natural defence tool against coastal erosion and, at the same time, allows the removal of the same only from the coasts where they prevent the regular use of the beaches during the summer season, defining, as of 2016, the operating procedures. The two protected areas have carried out interesting experimental projects on the application of NBS to manage Posidonia beach-dune systems.

In relation to this last aspect, the Region is currently working on the preparation of the specification for the classification of beaches and the drafting of regional formal guidelines for writing the management plan for Posidonia on beaches. We are confident that the implementation of this tool will allow better beach management by identifying the best management methods on a case-by-case basis.

### 3. COLLECTION AND ANALYSIS OF HISTORICAL CLIMATE DATA

#### 2.1 DESCRIPTION OF DATA COLLECTION METHODS

The climate database adopted by the Regional Strategy for Adaptation to Climate Change (SRACC) is based on the processing of the climatic data of

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<sup>7</sup> See this document here <https://iucn.org/resources/grey-literature/manual-conserving-mediterranean-posidonia-beaches-and-assessing-progress>



Sardinia measured and registered by weather stations homogeneously spread in the island territory (constantly monitored by the Regional Agency for Environmental Protection - ARPAS) for the thirty-year period 1981-2010 and for the main meteorological variables. This was achieved through procedures for controlling and processing historical data series of temperature and precipitation.

The climate scenarios adopted in the SRACC to highlight the trends up to 2050 of the main climatic variables and the resulting climate indicators are those provided by the regional climate model COSMO-CLM of the CMCC Foundation - Euro-Mediterranean Center on Climate Change. Regarding future climate, data from climate projections were used, expressed through the expected potential variations under the RCP4.5 and RCP8.5 scenarios for the period 2021-2050 compared to the reference period 1981-2010, with a spatial resolution of a grid of 2x2 km. After careful evaluation of the scenarios, only the RCP4.5 scenario was considered, which foresees the implementation of mitigation policies in the future, while the worst-case scenario RCP8.5, which does not foresee any mitigation policy, was disregarded.

The work was structured in the following phases: processing the climatology of the main meteorological variables based on available data; defining the database of daily series, quality control, and homogeneity analysis; calculating climate normals; interpolating the climatologies of the processed meteorological variables on a regular grid; comparing the interpolated climatology (from observations) and the synthetic climatology (numerically estimated) and correcting systematic errors in future temperature scenarios; calculating the climate normals for 1981-2010 and producing outputs: indices and indicators. On the regional website, maps of the main climatic variables and indicators are available, periodically updated at <https://portal.sardegna.sira.it/clima>.

The strategic sectors identified in the SRACC are as follows: coast and transitional environments, health and well-being in urban areas, infrastructure, water resources, forests, agriculture and livestock, hydrogeological instability, and fires. In defining action priorities, the involvement of stakeholders is essential. Therefore, at the regional level, for each strategic sector identified by the strategy, key stakeholders have been identified and interviewed.

To gather relevant information for assessing the adaptation capacity for each of the aforementioned sectors, the following categories of stakeholders were involved:

- Public entities: e.g., regional technical and political agencies, local administrations;
- Sector organizations;
- Economic operators;
- Research entities;
- Sector experts;
- Civil society actors.



With reference to the dataset, difficulties are recorded regarding the availability, quality, comparability, and continuity of the data. Some fundamental statistical data for the construction of adaptive capacity indicators are difficult to obtain and are not always available at different scales. Furthermore, the spatial resolution of climate scenarios does not allow for data to be available at the coastline due to the models used. For decision-making, the availability of data at the local scale is essential. A coordinated approach to the collection, production, storage, and processing of data would be necessary for a proper assessment of climate and environmental risks. Sector-specific data and related indicators are indeed crucial for measuring and monitoring risk factors, causes, and direct and indirect impacts related to various hazards, exposure, vulnerability, the extent of potential losses and damages concerning the population, ecosystems, and infrastructure. There is a lack of data regarding the impact of climate change on the health and well-being of the population, particularly concerning the generalized increase in temperatures and the frequency and intensity of heat waves. In reference to the tourism sector, particularly coastal beach tourism, there is no available data on sea-level rise and wave strength as there are insufficient monitoring systems in place. This issue affects the monitoring of coastal erosion, which is currently analyzed mainly through site-specific case studies. Additionally, specific studies on the effects of climate change on the socio-economic and sectoral system of the region have not yet been developed.





## 2.2 STATE OF THE ART OF CLIMATE ACTION PLANNING AND ASSESSMENT

The SRACC provides methods and tools to ensure that climate considerations are integrated into regional and local sectoral policies. The Strategy outlines how to integrate climate change adaptation into plans, programs, and projects, serving as a guide in this regard.

According to the provisions of the SRACC and the SRSvS, all regional plans and programs must include the integration of aspects related to climate change adaptation and sustainable development, in order to pursue "climate-compatible development." However, identifying adaptation actions in sectoral plans and programs is the responsibility of the holder of each individual Plan. The SRACC has chosen the approach of mainstreaming climate change adaptation, pursued through the identification of specific actions in plans, programs, and projects.

Therefore, also with reference to the coastal tourism sector, starting from the involvement of stakeholders, it will be necessary to identify:

- the risks and main potential impacts due to climate change in the sector;
- sources of danger;
- elements of the system exposed to climate risk;
- sensitivity factors and adaptive capacity for determining the vulnerability of the system;
- objectives to be pursued, related to adaptation goals;
- actions to be implemented, appropriately classified based on their contribution to the regional adaptation process.

The capacity to adapt depends on the context, processes, and determining factors such as:

- - governance, institutions, and policies;
- - human capital;
- - technology and research;
- - social capital;
- - biophysical factors;
- - infrastructure;
- - economic factors;
- - attitude/flexibility.



## 2.3 ANALYSIS OF PAST EXTREME WEATHER EVENTS

The analysis of climate data for the reference period 1981-2010 showed a **general positive trend for temperatures, both in maximum and minimum values, and a slight overall decrease in the average annual precipitation total**, although this is not observable in all areas of the region. These trends have been represented through the calculation of appropriate indicators of climate extremes, which have allowed for the representation of the trend of heatwaves, drought periods (frequency and duration), and intense precipitation events. Such phenomena produce effects on natural and human systems, particularly on water resources and ecosystems.

Changes in the water cycle pose the risk of significant quantitative and qualitative changes in water resources, a reduction in water availability during the summer period, and alterations in chemical-physical, biological, and ecological parameters. Regarding ecosystems, the impact on biogeochemical cycles and biodiversity can lead to the loss of habitats and species, changes in distribution areas, and the compromise of functionality and ecosystem services.

These factors contribute to a decline in the quality of life for the population, an increase in health risks for citizens (excess mortality and morbidity, diseases, impact of infectious diseases), and greater exposure to risk factors such as landslides, floods, inundations, and fires. Finally, the increase in energy needs and potential impacts on economic activities are a source of stress on infrastructure and network systems.

Below is the list of indicators used in the SRACC and data for the reference period 1981-2010.

Indicator	Unit	Description	min	max	mean	median	trend
<b>Maximum temperature (Tmax)</b>	°C	Maximum mean climatic temperature					↑
<b>Minimum temperature (Tmin)</b>	°C	Minimum mean climatic temperature					↑
<b>Average temperature (Tmean)</b>	°C	Maximum mean climatic temperature					↑
<b>Maximum of maximum temperature (TXX)</b>	°C	Maximum value of the maximum daily temperature	33,9	44,4	39,1	39,3	↑
<b>Tropical nights (TR)</b>	days	Number of days with a minimum daily temperature greater than 20°C					↑
<b>Consecutive dry days (CDD)</b>	days	Maximum number of consecutive days with daily precipitation less than 1 mm	44,8	88,7	61	61,2	↑↓
<b>Heat waves (HW)</b>	days	Number of days with a maximum daily temperature greater than 35°C					↑

<b>Number of heat waves (HWN)</b>	number	Number of heatwaves. A heat wave is identified by the exceeding, for at least 3 consecutive days, of the 90th percentile of maximum temperatures assessed over a moving window of 31 days in the 30-year reference period					↑
<b>Cumulative precipitation on rainy days (PRCPTOT)</b>	mm	Sum of daily precipitation for days with daily precipitation greater than or equal to 1 mm					↓
<b>Days with heavy precipitation (R20)</b>	days	Number of days with daily precipitation greater than 20 mm	3,4	15,2	8	7,8	↑
<b>95th percentile of daily precipitation (PR95prtile)</b>	mm	Value of daily precipitation associated with a probability level of not exceeding 95%, extracted from the sample of daily precipitation values greater than or equal to 1 mm	77,2	322,3	156,4	142,9	↑
<b>Maximum daily precipitation (RX1DAY)</b>	mm	Maximum daily precipitation value for days with daily precipitation greater than or equal to 1 mm	35,6	134,9	58	50,4	↑
<b>Maximum precipitation in 5 days (RX5DAY)</b>	mm/days	Maximum precipitation in 5 days	61,8	215,4	98	88,2	↑

Figure 5 :Indicators used in the SRACC (reference period 1981-2010)

The perception of the threats posed by climate change is strong in response to the occurrence of extreme weather events that cause direct damage. However, awareness and information regarding vulnerability, and therefore the prevention and adaptation measures to be adopted, are lacking.

The population groups most at risk are the elderly, children, and vulnerable individuals. Unemployed people and socially marginalized individuals, as well as those with lower incomes and less access to resources, are among the most susceptible to climate risks.

## 4. IDENTIFICATION OF VULNERABILITIES

### 3.1 EXPOSURE OF REGION TO CLIMATE HAZARDS

Local climate variability and the evaluation of future anomalies due to climate change resulted from the study of the climate situation in Sardinia for the thirty-year reference period 1981-2010 of Sardinian strategy.

Climate projections have highlighted how the region will be characterized in the future by a general increase in temperature values, a reduction in the amount of total annual precipitation, an increase in average sea level and a general increase in average sea temperature. Climatic extreme values both in temperature and precipitation events are expected in intensity and frequency, particularly leading to heavy precipitation, storms and floods, river floods,

drought and heat waves. Impacts are expected also in coastal erosion, saline intrusion and watershed salinization processes, with biodiversity loss and reduction in crop production.

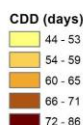
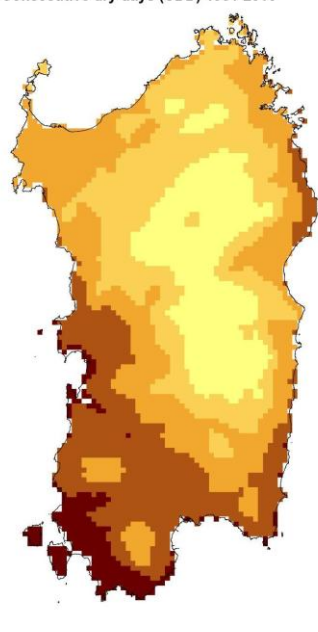
### 3.2 EXPOSURE OF TOURISM TO CLIMATE HAZARDS

The tourism-related sectors, which are particularly vulnerable to climate hazards, include:

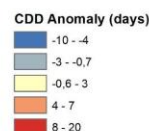
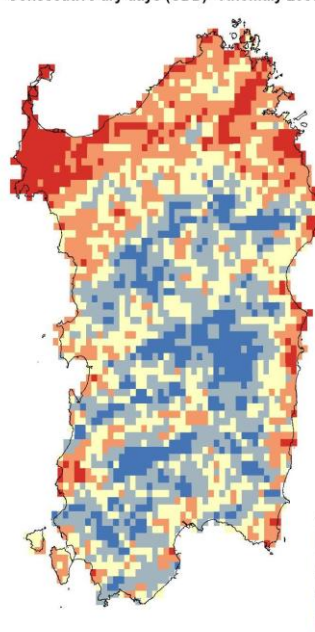
- the water-intensive production sectors (e.g., agriculture, energy) in relation to competitive use and the uneven spatial and temporal availability of water resources during the summer;
- fishing and aquaculture, due to changes in the structure of marine ecosystems caused by the combined effects of acidification, rising surface temperatures, and reduced oxygen content in the waters, leading to a decline in fish stock productivity;
- agriculture and livestock farming concerning the quality, quantity, and stability of production, the decrease in soil productivity and quality, the shifting of cultivation areas, and animal welfare;
- infrastructure and transportation, in relation to the increased demand for energy competing with the needs of the local population (e.g., for cooling environments and transportation means, etc.).

Future scenarios for Sardegna can be illustrated through spatial representations of the main climate change indicators (source SRACC).

Consecutive dry days (CDD) 1981-2010



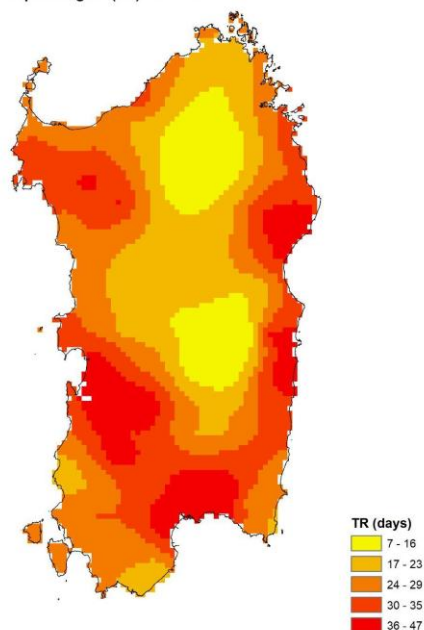
Consecutive dry days (CDD) - Anomaly 2050 RCP 4.5



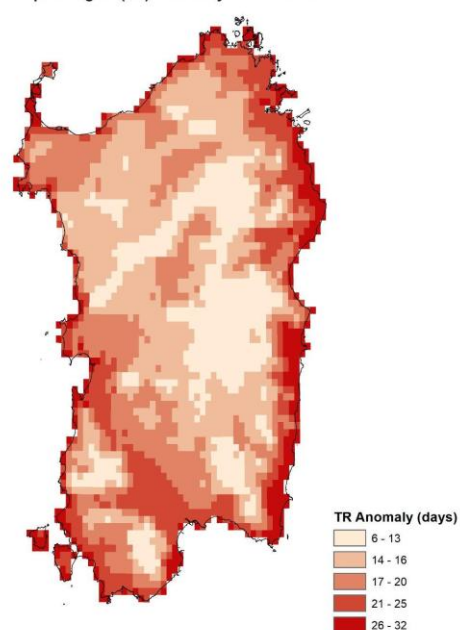
Map 4: Consecutive dry days 1981-2010

Map 5: Anomaly 2050 with RCP 4.5. Source SRACC

Tropical nights (TR) 1981-2010



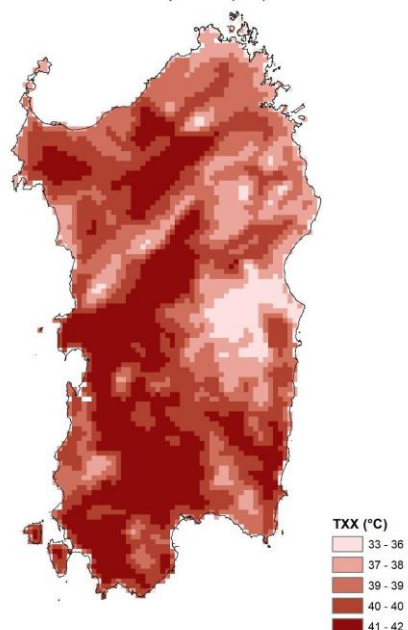
Tropical nights (TR) - Anomaly 2050 RCP 4.5



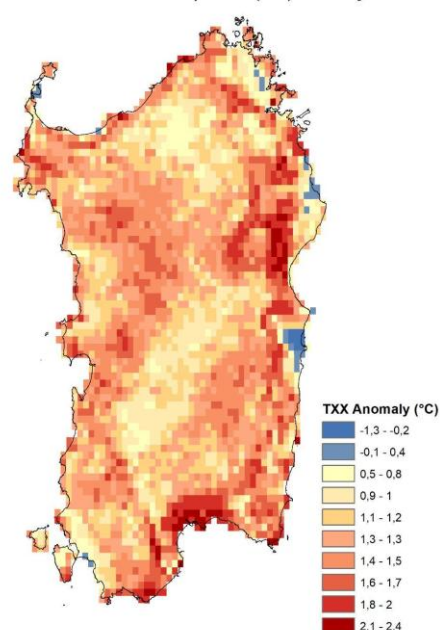
Map 6: Tropical nights 1981-2010. Source SRACC

Map 7: Anomaly 2050 with RCP 4.5. Source SRACC

Maximum of maximum temperature (TXX) 1981-2010



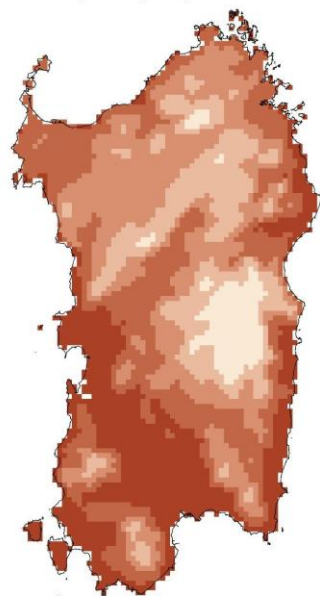
Maximum of maximum temperature (TXX) - Anomaly 2050 RCP 4.5



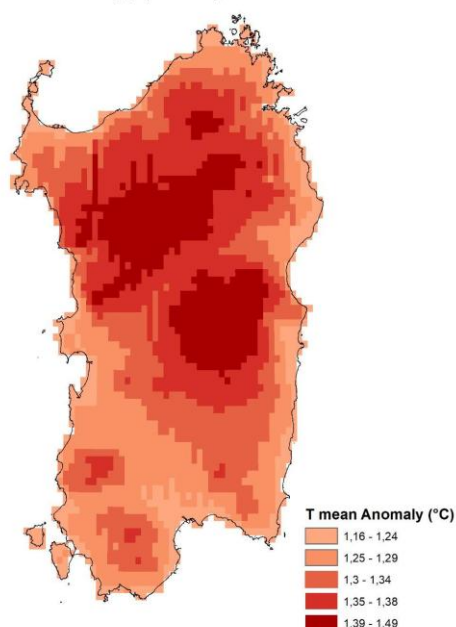
Map 8: Maximum of maximum temperature 1981-2010

MAP 9: Anomaly 2050 with RCP 4.5. Source SRACC

Maximum temperature (Tmax) 1981-2010



T mean Anomaly (°C) - Anomaly 2050 RCP 4.5



Map 10: Maximum temperature 1981-2010

Map 11: T mean Anomaly 2050 with RCP 4.5. Source SRACC

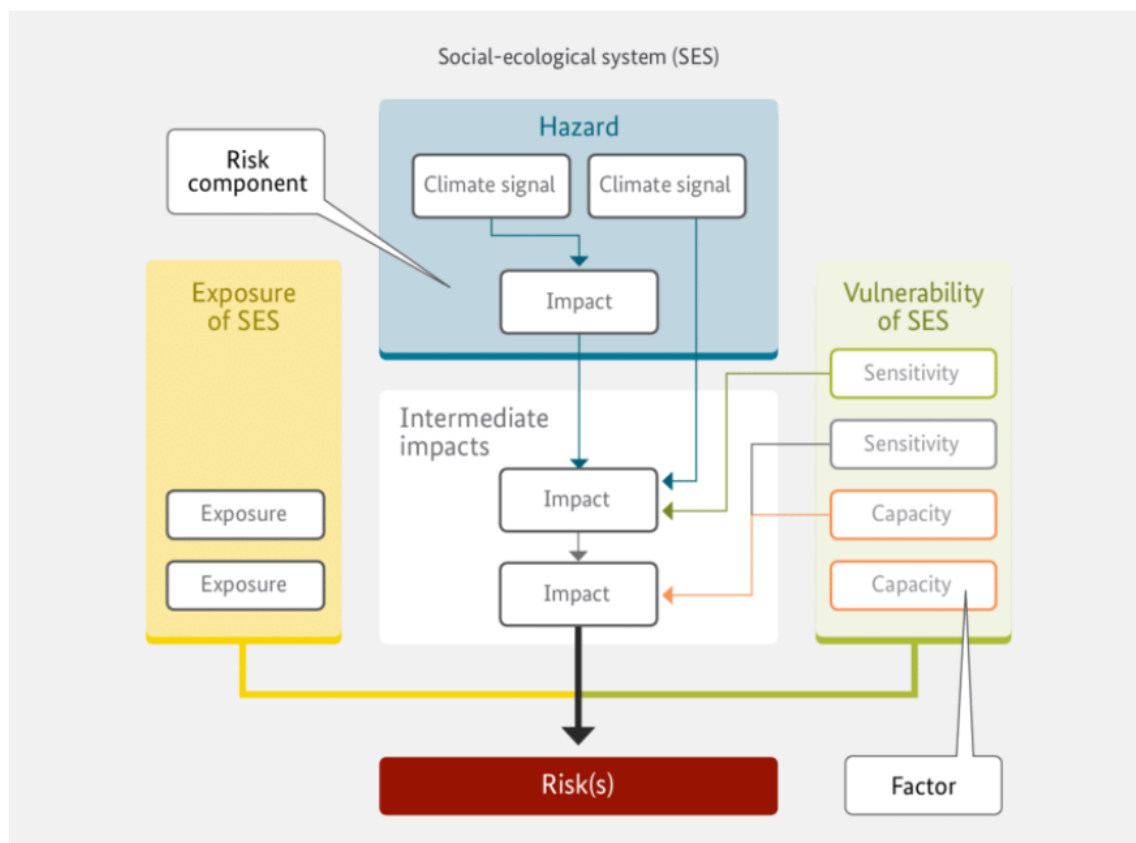
The Regional Strategy adopts Climate impact chains to define vulnerability, exposure to climate hazards and perturbations, sensitivity – adaptive capacity

Through this method it is possible to

- Determine and project hazards and sensitivity
- Determine and project adaptive capacity
- Integrate and map vulnerability
- Identify, assess, and review adaptation operations

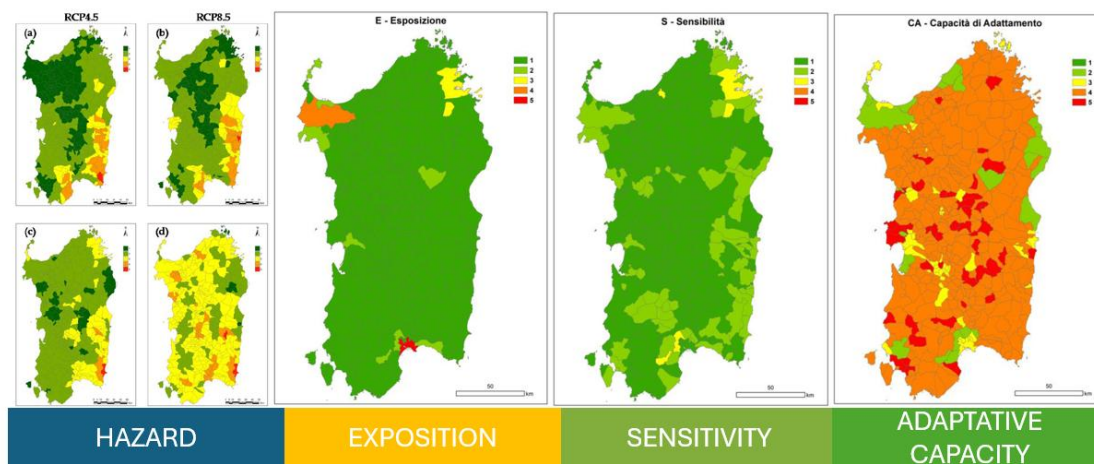
The method for creating vulnerability maps is shown below.





Structure and key elements of an impact chain (Source: GIZ and EURAC 2017)

Figure 6: Structure and key elements of an impact chain: Source GIZ and EURAC 2017



RISK OF FLOODING WITH LOSS OF HUMAN LIVES IN URBAN ENVIRONMENT

Map 12: Risk of flooding with loss of human lives in urban environments.



### 3.3 ASSESSMENT OF CURRENT IMPACTS ON TOURISM

The tourism sector, with particular reference to coastal tourism, suffers direct effects with respect to unfavourable climatic conditions and indirect effects on the tourist attractiveness of destinations with reference to the modification of the current layout of the coastline, its habitats and the tourist activities and infrastructures that contribute to wellbeing and social subsistence with consequent variation and shifting of tourist flows and seasonality.

To date, among the potential specific impacts on coastal tourism we can indicate:

- beach erosion and damage to the coastline;
- damage to coastal infrastructures and safety risks;
- pollution and environmental degradation;
- alteration of local tourism traditions;
- reduction of outdoor activities;
- increase in costs for stakeholders in the production chain;
- sudden change in tourism preferences and cancellation of bookings;
- slowdown in coastal tourism growth.

Some of these impacts can be estimated and described from regional environmental measures and monitoring campaigns, some others derive from economical statistical surveys and annual reports that will be incorporated in the Strategy. Further information will be pointed out in next phases of the project in the coming months.

### 3.4 FUTURE PROJECTIONS AND ANTICIPATED RISKS

The analysis of climate data and the outputs of climate models to 2050 have shown for the region:

- increase in temperatures;
- increase in the duration and frequency of heat waves
- increase in heat extremes
- reduction in the average annual precipitation accumulation;
- high intensity and frequency of extreme weather events;
- increase in the duration and frequency of drought periods

The main impacts attributable to the above-mentioned hazards can be summarised as follows

- hydrogeological instability;



- increase in mean sea level;
- increase in wave energy;
- coastal erosion;
- loss of ecosystem services;
- increase in mean sea temperature.

## 5. 4. GENERAL RECOMMENDATIONS FOR THE CLIMATE ACTION PLAN

The reference tool for the identification of adaptation actions is the National Climate Change Adaptation Plan (PNACC, 2024) which contains the climate framework with sectoral impacts and vulnerabilities on a national scale, measures, actions and governance.

The PNACC, guides the development of climate change adaptation strategies and plans at regional and local scales by identifying for each sector the framework of adaptation measures and reference planning directions.

The database of sector actions identified by the PNACC for the tourism sector represented below constitutes the basic matrix of regional and local adaptation objectives to be declined and implemented for the tourism sector at the local scale.

PNACC Actions	Description
Diversification of the tourism offer	Integrates or replaces traditional tourist products (e.g., beach tourism, winter mountain tourism, etc.) with other proposals that can be attractive to tourists: wellness tourism, food and wine tourism, sports tourism, cultural landscape tourism, etc.
Destagionalization	Encourages tourists to shift their vacations to periods different from the traditional ones.
Monitoring and alert systems for extreme events in urban areas	Alerts people present in a given area (residents and tourists) in case of extreme weather events (especially heatwaves).





Monitoring systems for the sustainability (environmental, social, and economic) of the tourist destination	Detects and monitors the sustainability of tourism development in a destination from an environmental, social, and economic perspective and identifies any signs that may indicate a decline in tourism in the destination.
Conservation and reconstruction of coastal natural environments	Conservation and reconstruction of dunes and wetlands (ponds, lagoons, etc.), river renaturation, conservation of <i>Posidonia oceanica</i> , and proper planning of beach cleaning.
Reforestation of urban areas and the creation of green spaces within cities	Increase in urban areas designated for public green spaces.
Preservation of local agricultural crops and non-timber forest products through brands, labels, or image enhancement campaigns	Incentives, branding, labeling, and communication campaigns to enhance the image of typical Italian agriculture, differentiated according to regional specificities.
Promotion of insurance policies for managing climate risks	Promotion of the use of insurance products and innovative financial products to reduce risks related to extreme weather events.