

## **D.1.3.1**

# **Report on the hazards and threats of the pilot areas in the medium and long term**

## **Neretva estuary pilot site**

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DEPARTMENT OF BIOLOGICAL, GEOLOGICAL, AND ENVIRONMENTAL SCIENCES



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## Abstract

This report presents a comprehensive analysis of the main climate change hazards and threats in the Neretva Estuary pilot area, with the aim of assessing the vulnerability levels of key sectors and identifying priorities for the implementation of adaptation measures. The analysis is based on a common methodology developed through cooperation among scientific, administrative, and management partners, providing an integrated framework for assessing climate risks and their impacts on socio-environmental systems.

The analytical approach includes the evaluation of system sensitivity, exposure, adaptability, and residual sensitivity, enabling both quantitative and qualitative insights into medium- and long-term risks. This approach has been applied to sectors that are crucial for the sustainable development of the area biodiversity, tourism, agriculture, fisheries, and aquaculture.

The results of the analysis indicate a high level of vulnerability of the Neretva Estuary to key climate stressors. The most significant identified risks include rising average air temperatures and the increasing frequency of extreme heat waves, more frequent and intense wildfires, changes in the hydrological regime (including the reduction of available water resources and altered flow dynamics), as well as sea level rise and the consequent intrusion of saltwater into coastal and agricultural systems. These processes generate complex, cross-sectoral, and systemic effects, manifested through ecosystem degradation, reduced natural resource productivity, and growing socio-economic pressures on local communities.

The findings clearly highlight the need for immediate action and the establishment of integrated climate change adaptation strategies based on the ecosystem approach and the principles of multi-sectoral coordination. Such strategies should include strengthening institutional capacities, systematic monitoring of climate indicators, proactive risk management planning, and the involvement of stakeholders at all levels of decision-making. Only through the implementation of coordinated, science-based measures will it be possible to enhance the socio-environmental resilience of the Neretva Estuary in the long term and ensure the sustainability of its ecosystems, resources, and socio-economic activities under increasing climate change pressures.



## 1. Introduction

This report presents a structured methodology for assessing climate vulnerability and resilience at the Neretva Estuary pilot site, as part of the ACTION project – Increasing the Resilience of the Coastal Ecosystem to Climate Change.

Situated in the coastal region of southern Croatia, this river-delta unit is characterized by high ecological sensitivity, significant socio-economic importance, and exposure to multiple stressors, making it highly vulnerable to the impacts of climate change. The main threats to the Neretva Estuary include rising air temperatures, changes in the hydrological regime that reduce river tributaries, and sea-level rise causing saltwater intrusion into soils and aquifers. These processes increase salinity, alter soil fertility, degrade water quality, and facilitate the spread of invasive species, collectively leading to the deterioration of ecological conditions and reduced ecosystem productivity.

The aim of this analysis is to identify the principal climate risks, sectoral vulnerabilities, and systemic interconnections within the Neretva Estuary, thereby providing a foundation for developing targeted adaptation measures and integrated site management plans.

The study applied a common assessment matrix, developed by project partners, to evaluate medium- and long-term hazards and threats and to determine their relative importance across key sectors: biodiversity, tourism, agriculture, fisheries, and aquaculture.

Overall, this report provides a scientific and operational basis for the development of localized scenarios and climate change adaptation solutions, which will be further elaborated in Activity D.1.4.1.

## 2. Methodology

. The methodology adopted in this study is based on a framework provided by the European Commission's *Technical Guidance on Sustainability Verification for the InvestEU Fund* (EU, 2021) and it is adapted to a local scale by integrating ecological, socio-economic, and governance dimensions.

The assessment combines:

- **Qualitative Sensitivity analysis** (Sheet 1 of attached file): evaluating how system components respond to climate threats.
- **Exposure analysis** (Sheet 2 of attached file): assessing expected impacts under climate projections.
- **Adaptation analysis** (Sheet 3 of attached file): identifying the capacity to mitigate risks through available measures.
- **Residual vulnerability assessment** (Sheet 4 of attached file): integrating the above to provide risk-based prioritization.

This multi-layered approach ensures a structured and transparent methodology for identifying climate-related risks and adaptation needs. Hazards and threats are identified based on the probability of occurrence (low, medium, high); expected severity of impact on ecological and socio-economic systems, and relevance at seasonal and long-term scales.



To ensure a more robust and representative assessment of the levels of environmental sensitivity/criticality, it was foreseen that for each pilot area the matrix would be compiled in at least three separate versions, each by a subject with a complementary perspective:

- A research organization, to ensure a scientific and technical analysis.
- A local government/public administration to integrate aspects of planning, governance and political feasibility.
- A representative from a protected area or environmental management body, to bring the operational and territorial point of view, rooted in concrete knowledge of the natural context.

A final matrix will be put together merging the three different contributions. This triangulation of inputs mitigated bias, enabled cross-sectoral comparisons, and ensured legitimacy of the results.

The following key stakeholders were involved to analyse hazards, threats and develop local scenarios for the Neretva Estuary pilot site:

- I) The Rudjer Boskovic Institute, as a research organisation;
- II) Ministry of environmental Protection and Green Transition, as a national administrative authority; and
- III) public institution for the management of protected natural values of Dubrovnik-Neretva County, as a representative of the territorial administration and operational environmental management.

## 2.1. Sheet 1 - qualitative sensitivity analysis

The goal of this evaluation is to identify how climate threats affect the components of each thematic area based on their inherent characteristics and role in the socio-ecological system.

The assessment is applied to four selected sectors that characterize the context of the pilot areas, each broken down into three key components (Fig. 1):

1. **Biodiversity** (protected habitats, species richness, ecosystem services).
2. **Tourism** (infrastructure and services, economic development and employment, cultural/natural attractions).
3. **Agriculture** (land use and landscape, agricultural income and employment; agricultural biodiversity).
4. **Fishing & Aquaculture** (resource use, income and employment, multifunctionality).

These four selected sectors represent both ecological and socio-economic pillars of coastal systems. They were selected for their high exposure to climate threats and their relevance for local communities.

Each component is assessed against four climate factors:

- **Temperature** (increase, heat/cold waves, wildfires),
- **Wind** (changes in the wind regime, storms; whirlwinds),
- **Water** (change in the hydrological regime and type of precipitation; sea acidification; saltwater intrusion; sea level rise; flooding.),
- **Solid Mass** (coastal erosion; soil degradation/erosion; landslide; subsidence).

These four climate factors allow for a comprehensive capture of different stressors. These categories encompass both gradual processes (e.g., sea level rise, acidification) and extreme events (e.g., storms, heat waves, floods).



Each key component is assigned a sensitivity level for each threat, ranging from ‘low sensitivity’ (score 1) to ‘high sensitivity’ (score 3).



**EVALUATION OF SENSITIVITY**

**OUTPUT: inviduating the sensitivity of the components of each area to climatic factors**

This analysis aims to:  
 \* Analyse how climate factors translate into climate threats and hazards.  
 \* Identify the impacts of these threats for the area of reference.

Guide for compilation:  
 \* Do not add rows, insert the info in the rows provided  
 \* Select the level of sensitivity from the drop-down menu in the respective cell

<b>AREA: BIODIVERSITY</b>			<b>Area of protected habitats</b>	<b>Species richness</b>	<b>Ecosystem services</b>
<b>CLIMATE FACTORS</b>	<b>THREATS</b>	<b>IMPACTS</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>
TEMPERATURE	Temperature increase, heat waves				
	Cold waves, frost				
	Wildfires				
WIND	Changes in the wind regime, storms (rain-snow and wind)				
	Whirlwinds				
WATER	Change in the hydrological regime (water stress, drought) and type of precipitation				
	Sea acidification				
	Salthwater intrusion				
	Sea level rise				
	Flooding (coastal, fluvial, pluvial, groundwater)				
SOLID MASS	Coastal erosion				
	Soil degradation/erosion				
	Landslide				
	Subsidence				

<b>AREA: TOURISM</b>			<b>Tourism infrastructure and services</b>	<b>Economic development and employmen</b>	<b>Preservation of tourist attractions</b>
<b>CLIMATE FACTORS</b>	<b>THREATS</b>	<b>IMPACTS</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>
TEMPERATURE	Temperature increase, heat waves				
	Cold waves, frost				
	Wildfires				
WIND	Changes in the wind regime, storms (rain-snow and wind)				
	Whirlwinds				
WATER	Change in the hydrological regime (water stress, drought) and type of precipitation				
	Sea acidification				
	Salthwater intrusion				
	Sea level rise				
	Flooding (coastal, fluvial, pluvial, groundwater)				
SOLID MASS	Coastal erosion				
	Soil degradation/erosion				
	Landslide				
	Subsidence				

AREA: AGRICULTURE			Land use and landscape	Agricultural income and employment	Agricultural biodiversity
CLIMATE FACTORS	THREATS	IMPACTS	SENSITIVITY	SENSITIVITY	SENSITIVITY
TEMPERATURE	Temperature increase, heat waves				
	Cold waves, frost				
	Wildfires				
WIND	Changes in the wind regime, storms (rain-snow and wind)				
	Whirlwinds				
WATER	Change in the hydrological regime (water stress, drought) and type of precipitation				
	Sea acidification				
	Saltwater intrusion				
	Sea level rise				
	Flooding (coastal, fluvial, pluvial, groundwater)				
SOLID MASS	Coastal erosion				
	Soil degradation/erosion				
	Landslide				
	Subsidence				

AREA: FISHING AND AQUACULTURE			Use of resources	Income and employment	Multifunctionality
CLIMATE FACTORS	THREATS	IMPACTS	SENSITIVITY	SENSITIVITY	SENSITIVITY
TEMPERATURE	Temperature increase, heat waves				
	Cold waves, frost				
	Wildfires				
WIND	Changes in the wind regime, storms (rain-snow and wind)				
	Whirlwinds				
WATER	Change in the hydrological regime (water stress, drought) and type of precipitation				
	Sea acidification				
	Saltwater intrusion				
	Sea level rise				
	Flooding (coastal, fluvial, pluvial, groundwater)				
SOLID MASS	Coastal erosion				
	Soil degradation/erosion				
	Landslide				
	Subsidence				

Fig. 1 – Structure and input fields for the qualitative sensitivity analysis.



## 2.2. Sheet 2 – Exposure analysis

The goal is to assess how climate risks are expected to affect the pilot site over time, based on global scenarios, local projections and seasonal variability.

Two IPCC Shared Socio-economic development Pathways (SSPs) were selected (IPCC, 2023):

- **SSP2-4.5 (“Middle of the Road”)**: an intermediate scenario where socio-economic and technological trends follow historical trajectories, without major shifts in development, leading to medium-level warming. CO<sub>2</sub> emissions remain roughly stable until mid-century before declining, but they do not reach net zero by 2100. This pathway results in a projected global warming of about 2.7 °C by 2100 (relative to 1850–1900), with a likely exceedance of 1.5 °C between 2021 and 2040.
- **SSP5-8.5 (“Fossil-Fueled Development”)**: a high-emission pathway characterized by energy-intensive growth driven by intensive fossil fuel use and reliance on technological progress, resulting in severe warming and associated impacts. Under this pathway, CO<sub>2</sub> emissions roughly triple by 2075, leading to a projected global warming of about 4.4 °C by 2100 (range 3.3–5.7 °C). In this scenario, exceeding 1.5 °C of warming in 2021–2040 is very likely, with severe consequences for ecosystems, societies, and economies.

These scenarios enable comparison of vulnerabilities under both realistic and extreme climate futures, highlighting the range of possible risks and adaptation needs.

The four climate factors from sheet 1 are converted into risk factors (Fig. 2):

- **Thermal risk and climate extremes** ← Temperature
- **Hydraulic and hydrogeological risk** ← Water
- **Wind and weather storm risk**
- **Geological and land degradation risk** ← Solid Mass

For each season (spring, summer, autumn, winter) and for each risk factor, an exposure level is assigned, ranging from ‘low exposure’ (score 1) to ‘high exposure’ (score 3).

Each risk is assessed for its probability and expected impact, establishing a baseline (current state) and projected future conditions under 2 selected IPCC climate (SSP2-4.5 and SSP5-8.5).

**EVALUATION OF EXPOSURE**

**OUTPUT: Identification of the climate risk factors of the location/area under consideration at present and in the two scenarios**

This analysis assesses future exposure to climate risks with reference to the location of the pilot action (macro-climatic area), using the climate projections available according to the latest IPCC Report, choosing scenarios SSP2-4.5 and SSP5-8.5. The expected seasonal climate variations and the resulting impacts in terms of risks for the pilot area are qualitatively assessed.

<b>Current climate exposure</b>				
Season	<i>Thermal risk and climate extremes</i>	<i>Hydraulic and hydrogeological risk</i>	<i>Wind and weather storm risk</i>	<i>Geological and land degradation risk</i>
Spring				
Summer				
Autumn				
Winter				
<b>Future climate exposure: SSP2-4.5 scenario - "Middle of the Road" world where trends largely follow their historical patterns</b>				
Season	<i>Thermal risk and climate extremes</i>	<i>Hydraulic and hydrogeological risk</i>	<i>Wind and weather storm risk</i>	<i>Geological and land degradation risk</i>
Spring				
Summer				
Autumn				
Winter				
<b>Future Climate Exposure: Scenario SSP5-8.5 - Fossil-fueled Development "Taking the Highway", a world characterised by rapid and unlimited growth in economic production and energy use</b>				
Season	<i>Thermal risk and climate extremes</i>	<i>Hydraulic and hydrogeological risk</i>	<i>Wind and weather storm risk</i>	<i>Geological and land degradation risk</i>
Spring				
Summer				
Autumn				
Winter				

**LEGEND**

- HIGH: High probability of occurrence with potential significant impacts
- MODERATE-HIGH
- MODERATE: Medium probability of occurrence with manageable impact
- MODERATE-LOW
- LOW: Limited probability and low impacts

Fig. 2 – Structure and input fields for the exposure analysis.



### 2.3. Sheet 3 – Adaptation analysis

This sheet evaluates the adaptive capacity of each area, focusing on strategies to mitigate or buffer impacts from the exposure risks (Fig. 3), such as:

- Infrastructural (e.g., barriers, drainage),
- Managerial (e.g., land use planning, irrigation solutions),
- Formative (e.g., awareness and training campaigns),
- Ecosystemic (e.g., wetland restoration, green infrastructure).

Capacity is scored qualitatively as High (robust systems in place, good governance, financial/technical resources - score 3), Medium (partial coverage, possibility for improvement - score 2), or Low (limited or no capacity, lack of awareness/tools/resources - score 1), reflecting governance, resources, and technical feasibility.

Adaptation analysis

OUTPUT: Adaptation strategies of the components examined for each area in relation to climate risks

Overall objective: Compile a vulnerability assessment for the future for each thematic area, identifying:  
 1. The adaptation measures needed for each component of the scope.  
 2. The level of adaptive capacity (High, Medium, Low) with respect to different types of climate risks.

For each component and type of risk, identify specific and concrete mitigation/prevention actions, e.g.:  
 \* Infrastructural (e.g. barriers, shelters, drainage)  
 \* Managerial (e.g. planning, monitoring, soil/water management)  
 \* Formative (e.g. capacity building, vocational training)  
 \* Ecosystemic (e.g. nature-based solutions)

Assign a level of adaptive capacity for each combination.

**LEGEND:**  
 \* High: if effective measures already exist or the context is favourable (resources, governance, awareness).  
 \* Medium: if supportive actions are needed but there is some operational scope.  
 \* Low: if tools, resources, knowledge or political will are lacking.

AREA: BIODIVERSITY					
Component	Scenario SSP2-4.5	Adaptation to thermal risk and climate extremes	Adaptation to hydraulic and hydrogeological risk	Adaptation to wind and weather storm risk	Adaptation to geological and land degradation risk
Area of protected habitats	Measures	List potential adaptation/prevention measures and their level			
	Adaptive Capacity				
Species richness	Measures	List potential adaptation/prevention measures and their level			
	Adaptive Capacity				
Ecosystem services	Measures	List potential adaptation/prevention measures and their level			
	Adaptive Capacity				
AREA: TOURISM					
Component	Scenario SSP2-4.5	Adaptation to thermal risk and climate extremes	Adaptation to hydraulic and hydrogeological risk	Adaptation to wind and weather storm risk	Adaptation to geological and land degradation risk
Tourism infrastructure and services	Measures				
	Adaptive Capacity				
Economic development and employment	Measures				
	Adaptive Capacity				
Preservation of tourist attractions	Measures				
	Adaptive Capacity				

AREA: AGRICULTURE					
Component	Scenario SSP2-4.5	Adaptation to thermal risk and climate extremes	Adaptation to hydraulic and hydrogeological risk	Adaptation to wind and weather storm risk	Adaptation to geological and land degradation risk
Land use and landscape	Measures				
	Adaptive Capacity				
Agricultural income and employment	Measures				
	Adaptive Capacity				
Agricultural biodiversity	Measures				
	Adaptive Capacity				
AREA: FISHING AND AQUACULTURE					
Component	Scenario SSP2-4.5	Adaptation to thermal risk and climate extremes	Adaptation to hydraulic and hydrogeological risk	Adaptation to wind and weather storm risk	Adaptation to geological and land degradation risk
Use of resources	Measures				
	Adaptive Capacity				
Income and employment	Measures				
	Adaptive Capacity				
Multifunctionality	Measures				
	Adaptive Capacity				

Fig. 3 - Structure and input fields for the adaptation analysis.



## 2.4. Sheet 4 – Residual vulnerability assessment

The goal is to quantify residual vulnerability after adaptation is considered, allowing for risk-based planning. Residual vulnerability provides a prioritization tool for identifying critical areas requiring urgent adaptation measures.

Residual vulnerability is automatically calculated using the formula:

$$\textit{Residual Vulnerability} = \textit{Sensitivity} * \textit{Exposure} / \textit{Adaptation Capacity}$$

Under SSP2-4.5, adaptation capacity is considered active, while under SSP5-8.5 it is fixed at 1, reflecting the nullification of adaptation in extreme scenarios. Final residual vulnerability (Fig. 4) is scaled from 1 to 9, where higher values indicate greater climate risk, based on the following categories:

- o 1–2: Low residual vulnerability
- o 3–5: Moderate vulnerability
- o 6–9: High residual vulnerability which suggest need od critical intervention.

**Residual vulnerability analysis**

**OUTPUT: weighted assessment of sensitivity and exposure and how adaptation measures can reduce the impacts of risks**

On the basis of the matrices in the previous sheets, a summary is made to allow verification of the impact of the different types of risks for each area. If every part is compiled correctly, the table below will automatically upload and it will not be necessary to insert any input

AREA: BIODIVERSITY	Scenario	Sensitivity	Exposure	Adaptation	Residual vulnerability
Thermal risk and climate extremes	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Hydraulic and hydrogeological risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Wind and weather storm risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Geological and land degradation risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D

AREA: TOURISM	Scenario	Sensitivity	Exposure	Adaptation	Residual vulnerability
Thermal risk and climate extremes	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Hydraulic and hydrogeological risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Wind and weather storm risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Geological and land degradation risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D

AREA: AGRICULTURE	Scenario	Sensitivity	Exposure	Adaptation	Residual vulnerability
Thermal risk and climate extremes	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Hydraulic and hydrogeological risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Wind and weather storm risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Geological and land degradation risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D

AREA: FISHING AND AQUACULTURE	Scenario	Sensitivity	Exposure	Adaptation	Residual vulnerability
Thermal risk and climate extremes	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Hydraulic and hydrogeological risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Wind and weather storm risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D
Geological and land degradation risk	SSP2-4.5	#N/D	#N/D	#N/D	#N/D
	SSP5-8.5	#N/D	#N/D	1.00	#N/D

**Sensitivity:** the sensitivity to climate factors is averaged for each area, evaluated as a number from 1 (low sensitivity) to 3 (high sensitivity)

**Exposure:** the exposure to the individual risks in the case of SSP2-4.5 and SSP5-8 is evaluated as a number from 1 (low exposure) to 3 (high exposure)

**Adaptation:** averaged over the effectiveness of the adaptive capacity of the measures that can be implemented in the SSP2-4.5 scenario (=1, i.e. null, in case of SSP5-8.5), evaluated as a number from 1 (low mitigation/adaptation capacity) to 3 (high capacity)

**Residual vulnerability:** calculated as the product of sensitivity and exposure, divided by the effectiveness of adaptation

Fig. 4 - Structure and input fields for residual vulnerability assessment.

### 3. Results

The following is a description and discussion of the main threats and impacts of climate change on key sectors in the Neretva Estuary Pilot area.

#### 3.1. Biodiversity

The Neretva Estuary is a unique mosaic of wetlands, riverine, and agricultural habitats, characterized by high biodiversity, particularly avian fauna. The estuary is recognized as a Ramsar site—a wetland of international importance. The objective of the Ramsar Convention is to preserve wetlands that are vital to the survival of numerous plant and animal species and their communities, which provide essential benefits to humans.

Additionally, the Neretva area has been recognized internationally as part of the Natura 2000 Delta Neretva ecological network, important for the conservation of habitat types and species. Areas important for bird conservation have been designated under the Regulation on the ecological network and the competencies of public institutions for the management of ecological network areas.

Within the Neretva Estuary, there are seven protected areas, including ornithological sites (Prud, Orepak, Pod Gredom, Modro Oko, and Lake Kuti), an ornithological and ichthyological reserve (the mouth of the Neretva), and the significant landscape area Predolac-Sibenica. These areas support diverse habitat types such as wetlands, reed beds, shrubs, and forests, providing homes to a wide variety of plant and animal species.

Despite its significant biodiversity, the area has already suffered partial degradation due to a combination of natural vulnerability, anthropogenic pressures, and climate change, and it continues to face long-term threats. Similar conditions exist elsewhere in the Mediterranean, where climate change intensifies existing natural and human pressures.

Sensitivity analyses show that many threats generate high sensitivity in biological components, including protected habitats, species abundance, and ecosystem services, while other threats are of medium concern. Some threats, such as coastal erosion, landslides, and subsidence, are not relevant to the Neretva Estuary.

### **Temperature-Related Threats**

Rising temperatures and heat waves significantly affect the metabolism and reproductive cycles of birds, alter migration timing, and lead to nest loss. In aquatic ecosystems, higher temperatures increase metabolic rates, destabilize predator-prey dynamics, increase disease susceptibility, and promote the spread of invasive species. Consequently, protected habitats and species abundance are highly sensitive, and ecosystem services such as water regulation, vegetation cover, and carbon storage also exhibit high vulnerability.

Cold waves and frost, especially outside normal seasons, affect temperature-sensitive species (amphibians, reptiles, insects, and plants) and can cause mortality among migratory birds. Ecosystem and habitat services show moderate resilience, while species richness can be moderately threatened.

Forest fires destroy habitat structure and ecosystem integrity, alter soil microbial communities, increase susceptibility to invasive species, and lead to erosion and the release of harmful compounds. Consequently, habitats, species abundance, and ecosystem services—including carbon regulation, cultural values, and recreational functions—show high sensitivity.



## Wind-Related Threats

Extreme winds and storms affect water mixing, sediment resuspension, and turbidity, and can cause soil erosion and saltwater intrusion into freshwater areas. Nesting birds lose breeding sites, and some species suffer mortality from hypothermia or collisions. Habitats and species abundance show medium sensitivity, while localized whirlwinds cause moderate sensitivity due to their limited spatial impact.

## Water-Related Threats

The natural characteristics of the estuary, combined with anthropogenic influences, make aquatic ecosystems extremely sensitive. Changes in the hydrological regime, including prolonged droughts, altered rainfall patterns, and seasonal cycle shifts, reduce habitat suitability and cause soil and water salinization.

Additional anthropogenic pressures include:

- Trench excavation and hydromelioration of formerly extensive wetlands, reducing natural protection against extreme water fluctuations;
- Intensive agriculture causing eutrophication and nutrient pollution;
- Irrigation practices that reduce freshwater availability and increase salinization risk, especially during summer months.

Climate change exacerbates these pressures: warmer, drier summers, increased evaporation, and reduced rainfall heighten ecosystem sensitivity. Saltwater intrusion and sea-level rise induce osmotic stress, reduce freshwater organism growth and reproduction, alter plant and microbial community composition, and decrease freshwater availability. Collectively, these factors lead to high vulnerability of habitats, species abundance, and ecosystem services, highlighting systemic risk and the need for urgent intervention.



Seasonal floods cause erosion and sediment deposition, further increasing pressure on ecosystems, while soil degradation and erosion reduce habitat fertility and functionality, moderately threatening species richness and the provision of ecosystem services.

### 3.2. Tourism

Tourism in the Neretva Estuary relies heavily on climate-sensitive assets, including infrastructure and tourism services, local economic development and employment, and the preservation of cultural and natural heritage. Due to its specific geographical location and exposure to multiple climate factors, the tourism sector remains vulnerable to various climate pressures. The main impacts and vulnerabilities on tourism are presented in Annex 2, with a summary provided below.

#### Temperature-Related Threats

Rising temperatures and recurrent heat waves have significant impacts on economic development and employment, and moderate impacts on infrastructure, services, and the preservation of tourist attractions. Key consequences include:

Shifts in peak tourist seasons, decreased attendance during the warmest months, and reduced appeal of seasonal activities such as bird watching;

Higher operational adaptation costs (air conditioning, insulation, increased demand for cooling and water);

Reduced comfort and satisfaction for tourists;



Increased health risks, including heat stroke and dehydration;

Uncertainty in timing, complicating event booking and organization.

Collectively, these effects result in high sensitivity of the tourism sector in terms of economic reliability and employment. Forest fires present an additional threat to infrastructure, attractions, and economic activities. The destruction of natural landscapes and tourist sites reduces air quality, poses safety risks to visitors, and can damage the region's tourist image over the long term, resulting in medium vulnerability for economic development and employment.

#### Wind-Related Threats

Extreme winds and storms have moderate impacts on infrastructure, economic activities, and tourist attractions. Consequences include:

Limitation of wind-dependent activities (sailing, paragliding), tourist discomfort, and cancellation of outdoor events;

Damage to infrastructure and attractions, higher maintenance costs, and prolonged recovery periods;

Restricted access to natural areas, necessitating additional safety measures.



Swirling winds cause moderate damage, particularly to transportation and tourism infrastructure, disrupting services related to nature tourism and water sports. Their unpredictability can negatively affect visitors' perception of safety and the destination's attractiveness.

### Water-Related Threats

Changes in the hydrological regime, including droughts, water stress, and irregular rainfall, result in high sensitivity for tourism services and moderate sensitivity for economic activities and attractions. Reduced water availability and quality impact seasonal tourism activities and complicate tourism program planning. The degradation of natural landscapes diminishes the destination's appeal, particularly for water-based and ecotourism activities.

Marine acidification has no significant impact on tourism in the pilot site, whereas saltwater intrusion moderately affects attractions and economic activities due to reduced freshwater availability, which is essential for conserving wetlands and river habitats. Sea-level rise exhibits high sensitivity for attractions, infrastructure, and economic activities, leading to constraints on water use, potential resource conflicts, landscape degradation, and impacts on fishing-related tourism. Floods are not considered relevant for the tourism sector in the Neretva Estuary, as they occur outside the main tourist season.

### Solid Mass-Related Threats

Coastal erosion, landslides, and subsidence are not relevant for the pilot site. Soil degradation and erosion show moderate sensitivity for economic development and attractions, reducing the visual quality of landscapes and the overall attractiveness of the destination.



### 3.3. Agriculture

The Neretva Estuary is among Croatia's most fertile regions, renowned for its intensive agricultural production. Agriculture represents the primary economic activity, and the region's rich agro-biodiversity—including citrus, vegetables, vines, and traditional crops—is an important aspect of cultural heritage and a key factor in preserving local landscapes, habitats, and associated biodiversity.

Due to its low-lying position and exposure to coastal climate influences, agricultural systems in the Neretva Estuary are particularly vulnerable to climate stressors, including extreme temperatures, changes in the hydrological regime, saltwater intrusion, and soil erosion and degradation. The vulnerability assessment of three key agricultural components—land use and landscape, agricultural incomes and employment, and agricultural biodiversity—against the most significant climate threats is presented in Annex 2.

#### **Temperature-Related Threats**

Rising temperatures and heat waves exhibit high sensitivity across all dimensions. They disrupt planting and harvesting schedules, cause early blooms with the risk of late frosts, reduce yields of key crops (citrus fruits, mandarins, vegetables), and affect fruit quality. Additionally, they increase water stress and irrigation requirements and impact livestock and feed crop yields. Cold waves and frost show moderate sensitivity, as they can damage spring crops and affect vines, olives, and other sensitive crops. Forest fires in agricultural areas demonstrate high vulnerability, as they destroy rural infrastructure, plantations, and pastures, reduce available forage, and compromise farm safety.



## Wind-Related Threats

Changes in wind patterns and storm events show moderate sensitivity. Consequences include disrupted pollination, increased spread of diseases and pests, direct damage to crops and agricultural infrastructure, and higher insurance and production costs. Swirling winds, though rare, show low sensitivity, causing possible localized damage to small areas. Strong sirocco and bora winds can lead to soil and water salinization, reducing crop quality and limiting the availability of fresh irrigation water.

## Water-Related Threats

Changes in the hydrological regime, including droughts and irregular rainfall, are highly sensitive to income, employment, and land use, as they limit the availability of groundwater and surface water for irrigation and affect the reliability of sowing and harvesting.

Saltwater intrusion shows moderate sensitivity across all agricultural components, as it reduces irrigation water quality and promotes soil salinization in low-lying coastal areas, threatening long-term yields.

Sea-level rise demonstrates moderate sensitivity, causing soil salinization, drainage problems, reduced irrigation water availability, conflicts between agricultural and urban demands, and potential loss of water-sensitive crops.

Fluvial floods exhibit medium sensitivity, as they can result in loss of arable land, delayed or failed sowing, and damage to infrastructure.

## Solid Mass-Related Threats

Coastal erosion, subsidence, and landslides are not significant in the Neretva Estuary. However, soil degradation and erosion show moderate sensitivity across all dimensions, reducing long-term fertility, increasing land management costs, and threatening sustainable agricultural production.



### 3.4. Fishing and aquaculture

In the Neretva Estuary, commercial fishing and aquaculture focus on rivers, channels, and coastal freshwater and semi-saltwater ecosystems, while sport and recreational fishing represent important tourist and cultural activities. More than 20 fish species, including native and non-native species, have been recorded in the estuary. Among these, species such as carp, catfish, and pike are prized as trophy fish for sport fishing, whereas native species, including eels and local cyprinids, face population declines and are at genuine risk of extinction.

The deliberate introduction of non-native species in the past has significantly impacted local ecosystems, altering fish community structures, accelerating eutrophication, and affecting sedimentary communities. Fisheries and aquaculture management is conducted by the competent environmental and aquatic resource protection authority, ensuring the sustainability of activities within the estuary.

The analysis of climate drivers—including temperature, wind, and changes in water and soil dynamics—assesses impacts on three key components: resource use, income and employment, and multifunctionality, encompassing environmental services, cultural values, and the connection between fisheries and tourism. The results are presented in Annex 2.

#### **Temperature-Related Threats**

Rising temperatures and heat waves pose the highest risk, with high sensitivity for resource use, employment, and multifunctionality. Increased water temperatures affect fish reproduction, migration, and metabolism, favoring invasive species such as Prussian carp and sunfish while hindering native species. Reduced oxygen levels and algal blooms increase fish mortality and susceptibility to disease, threatening ecosystems and fishing revenues. Forest fires show medium sensitivity, with indirect effects from ash and sediment reaching water bodies, impacting water quality and ecological balance.

#### **Wind-Related Threats**



Changes in wind patterns and storm events show medium sensitivity. They influence water circulation, fish distribution, and nutrient availability, while restricting fishing activities. Swirling winds have low sensitivity due to their localized and short-term effects.

### **Water-Related Threats**

Changes in the hydrological regime, including droughts and altered rainfall, have medium sensitivity, affecting water salinity, nutrient loads, oxygen levels, and water availability for fish migration and aquaculture, thereby negatively impacting native species. Marine acidification exhibits medium sensitivity for multifunctionality, influencing food chains and environmental services. Saltwater intrusion is highly sensitive for resource use and multifunctionality and moderately sensitive for income and employment, as it increases salinity and affects freshwater and semi-saltwater fish populations critical for sport and recreational fishing. Sea-level rise demonstrates high sensitivity for resource use and medium sensitivity for income, employment, and multifunctionality, as it reduces freshwater supply, increases salinity, and alters species composition. Floods show medium sensitivity, as erosion and sediment/nutrient loads can threaten fish habitats and ecosystems.

### **Solid Mass-Related Threats**

Coastal erosion, subsidence, and landslides are not significant within the estuary, whereas soil degradation and erosion show medium sensitivity for resource use and multifunctionality, due to increased sedimentation, reduced water quality, and impacts on fish habitats.

## 4. Discussion



The vulnerability of the Neretva Estuary arises from the complex interplay of its natural characteristics, intense climate pressures, and human activities, which together contribute to ecosystem degradation and unsustainable resource use. Analysis of the biodiversity, tourism, agriculture, and fisheries sectors reveals common exposure to multiple climate drivers, with the most significant being rising temperatures, frequent heat waves, forest fires, changes in the hydrological regime, saltwater intrusion, and sea-level rise. While each sector responds to its specific environmental and economic dependencies, the findings highlight profound interconnections: habitat degradation leads to the loss of cultural and recreational values, and reductions in freshwater availability affect agricultural yields, fisheries, and tourism potential.

### **Temperature-Related Threats**

Rising temperatures, frequent heat waves, and prolonged droughts strongly affect all sectors of the Neretva Estuary. Elevated temperatures disrupt the biological cycles of native plant and animal species, reduce freshwater availability, threaten local fish and bird populations, and diminish the seasonal attractiveness of tourism. In agriculture, early fruit blooms pose risks, yields of crops such as citrus fruits, mandarins, and vegetables decline, and irrigation demands increase. In fisheries, higher water temperatures favor invasive species while reducing populations of native fish. For tourism, heat waves compromise visitor comfort and elevate health risks.

### **Hydrological Stress and Changes in the Water Regime**

Altered rainfall patterns, droughts, and reduced river flow result in the loss of aquatic habitats, soil and water salinization, and deteriorating water quality, impacting all sectors reliant on freshwater resources. Agriculture faces increased drought risk and reduced yields, fisheries lose native species sensitive to salinity, and tourism suffers from reduced appeal of ecological and water-based attractions. Furthermore, eutrophication caused by nutrient runoff from agriculture and the proliferation of invasive species further undermines aquatic ecosystems.

### **Salinity and Saltwater Intrusion**



Increased seawater intrusion and soil salinization particularly threaten wetland habitats, soil fertility, and agricultural productivity in the coastal parts of the Neretva Estuary. In fisheries, salinity alters fish community composition, reduces populations of native species, and increases the dominance of invasive species. In tourism, changes in aquatic ecosystems diminish the attractiveness of ecotourism and recreational fishing.

### **Extreme Events — Fires and Storms**

Forest fires and storms damage infrastructure, habitats, and wildlife refuges, causing direct economic losses in agriculture and tourism, increasing the risk of soil, air, and water pollution, and reducing overall ecosystem resilience. Changes in wind patterns and the occurrence of swirling winds further exacerbate soil erosion, infrastructure damage, and crop losses, affecting both resource availability and visitor safety.

### **Cumulative Pressures and Cross-Sectoral Links**

The combined impacts of climate extremes, intensive land use, and anthropogenic pressures lead to cumulative degradation of ecosystem services. Habitat and biodiversity loss threaten agriculture, fisheries, and tourism, while the economic stability of local communities becomes increasingly vulnerable. The primary threats—water stress (drought and salinization), climate extremes (heat waves and fires), invasive species, and habitat loss—are mutually reinforcing, creating multi-sectoral vulnerability across the Neretva Estuary.



## 5. Conclusions

The Neretva Estuary is an extremely valuable and productive region, yet it is highly sensitive to a range of climate change risks that strongly affect ecosystems, agriculture, tourism, and fisheries. Rising temperatures, more frequent heat waves, and prolonged droughts disrupt natural biological cycles, reduce freshwater availability, and increase stress on aquatic resources, leading to habitat degradation and elevated mortality of sensitive species, including birds, fish, and wetland fauna.

Altered rainfall patterns and hydrological variability further exacerbate water stress, promote saltwater intrusion into lowland areas, reduce soil fertility, and contribute to the eutrophication of canals and wetland systems, while threatening biodiversity and ecosystem services essential for agricultural production and the local economy.

Sea level rise and saltwater intrusion additionally increase osmotic stress on freshwater and agricultural ecosystems, reduce irrigation availability, and compromise the function of natural barriers, thereby threatening the stability of rural landscapes and the long-term security of food production. Extreme weather events, including wildfires, storms, and floods, intensify habitat degradation, damage infrastructure, and heighten community vulnerability.

The cumulative impacts of climate change on the Neretva Estuary clearly underscore the urgent need for integrated adaptation strategies. Such strategies should combine ecosystem preservation, sustainable water resource management, climate-resilient agriculture, and the protection of tourism and cultural heritage to mitigate long-term environmental and socio-economic risks and enhance the resilience of local systems to escalating climate threats.



## Annexes

- 1 - The working Excel file used to perform the analysis of hazards and threats under different local climate scenarios.
- 2 - The sensitivity assessment, resulting from the integration of the analyses completed by PP8, on threats and related impacts for the Neretva Estuary pilot site.

AREA: BIODIVERSITY			Area of protected habitats	Species richness	Ecosystem services
CLIMATE FACTORS	THREATS	IMPACTS	SENSITIVITY	SENSITIVITY	SENSITIVITY
TEMPERATURE	Temperature increase, heat waves	Effects on metabolism, growth and reproduction; change in reproductive cycles (i.e. nest failure and migration timing for birds), biological cycles (i.e. increased metabolic rates with stress organism); alterations of survival of key species ; altered predator-prey dynamics; increased vulnerability to disease outbreaks and non native, including invasive species stress in pine forest ecosystem where canopy cover and water regulations are insufficient to buffer high temperature; reduced plant productivity	High	High	Medium
	Cold waves, frost	Sensitive species (e.g., cold-water fish, wetland amphibians, reptiles, insects, temperature-dependent plants AND OTHER/ALL AQUATIC ANIMALS ) are replaced by generalists or non-native species more tolerant to heat, reducing overall biodiversity; carbon storage and nutrient cycling in wetlands may be impaired if plant productivity and microbial activity are reduced;	High	High	Medium
	Wildfires	destruction of the ecosystem; destruction of habitat structure and faunal shelter	High	High	High



WIND	Changes in the wind regime, storms (rain-snow and wind)	<p>extensive habitat and coastal damage Potential impacts on dune dynamics and coastal vegetation. Soil erosion Coastal dunes and wetlands may experience blowouts, sand displacement, or saltwater intrusion due to storm surges driven by high winds. Lagoon systems (e.g., Piailassa Baiona) may see sediment resuspension and breaching of protective embankments. nesting birds can lose breeding sites and suffer mortality during extreme wind events. Invertebrates and all other ground-dwelling species (e.g., amphibians in Bardello or Valle Mandriole) may be buried, displaced, or exposed.</p>	Medium	Low	Low
	Whirlwinds	<p>Forested areas (e.g., <i>San Vitale</i> and <i>Casalborsetti pinewoods</i>) are highly vulnerable to windthrow (uprooting or breakage of trees), altering forest structure and canopy. Coastal dunes and wetlands may experience blowouts, sand displacement, or saltwater intrusion due to storm surges driven by high winds. Lagoon systems (e.g., Piailassa Baiona) may see sediment resuspension and breaching of protective embankments. Same problems can occur on aquaculture installations, what will lead to the high economic losses. nesting birds can lose breeding sites and suffer mortality during extreme wind events. Invertebrates and ground-dwelling species (e.g., amphibians in Bardello or Valle Mandriole) may be buried, displaced, or exp</p>	Medium	Medium	Medium



WATER	Change in the hydrological regime (water stress, drought) and type of precipitation	change in seasonal cycles affecting habitat suitability and water dependent species change in hydrological cycle impacting wetland dynamics and aquatic habitats Reduced water availability for ecosystems, especially in summer; decrease in aquifer recharge (water deficit) causing problems for aquaculture and fisheries;	High	High	Medium
	Sea acidification	New dangerous species (alloctonus) living our coastal environments	Medium	Medium	Medium
	Saltwater intrusion	decrease in freshwater availability; change in plant communities; soil salinization and decrease in soil fertility; fresh water salinization will change flora and fauna of aquatic environment, causing also problems for fisheries and mariculture as well as for water biodiversity	High	High	High
	Sea level rise	coastal erosion; dune destruction; saltwater intrusion and encroachment of marine water along the rivers and canals open to the sea; soil salinization; decrease of freshwater ecosystems	High	High	High
	Flooding (coastal, fluvial, pluvial, groundwater)	flooding of habitats; erosion and sediment load impacting ecosystems; habitat loss floods will cause damages in all areas of economy,	High	High	High
SOLID MASS	Coastal erosion	increase of exposure to storm surge, flooding, saltwater intrusion; destruction of coastal habitats;	High	High	High
	Soil degradation/erosion	decrease in fertility; increase in runoff, will increase primary production and possibly increase eutrofication of coastal waters that potentially can present a problem for aquaculture, fisheries as well as aquatic biodiversity	High	Medium	High
	Landslide	n/a for Lamone but maybe for the other PPs	Low	Low	Low
	Subsidence	increase of pilot area vulnerability to flooding, salinization, coastal erosion; effects on ecosystem productivity and services	High	High	High



<b>AREA: TOURISM</b>					
<b>CLIMATE FACTORS</b>	<b>THREATS</b>	<b>IMPACTS</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>
TEMPERATURE	Temperature increase, heat waves	Shift in peak tourism seasons; loss of appeal in seasonal destinations (beach resorts birdwatching); higher operating costs for adaptation to hottest periods (e.g., air conditioning, insulation). Reduced tourist comfort and satisfaction; increased health risks (heatstroke, dehydration); potential declines in visitation during hot months. Unpredictable weather discourages bookings; difficulty in planning travel packages and events; risk to outdoor tourism reliability. Cancellation of outdoor events and activities; increased demand for cooling and water; health risks; lowered tourist satisfaction.	Medium	Medium	Medium
	Cold waves, frost	Risk to transportation and accessibility; temporary closures of tourist services; increased heating costs.	Low	Low	Low
	Wildfires	Destruction of natural landscapes (coastal and historical pinewoods) and tourist attractions (damages in coastal pinewood and beach establishments); evacuation of areas; air quality issues; long-term damage to tourism brand.	High	Medium	High
WIND	Changes in the wind regime, storms (rain-snow and wind)	Altered patterns of wind-dependent activities (e.g., sailing, paragliding); discomfort for tourists; potential safety concerns. Event cancellations; damage to attractions and property; reduced safety and accessibility; increased maintenance costs.	Low	Low	Low
	Whirlwinds	Damages to transport infrastructure and services; long recovery periods; insurance challenges; safety concerns reduce demand. Damages also to private infrastructures; visitor panic and safety risks; reduced trust in safety of destination. Unpredictable water availability affects rural/ecotourism; problems for water sports and nature-based tourism.	Medium	Medium	Medium



WATER	Change in the hydrological regime (water stress, drought) and type of precipitation	Change in seasonality and reliability of tourism seasons (also extension of the touristic season).	Medium	Medium	Medium
	Sea acidification	New dangerous species (alloctonus) living our coastal environments	Low	Low	Medium
	Saltwater intrusion	Affects freshwater availability for hotels/resorts; deteriorates agricultural landscapes used for agritourism.	Low	Low	Low
	Sea level rise	Loss of beaches; relocation of coastal infrastructure; increase in flooding of tourist areas; higher insurance costs. Conflict over water use between tourists and locals; reputational damage; reduced quality of service. Landscape degradation; fire risk increases; impacts on wildlife tourism; restrictions on water use. Infrastructure strain; flash floods; access limitations; damage to heritage sites and trails.	High	Medium	High
	Flooding (coastal, fluvial, pluvial, groundwater)	Direct damage to tourist areas; reduced tourist confidence; interruption of public services.	High	High	High
SOLID MASS	Coastal erosion	Beach loss; decline in coastal tourism; costly protective infrastructure investments; loss of tourism revenue. Need of rigid protection infrastructures	High	Medium	High
	Soil degradation/erosion	Degradation of scenic landscapes; reduced attractiveness of destination.	Low	Low	Low
	Landslide	n/a for Lamone but maybe for the other PPs	Low	Low	Low
	Subsidence	Beach loss; Structural damage to heritage buildings and accommodations; disruption in services and access.	High	Medium	Medium





<b>AREA: AGRICULTURE</b>					
<b>CLIMATE FACTORS</b>	<b>THREATS</b>	<b>IMPACTS</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>
TEMPERATURE	Temperature increase, heat waves	Alters crop cycles; risk of early blooming followed by late frost damage. Stress on crops (e.g., grapes, fruit trees) and livestock; reduced agricultural yields. Affects pollination, fruit set, and overall crop quality. Risk of overripening or sunburn in fruit and vegetables; water stress and increased irrigation needs.	Medium	High	Medium
	Cold waves, frost	Damages to spring crops (e.g., orchards); affects vines and olive trees.	Medium	High	Low
	Wildfires	Damage to rural lands and pastures; loss of forage, crops and fire risk to farm buildings.	Medium	Medium	Low
WIND	Changes in the wind regime, storms (rain-snow and wind)	Impacts pollination; spreads pests and diseases; potential damage to greenhouses. Direct damage to crops (especially grapes, fruit, vegetables); increases insurance and production costs.	Medium	Medium	Low
	Whirlwinds	Localized destruction of crops, greenhouses, and farm equipment.	Medium	High	Low
WATER	Change in the hydrological regime (water stress, drought) and type of precipitation	Altered irrigation scheduling; unpredictable sowing and harvest periods. Impacts on groundwater recharge and surface water availability for irrigation.	Low	High	Low
	Sea acidification	//	Low	Low	Low
	Saltwater intrusion	Affects water quality for irrigation in low-lying coastal areas; reduces crop yield.	Medium	Medium	Low
	Sea level rise	Long-term threat to coastal farmland; soil salinization and drainage problems. Reduced availability of irrigation water; conflict between agricultural and urban uses. Crop failure, especially in water-sensitive crops; increased reliance on emergency irrigation. Soil erosion, nutrient leaching, waterlogging, and crop loss.	High	High	Medium
	Flooding (coastal, fluvial, pluvial, groundwater)	Loss of arable land and delayed or canceled planting; infrastructure damage.	High	High	Medium
SOLID MASS	Coastal erosion	Reduces usable farmland in coastal zones; threatens protective infrastructure.	Medium	Medium	Low
	Soil degradation/erosion	Loss of soil fertility; impacts on long-term productivity and land management costs.	Medium	High	Medium
	Landslide	n/a for Lamone but maybe for the other PPs	Low	Low	Low
	Subsidence	Ravenna is historically affected; lowers land level and increases flood risk in farmlands.	High	High	Medium



<b>AREA: FISHERIES AND AQUACULTURE</b>					
<b>CLIMATE FACTORS</b>	<b>THREATS</b>	<b>IMPACTS</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>	<b>SENSITIVITY</b>
TEMPERATURE	Temperature increase, heat waves	Alters water temperature, affecting aquatic animals reproduction, migration, and metabolism. Some species may decline or disappear. Non-native, of which some are invasive, will establish their population and compete with native species for feed and area. Such an example of newcomers that established its' population out compete native species, disrupt food chains, damage gears, but also poses economical potential is blue crab ( <i>Callinectes sapidus</i> ). High temperatures reduce oxygen levels in water as well as influence consequently other water/sea physico-chemical water quality parameters (ecological factors) that influence aquatic animals mortality and stress that increase vulnerability to diseases. Apart from the fact that stress increase vulnerability to diseases, these condition can brought to appearance of new pathogens, or increase density of present pathogens (causes of diseases) due to their favourable conditions in water).	High	High	Medium
	Cold waves	High mortalities of aquatic animal in shallow waters; to aquaculture facilities and equipment; high mortalities because of unfavourable conditions for farmed species, loss of native population, settlement of non-native speacies for which these conditions are optimal. All mentioned facts will highly influence aquatic biodiversity.	Medium	Medium	Low
	Wildfires	Indirect effects through ash, toxic compound, and debris entering water bodies and consequently impacting water quality.	Low	Low	Low
WIND	Changes in the wind regime, storms (rain-snow and wind)	Alters upwelling and water circulation, influencing nutrient availability and aquatic organisms distribution. Disturb aquaculture infrastructure; limit fishing activity; risk of fish escapes.	Low	Low	Low
	Whirlwinds	Can damage boats and onshore facilities; very localized impact.	Medium	Medium	Low



WATER	Change in the hydrological regime (water stress, drought) and type of precipitation	Affects salinity and nutrient load in coastal lagoons; impacts aquatic organisms sensitive to water quality. Alters estuarine and lagoon conditions; affects breeding of migratory and freshwater-dependent fish.	Medium	Medium	Low
	Sea acidification	Threatens mollusks by weakening shells; high acidification can cause negative impact on all aquatic organisms physiology and consequently impacts food chains.	Medium	Medium	Medium
	Saltwater intrusion	Increases salinity in brackish lagoons, even rivers; negatively affects freshwater species, biodiversity (loss of species that can't tolerate salt water), fisheries and aquaculture.	Medium	Medium	Medium
	Sea level rise	Inundates coastal aquaculture sites and infrastructure; loss of brackish ecosystems like Valli di Comacchio. Reduces freshwater input into lagoons; imbalance in ecosystems and species decline. Decline in water levels and quality; increased salinity in coastal waters affecting species composition. Alters water chemistry; causes flooding of fish farms and infrastructure damage.	High	High	Medium
	Flooding (coastal, fluvial, pluvial, groundwater)	Physical damage to fish farms, tanks, and processing facilities; fish escapes.	Medium	Medium	Medium
	Coastal erosion	Loss of coastal lagoons and habitats vital for nursery areas; threats to aquaculture farms infrastructure.	High	High	Medium
SOLID MASS	Soil degradation/erosion	Increased sediment load in water; impacts water quality, primary production and gills of aquatic animals.	Low	Low	Low
	Landslide	n/a for Lamone but maybe for the other PPs	Low	Low	Low
	Subsidence	Worsens flood risk in coastal aquaculture zones; increases salinity intrusion.	High	High	Medium

