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Report on the local scenarios

Regional Natural Park “Coastal Dunes from Torre Canne to Torre San Leonardo” pilot site

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Partner in charge	Unibo
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Index

Abstract

XXXXX.

1. Introduction

Main points:
Scope of the report/objectives of the scenario analysis:
Based on the results of the analysis conducted with A.1.2 (pilot area characterization) and A1.3. (threats and hazards evaluation), the scenarios and adaptation solutions for each pilot area are discussed.

2. Methodology

Same as D.1.3.1
TO BE NOTED: IN THIS SECTION WE COMMENT AND DESCRIBE SHEETS REGARDING EXPOSURE, VULNERABILITY AND RESIDUAL RISK

2.1. .....

Fig. 1 – (a) .....

Table 1 - .....

3. Results and discussion

3.1. Exposure

3.1.1. Current and Future Climate Exposure

As described in the deliverable D.1.3.1 "Report on the hazards and threats of the pilot areas in the medium and long term", the Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo pilot site is a fragile area exposed to a multifaceted and systemic vulnerability of the area to climate change. The evaluation of key investigated sectors (geo-biodiversity, tourism, agriculture, and fishing/aquaculture) reveals how climate drivers such as temperature increase, changes in precipitation and hydrological regimes, sea level rise, saltwater intrusion, and coastal erosion interact with ecological processes and socio-economic dynamics, resulting in widespread sensitivity across the system.

Related to the thermal risk and climate extremes risk, the pilot site is exposed to an increase of frequent heatwaves especially during the summer period with the related reduction of water availability, with a direct impact on ecosystem, agriculture and tourism. In detail, based on the analysis the key coastal and backdunal habitats as well as wetlands are highly sensitive to wildfires, which are expected to destroy habitat structure, faunal shelters, and ecosystem integrity. Moreover, the impacts of the temperature increase affect all the dimensions considered for the agricultural sector, since high temperatures and heat waves can alter the crop cycles, as they disrupt crop calendars, reducing yields in grapes, fruit trees, and vegetables. As a consequence, higher irrigation and plant protection treatments are required.

The pilot site presents a moderate-high hydraulic and hydrogeological risks arising from the combined influence of natural processes, human-induced alterations, and the effects of climate change. In detail, recent extreme rainfall events have confirmed its vulnerability: in 2025, as well as in 2016, a violent cloudburst struck Ostuni and the surrounding coastal zone, producing up to 70 mm of rain within three hours, accompanied by strong winds and hail. This episode exemplifies the intensity and suddenness of convective storms increasingly affecting the Adriatic coast. Saltwater intrusion is also associated with high sensitivity across all the accounted components, since it strongly reduces irrigation water quality, drives soil salinization, and forces shifts in crop selection.

Related to the geological and land degradation risk that the pilot site is exposed with a moderate-high level. In detail, the coastal erosion and soil degradation affect habitat quality and ecosystem functioning. Coastal erosion favours shoreline retreat and the loss of sediments, leading to the narrowing of beaches and the degradation of natural habitats, such as dunes and wetlands. It can also result in the exposure of natural and anthropogenic structures to wave action and storm surge, and in the increase of the risk of coastal flooding. By way of example, erosion of wetland margins leads to the collapse of nesting banks used by birds, while also reducing shallow-water nursery zones essential for juvenile fish and invertebrates. Soil degradation and erosion reduce fertility, increase runoff, habitat productivity, and regulating services, and as a consequence, species richness is also rated as high sensitive.

The current and near-future climate exposure of the Dune Costiere pilot area is moderate-high, shaped by the interplay of hydraulic, thermal, and geomorphological risks amplified by land-use change and reduced soil permeability. The 2025 Ostuni flood stands as tangible evidence that extreme weather is already impacting the area, underlining the urgency for

integrated adaptation, soil restoration, and nature-based protection measures to preserve the ecological and socio-economic resilience of this coastal landscape.

Scenario SSP2 – 4.5

The SSP2-4.5 Scenario highlights a generalized increase in the level of risks and represents a transition scenario, where risks continue to follow a moderate-to-high trend.
For the pilot site of the Dune Costiere da Torre Canne a Torre San Leonardo Regional Natural Park, the main projections analyzed were obtained from the dataclime platform (https://www.cmcc.it/it/scenari-climatici-per-litalia) managed by the Euro-Mediterranean Center on Climate Change (CMCC).

In the SSP2-4.5 scenario, regarding thermal risk and climate extremes risk, the platform indicates an increase in the duration of hot days, rising from approximately 256 to approximately 552 in the pilot site, with an increase in annual temperatures by approximately +1.5°C by mid-century, taking the 1981-2010 period as a reference.

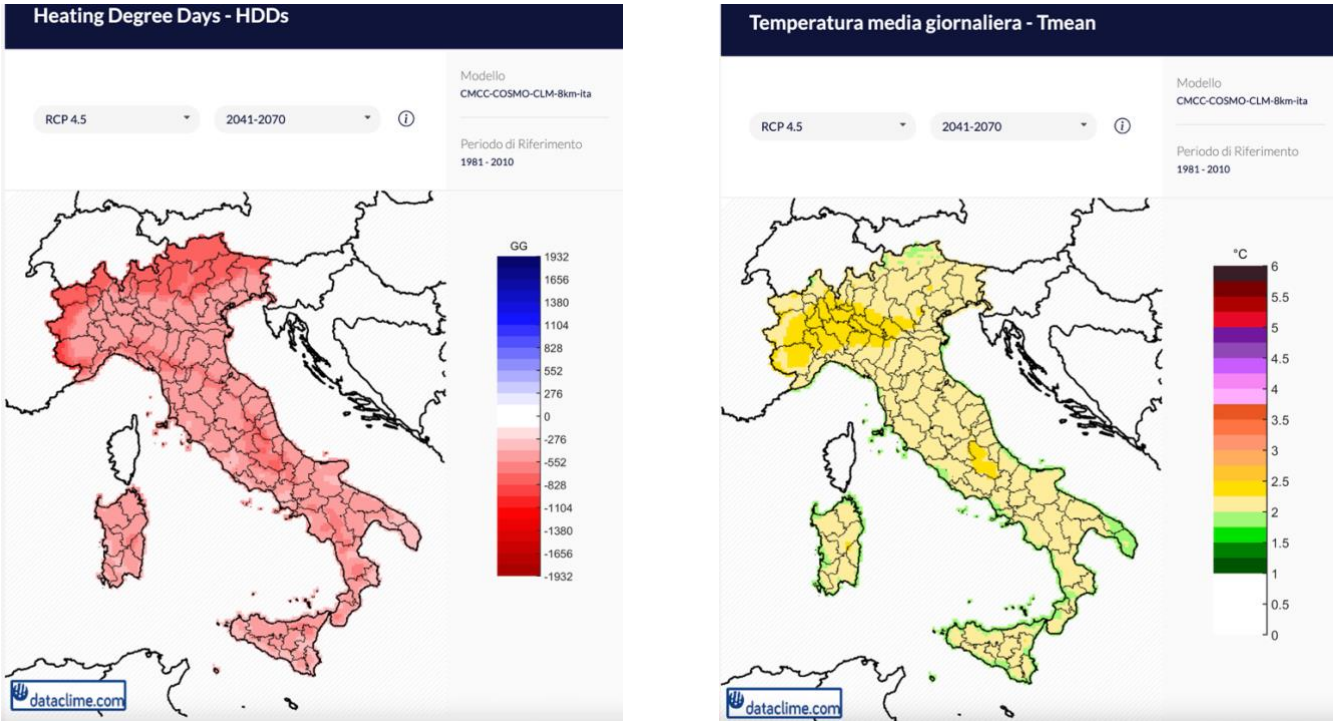

Figure 1 Projected anomaly of number of hot days to 2041-2070 and annual temperatures under SSP2-4.5 relative to a reference period 1981-2010

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Thermal risk increases compared to the current scenario, reaching moderate-to-high. This means that the intermediate and cold seasons, which currently show moderate values, could progressively become warmer, with more frequent episodes of thermal anomaly. For dune ecosystems, this implies an acceleration of resilience loss: the germination and spring growth of psammophilous species will be compromised by early water and heat stress, while in winter, the greater mildness will lead to premature vegetative reactivations and phenological instability. In agriculture, the extension of the thermal stress period further reduces the physiological recovery capacity of olive trees and seasonal crops, while for tourism, it means a longer bathing season but with the risk of unhealthy and uncomfortable conditions.

Hydraulic and hydrogeological risk remains classified as moderate-to-high. Apparently stable compared to the current situation, this data must be interpreted in light of the expected intensification of precipitation: rainfall will become more concentrated and irregular, increasing the risk of flood events and erosion, without, however, changing the assigned risk category. The dunes and back-dune environments, already subject to recession and temporary flooding, could be more frequently exposed to episodes of marine intrusion combined with torrential rains. For agricultural areas, the risk translates into soil loss, compaction, and reduced fertility, while from a management perspective, the Park will have to face greater instability of road and trail infrastructures.

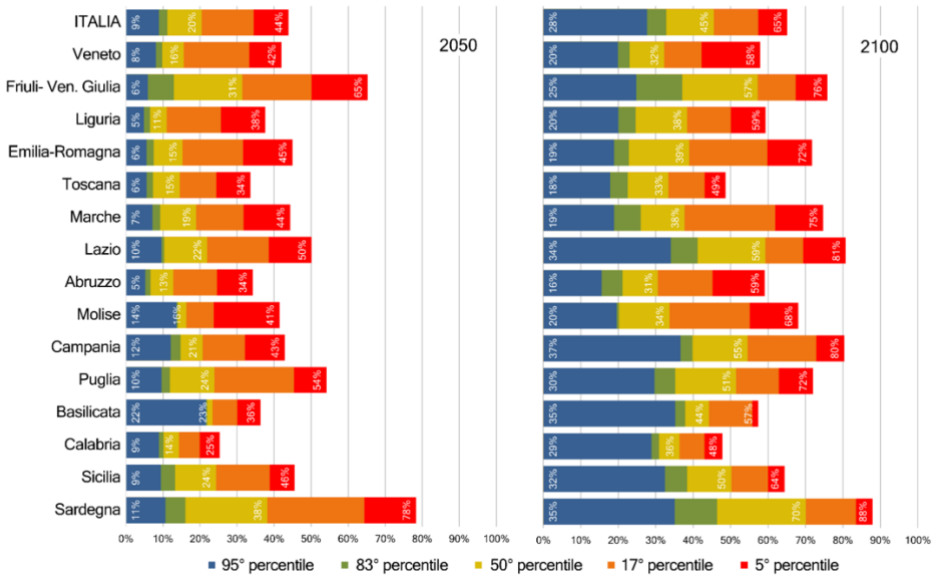

Figure 2 The labels indicate the projection for the 5°, 50° and 95°percentiles. Source: processing based on data from Vousdoukas et al., 2020, RCP 4.5 scenario, and ISPRA geodata.

In this scenario, the risk related to wind and storms is classified as high. This entails direct impacts on the stability of coastal dunes, with greater erosion and loss of vegetation cover, as well as structural risks for tourism and agricultural infrastructures. The increased frequency of storm surges (mareggiate) and local tornadoes could also amplify the danger to visitor safety, compelling the Park to implement stricter access and alert management.

The geological and soil degradation risk shows a variation to moderate-to-high values. This trend reflects the increase in desertification processes and the loss of organic matter, with clear consequences for the stability of agricultural soils and the dunes. In the rainier months, however, although remaining high, the risk is more linked to surface erosion and hydrogeological instability, which, while not reaching the maximum level, is nonetheless more severe than in the current scenario.

The analysis highlights a progressive upward homogenization of risk levels. The Dune Costiere Park, in the SSP2-4.5 scenario, will therefore be operating in a context where the seasonality of risk is attenuated and the pressures and exposures to risk become constant, necessitating cross-cutting adaptation strategies that can no longer rely on an annual cycle alternating between critical periods and periods of respite.

Scenario SSP5 – 8.5

The SSP5-8.5 scenario represents the most critical trajectory for the Dune Costiere da Torre Canne a Torre San Leonardo Regional Natural Park. This scenario results in a condition of chronic exposure, in which every type of risk reaches the maximum level, based on the classification of the RCP 8.5 scenario as one where it is assumed that no emissions reduction strategy is undertaken (business as usual), which corresponds to a radiative forcing of 8.5 Watts per m2 at the end of the century.

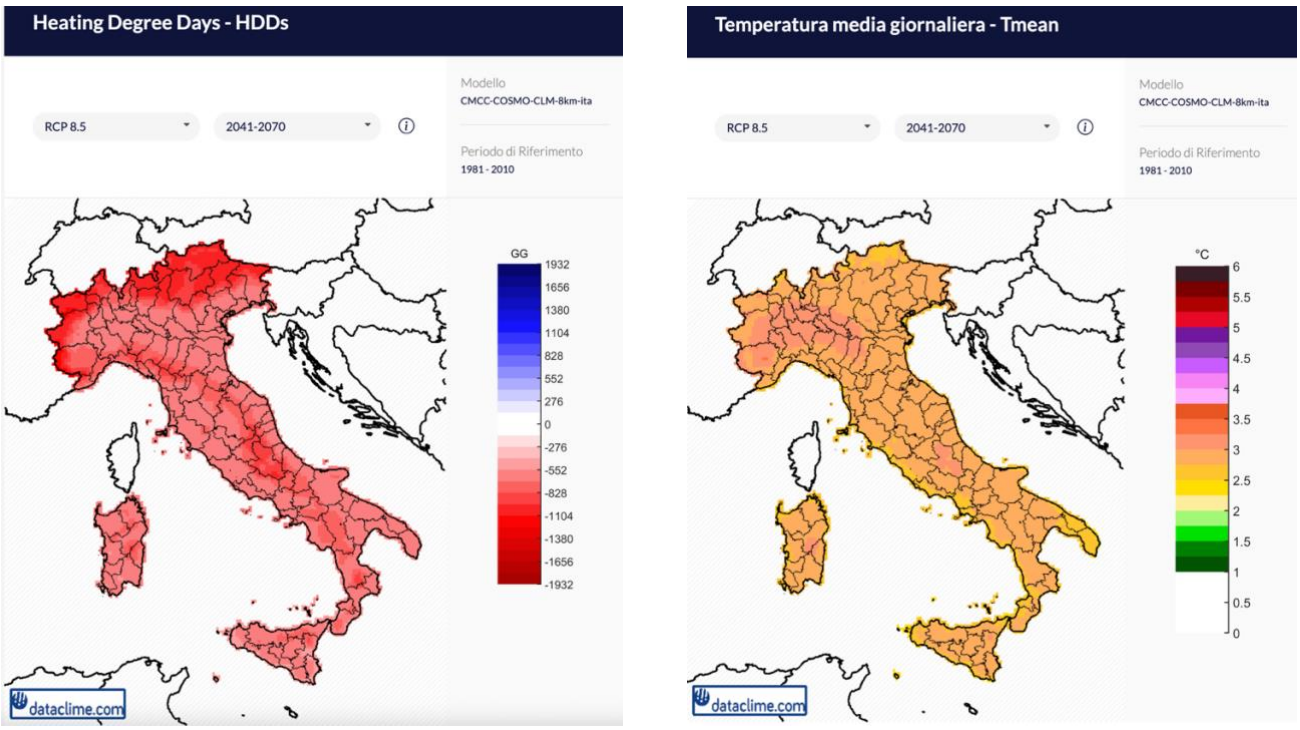

Figure 2 Projected anomaly of number of hot days to 2041-2070 and annual temperatures under SSP8.5 relative to a reference period 1981-2010

Thermal and climate risk becomes high. This means that in the pilot site there will no longer be mitigation phases; heat waves, once concentrated, could extend throughout the year, causing a radical alteration of natural cycles. Psammophilous plant communities, adapted to specific conditions of aridity and salinity, suffer collapse due to continuous physiological stress, while wetlands see an increase in salt concentration due to evaporation, resulting in a loss of biodiversity. On the agricultural front, desertification becomes an irreversible process: soils lose organic matter, yields are drastically reduced, and traditional tree crops, such as the olive tree, struggle to maintain productivity and quality. Tourism is also heavily affected by this condition: bathing and recreational stays are compromised by constantly high temperatures and unsustainable heat indices, resulting in a drop in attractiveness and an increase in health risks for visitors.

Hydraulic and hydrogeological risk takes on a structural character, with exposure classified as high. Precipitation becomes increasingly violent and concentrated, causing widespread flooding, surface erosion, and hydrogeological instability. The back-dune areas and agricultural environments suffer inundations, while the coastline constantly retreats due to

the combination of storm surges, sea-level rise[1], and torrential rains. In this context, the Park's ability to maintain the functionality of its coastal habitats and agricultural infrastructure is drastically reduced.

Meteorological risk linked to wind and storms also stabilizes at high levels. Marine storms, tornadoes, and extreme winds cease to be exceptional episodes and become recurrent events. The effects are evident on the stability of the dunes, which are continuously eroded and reshaped, on the destruction of vegetation cover, and on the cyclical damage to tourist and agricultural infrastructures. The safety of people, both residents and visitors, is constantly challenged, with an exponential increase in maintenance and restoration costs.

Geological and soil degradation risk completes the critical picture: it also reaches high values. The process of coastal erosion accelerates, with dune recession and loss of useful sandy areas. Agricultural soils undergo phenomena of compaction, loss of fertility, and saline intrusion, definitively compromising the productive capacity of the territory. The combined effects of drought, extreme rain events, and wind determine irreversible degradation that drastically reduces the ecosystem services provided by the Park, such as protection from storm surges, water regulation, and quality agricultural production.

In the SSP5-8.5 scenario, the Dune Costiere Park faces a prospect of systemic collapse. The adaptation capacity of biological communities, agricultural practices, and tourist infrastructures is cancelled out by constant climate pressure, which grants no respite and renders any traditional mitigation measure insufficient.

3.2. Adaptation strategies and adaptive capacity

Considering the two risk scenarios presented in the previous chapter, the objective of this section is to analyze the adaptation strategies and capacities of each sector identified in the present study, and in detail of biodiversity, tourism, agriculture, and fishing and aquaculture. These are key productive sectors in the Park area, in terms of socio-economics, and protection and conservation.

3.2.1. Biodiversity

Nel quadro attuale la priorità è preservare la funzionalità degli habitat dunali, retrodunali e umidi mantenendo continuità ecologica e cicli idrologici. Il rischio termico elevato e quello meteorologico

[1] Annual Report of the Italian Geographical Society "2025 – Submerged Landscapes. Geographies of the climate crisis in Italian coastal territories" (https://societageografica.net/wp/2024/06/12/rapporto-annuale-della-sgi-new-estore/)

In the current situation, the priority is to preserve the functionality of the dune, back-dune, and wetland habitats by maintaining ecological continuity and hydrological cycles. The high thermal risk and meteorological risk suggest a dual trajectory: reducing stress on species and communities through natural shading, drought-resistant plant cover, and control of anthropogenic pressure during the hottest hours; increasing the capacity to absorb storm events and intense rainfall by restoring dune morphologies, gaps, and natural barriers that slow down wave energy and favor sand recharge and migration. In the SSP2-4.5 scenario, with high storms year-round and moderate-to-high thermal risk even in shoulder seasons, measures must become systemic: active dune regeneration with psammophilous plantings and soft fencing at the stretch level, renaturalization of banks and shores in wetlands to increase lamination capacity, fine hydraulic management of back-dune channels to limit salinization and favor more resilient ecotonal gradients. The rise in geological risk in spring-summer also necessitates soil conservation interventions and an increase in organic matter, because the stability of psammophilous vegetation depends on less extreme micro-habitats. In the SSP5-8.5 scenario, with all risks high, punctual mitigation alone is insufficient: it is necessary to plan for the managed realignment of coastal fronts where regression is irreversible, create supporting back-wetland networks with controlled expansion capacity, and favor altimetric corridors that allow for the transmigration of habitats inland, including by reviewing the use of currently anthropized marginal portions. In parallel, a continuous microclimate and biological monitoring network must be stabilized, capable of guiding rapid decisions on temporary closures, post-event interventions, and the redefinition of regulated use zones.

Furthermore, the priority habitats and protected species present within the Park territory, and generally in the reference area, require the identification of strategies that take into account the multi-stakeholder and multi-level context. In detail, in addition to the identification of mitigation actions such as the replanting of native species, the restoration of priority habitats, as well as the control and recovery of the Park's dune belt, and coastal habitats such as *Posidonia oceanica* seagrass meadows (banquettes), psammophilous habitats, back-dunes, and mitigation actions for aquifer salinization through targeted projects for the back-dune wetland area and well control, the establishment of an intersectoral coordination table becomes crucial. This table can enhance the know-how of every entity responsible for the protection and enhancement of biodiversity in various capacities. Specifically, regional and local bodies for area management, the Park Management Consortium, as well as environmental and seaside tourism operators, research bodies, and Universities with a multidisciplinary team. The periodic establishment of the intersectoral table, with the identification of an action plan, well-defined projects, and KPIs

(Key Performance Indicators) for monitoring such progress, will allow for the mitigation of climate change on biodiversity in the short, medium, and long term, where the Park and local bodies have a margin of possibility for prevention and mitigation, continuing their institutional functions to protect the territory's biodiversity. In this context, in order to comply with European regulations on the expansion of protected areas and the restoration of priority habitats, the Park will promote awareness-raising and involvement actions for local stakeholders, an involvement that is no longer to be considered optional in any scenario.

3.2.2. Tourism

The tourism sector is an economic sector with significant repercussions on the territory, and considering the SSP2-4.5 and SSP5-8.5 scenarios, it could suffer an economic and social contraction in the resilience of local communities. Even considering that in the current scenario, tourism still has a significant impact on the territory's biodiversity, which should be adequately monitored through studies and analyses of the carrying capacity of certain parts of the park's territory where priority habitats or protected species exist, as highlighted during the summer season of 2025 by the presence of a Kentish Plover nest and four Loggerhead Sea Turtle (*Caretta caretta*) nests. Although regional efforts for de-seasonalization lend relevant importance to the role of Parks, functioning as alternative tourist attractions, the main attractor for inbound and international tourism remains coastal/beach tourism, which currently occupies a large market share. Considering that the latest research on the perception of sustainable tourism among tourists shows greater willingness from the end-user to spend more, with positive effects in terms of territorial protection and sustainability, it becomes important to plan adequate strategies for the various risks in all analyzed scenarios. For example, considering the increase in hydrogeological risk, it becomes important to develop a multi-stakeholder strategy, as on the one hand it is necessary to raise awareness among tourism operators to adopt actions to combat water waste and guide them towards environmental sustainability certification paths, such as eco-labels. On the other hand, at the local and regional level, it would be appropriate to diversify the offer as much as possible and plan cross-cutting rules to be respected for all the risks considered.
In the present, the management effort revolves around making enjoyment safe and comfortable during summer peaks and episodes of wind and storm surges. With the SSP2-4.5 scenario, which uniformly elevates risks and makes temperatures high in every season, tourism must evolve towards a model of operational resilience: less impactful beach

infrastructures, introducing heat-resistant vegetation within and around attractions; using reflective or breathable materials in protected areas; limiting access during conditions of extreme heat, and diversifying off-beach offerings to distribute flows and reduce exposure. The growth of geological risk also requires the localized retreat of structures currently too close to the wave front and nature-based protection solutions instead of rigid works that would aggravate sand loss. In the SSP5-8.5 scenario, where every risk remains high year-round, the sustainability of use depends on the capacity to adapt the tourist product to microclimatic windows and to more internal spaces, focusing on shaded nature trails, observation in wetlands with resilient hides, slow mobility, and decentralized services. Governance must include an integrated alert system with real-time public communication, dedicated insurance and restoration funds, and concession criteria that reward reversible structures and planned retreat schemes over multi-year horizons.

3.2.3. Agriculture

In the current situation, the combined impact of the *Xylella fastidiosa* bacterium and water scarcity is evident in the reduction of olive yields, the progressive loss of monumental trees, and the growing need for cultivation inputs (supplementary irrigation, phytosanitary treatments, soil support). In many farms in the Plain, it is observed that during 2025, the plants are producing oils with low yields, also due to water stress induced by root competition or surface salinization. The high thermal exposure scenario exacerbates these conditions: the evaporative demand of the leaves rises, the soil rapidly loses moisture, and concentrated rain (moderate-to-high hydraulic risk) contributes to erosion and loss of fertile soil, further reducing the plants' ability to overcome stress. In this context, the main adaptive measures are linked to water efficiency, control of the *Xylella* vector, and soil stability: dry stone walls, terracing, drainage, or cover crops within farms should be associated with conservative practices.
Today the objective is to maintain productive stability in the presence of high summer heat and concentrated intense rainfall, by acting on water resources and soil.

In the SSP2-4.5 framework, with extended thermal stress and persistent moderate-to-high hydraulic risk, the strategy becomes agroecological: rotations and intercropping with greater thermal tolerance, expansion of agrarian biodiversity with resilient crops and ecosystem services, agro-hydraulic arrangements that slow runoff and recharge profiles, farm-level basins for collecting and reusing rainwater, along with salinity protocols that include irrigation mixtures, dedicated drainage, and less sensitive crops in lower-lying areas.

In the SSP5-8.5 case, the combination of extreme heat, violent rain events, and permanent saline intrusion necessitates more radical choices: reconfiguration of parcels near the back-dunes towards ecosystem functions and wet buffer zones, progressive relocation of the most sensitive crops towards internal or higher-altitude areas, adoption of rootstocks and varieties with proven tolerance to salinity and heat, anti-erosion green infrastructures, and climate insurance and value chains that reward resilient production. In every scenario, adaptive capacity increases if the Park coordinates with decision-makers and key stakeholders, irrigation consortia, farm microclimatic data, shared technical consultation, and access to financial instruments for investments in water efficiency and soil health.

3.2.4. Fishing and Aquaculture

In the current situation, the moderate thermal and climatic risk in spring, autumn, and winter, and high risk in summer, translates for the sector into summers with warmer waters, lower dissolved oxygen during critical hours, and greater sensitivity to algal blooms or seasonal shifts of target species. This entails shorter fishing days during peak insolation hours, attention to managing heat peaks, and first-mile logistics to prevent drops in fish quality and handling stress.

The moderate-to-high hydraulic and hydrogeological risk year-round manifests as rapid floods and solid loads that temporarily alter turbidity and seabeds, reshape back-dune riverbeds, and, near estuaries, influence salinity with mixing that can push euryhaline species to enter or exit the ecotonal channels. The meteorological risk from wind and storms impacts small and medium-sized boats, characteristic of the pilot site, with narrower weather windows, sudden interruptions of outings, and storm surges that damage equipment, moorings, and landing points.

With the SSP2-4.5 scenario, the favorable seasonality shrinks. Thermal risk rises to moderate-to-high even in shoulder seasons and remains high in summer, making conditions of low oxygenation and the movement of species that flee warm surface waters more frequent; periods suitable for daytime fishing are compressed, and it becomes more useful to schedule outings during hours with less thermal stress, with greater reliance on high-resolution forecasts. Furthermore, the increase in temperatures would lead to the creation of conditions for "alien" species, such as the blue crab, to colonize the sea portion available for fishing. To counter this risk, information and training actions for fishermen, on the one

hand, and community awareness actions to direct a change in consumption, on the other, should be developed and adopted.

In the SSP5-8.5 scenario, all risks remain high in every season, and coastal fishing enters a regime of continuous pressure. Year-round warm waters and frequent episodes of stratification and hypoxia radically alter the phenology and local availability of traditionally fished species; stocks may shift permanently, and operational windows become shorter and more irregular. The chronic nature of storms and storm surges entails an increase in days of inoperability and a cycle of damage and repair to equipment and infrastructures, resulting in higher fixed costs and greater uncertainty regarding revenues. Coastal regression and soil degradation push towards functional retreat of slipways and landing areas and adaptive planning of access points, while supply chain businesses without local facilities must operate on a broader and more resilient logistical network to ensure product continuity when the local fleet is inactive.

In this context, operational efficiency alone is not enough: co-management with the Park becomes central, including temporary closures and spatial rotations to protect nurseries and essential habitats, funded post-event restoration plans, and concession criteria that favor reversible and quickly restorable structures. Adaptive capacity also relies on innovation in products and markets, valorizing emerging species with greater thermal tolerance, fish-tourism services during safe microclimatic windows, and involving cooperatives in environmental monitoring and citizen science activities that feed more accurate forecasting systems.

3.2.5 Residual vulnerability assessment

Based on the "Residual vulnerability assessment" for the geo/biodiversity sector, two recurring signals emerge. For thermal and climatic risk, residual vulnerability increases from 4.03 in the intermediate scenario to 7.67 in the most severe scenario, a combined effect of increased exposure and, above all, lower adaptive capacity in the extreme scenario. A similar dynamic is observed for hydraulic and hydrogeological risk, with a jump from 3.50 to 8.40, reflecting how the increase in intense rainfall and the reduction in adaptation quickly lead to high residual values. The risk from wind and storms grows moderately (2.70 to 4.50) when adaptation remains greater than one, while geological and soil degradation risk approximately doubles (from 2.53 to 5.06) as adaptive capacity decreases. In summary, in this area, the transition to SSP5-8.5 amplifies all vulnerabilities when adaptation is reduced, doing so particularly sharply for the thermal and hydrogeological components.
For the tourism area, the table shows a picture in which meteorological risks become structural: wind and storms are already high in the intermediate scenario and remain so

even in the most severe scenario, with residual vulnerability settling at 3.50 in both, a value that remains constant because, with the same sensitivity and exposure, the adaptive capacity fixed at one does not dampen the product. The thermal-climatic component increases from 5.25 to 7.00 between the two scenarios, marking the extension of thermal discomfort beyond the summer months. The hydraulic-hydrogeological risk grows from 6.67 to 8.00, indicating underlying pressure that challenges accessibility, safety, and the continuity of tourist services. Geological risk increases from 2.52 to 5.50, highlighting that, as adaptation decreases, erosive processes and soil degradation increasingly impact use and accommodation infrastructures.

In the agriculture sector, the assessment makes it clear how the four risks move with differentiated but upwardly converging trajectories when adaptive capacity is reduced. Thermal-climatic risk rises from 4.81 to 7.33, coherently with higher exposure and with adaptation that, dropping to one, no longer compensates for the stress. Hydraulic-hydrogeological risk increases from 3.08 to 7.40, showing how much of the vulnerability derives from the interaction between soils, concentrated runoff, and erosion when agronomic mitigation is insufficient. The risk from wind and storms remains stable at 5.50 in both scenarios because sensitivity and exposure remain the same and adaptation is already at the minimum, a sign that for this factor, the criticality is fundamental and does not differentiate between scenarios. Geological risk grows from 3.44 to 6.25, certifying that the loss of organic matter and soil destabilization become progressively more incisive as the climatic context worsens.

For the fishing and aquaculture area, where cooperatives and supply chain businesses are present in the Park but no on-site farming facilities, the table shows a decided increase in hydraulic-hydrogeological and geological risks with the transition to the most severe scenario: hydraulic risk rises from 6.67 to 8.00, a value that accurately captures the combined effect of floods, turbidity, reshaping of sandbars, and difficulties in safe access; geological risk increases from 5.27 to 5.75, indicating that erosion and coastal regression become a constant to be managed. Thermal-climatic risk increases from 5.25 to 6.00 and the risk from wind and storms remains at 3.50 in both scenarios, signalling that for sea outings the wind factor remains critical but is essentially already at the most stringent level of operational management.

Overall, the assessment clarifies three properties useful for interpreting the scenarios. The first is that residual vulnerability responds non-linearly to the reduction of adaptation: when adaptive capacity drops to one, even modest increases in sensitivity or exposure generate sharp jumps in the final values. The second is that not all risks grow in the same way between scenarios: where sensitivity and exposure do not change and adaptation is already minimal, residual vulnerability remains unchanged, revealing structural criticalities that do not

depend on the climate but on the baseline management. The third is that the risk profiles most reactive to climate worsening are the thermal-climatic and the hydraulic-hydrogeological, in all areas considered, while the risks from wind and storms and the geological risk follow increases more specific to the sector and adaptive configuration.

3. Conclusions

The analyses conducted on the exposures, the sensitivity of the ecological and socio-economic systems, and the residual vulnerability provide a coherent and convergent picture: the Dune Costiere Park is already inserted into a trajectory of increasing climatic pressure, which in plausible futures tends to uniformly rise until it becomes chronic in the most severe scenario. The cross-reading of the data shows that the thermal-climatic and hydraulic-hydrogeological risks (Coastal erosion, Soil degradation/erosion, Landslide, Subsidence) are the main drivers of risk evolution, while the meteorological risk from wind and storms and the geological risk linked to soil degradation act as multipliers, accelerating the loss of environmental functionality and the vulnerability of human activities.

The adaptive capacity component proves decisive in determining the outcomes: with the same sensitivity and exposure, the simple lowering of adaptation leads to marked jumps in residual vulnerability. This is particularly evident in geo-biodiversity and in sectors heavily dependent on ecosystem functions such as dune stability and water regulation.

Across the sectors, biodiversity and coastal soil show that the stability of habitats depends on the morphological continuity of the dunes, the capacity to laminate flood events in the back-dune areas, and the quality of the saline gradients in the wetlands. Tourism highlights that resilience shifts from seasonal use to adaptive use, capable of suspension, retreat, and diversification based on microclimatic and marine windows. Agriculture, already penalized by water stress and the presence of *Xylella* in the broader area of the Plain of Monumental Olive Trees, is the sector where the interaction between heat, water scarcity, intense events, and pathogens produces the most direct economic impacts; the intermediate scenario encourages the institutionalization of conservative practices, tolerant varieties, and water infrastructure, while the extreme scenario requires spatial reconfigurations and radical varietal and supply chain choices. Artisanal fishing and the supply chain without on-site facilities depend on operational safety, the stability of access points, and the continuity of coastal nurseries; when storms become high and the shoreline retreats, the co-management of essential habitats and the cold logistics become enabling conditions.

The analysis of local scenarios provides the Park's governance with a map of priorities: protecting and regenerating the dune and back-dune systems as the backbone of adaptation, making soil and water conservative practices permanent on farms with attention to water stress and salinity, structuring a reversible and modulable model of tourist use, and ensuring artisanal fishing with tools for forecasting, shelter, and recovery. These lines are

not mutually exclusive but form a single resilience strategy that must be programmed across multiple time scales: rapid response in the current regime, institutionalization of measures in the intermediate regime, and capacity for reconfiguration in the extreme scenario.

References

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Annexes

Compiled matrix (final version resulting from the analysis of, at least, three different stakeholders (.xls file)

1 - The working Excel file used to perform Exposure, Adaptation and Risk assessments for the different local climate scenarios.

2 - The Exposure, Adaptation and risk assessments, resulting from the integration of the analyses completed by PP7 for the Coastal Dunes pilot site.