D.1.4.1

Report on the local scenarios

Po Delta and Lamone River pilot site

Version of 27/09/2025

(PP3 UNIBO, PP4 IDECO, LP MR, and PP2 PDP contribution to

Deliverable Number D.1.3.1)

Interreg Co-funded by the European Union
Italy – Croatia
ACTION

Project acronym	ACTION
Project ID Number	ITHR0200390
Project Title	Increasing coastal ecosystem resilience to climate change
Programme priority	Green and resilient shared environment
Specific objective	1.2: Ecological and socio-economic analyses
Work Package Number	1
Work Package Title	Analysis of Pilot areas
Activity Number	1.4
Activity Title	Report on the local scenarios
Partner in charge	PP3 UNIBO
Partners involved	PP3 UNIBO, PP4 IDECO, LP MR, and PP2 PDP
Status	Final
Distribution	Internal partners repository

Interreg Italy – Croatia
Co-funded by the European Union
ACTION

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Abstract

This report analyses the exposure and vulnerability of the Po Delta and Lamone River pilot site (Ravenna) to climate change across four key sectors: biodiversity, tourism, agriculture, and fisheries/aquaculture. For each sector, adaptation strategies and their feasibility and applicability within the environmental, socio-economic, and governance context are discussed. The assessment considers two IPCC scenarios, SSP2-4.5 and SSP5-8.5. Results reveal that biodiversity is critically exposed to hydraulic/hydrogeological and thermal risks, while agriculture also faces high vulnerability to geological and land degradation risks. Tourism shows its highest vulnerability to flooding and coastal hazards, and fisheries/aquaculture to lagoon salinization and hydraulic risk. Under SSP5-8.5, adaptation capacity is ineffective, and all sectors shift to high vulnerability values. Overall, the pilot site emerges as a climate hotspot with high exposure, where urgent, cross-sectoral adaptation measures are required to protect ecosystems, infrastructure, and livelihoods.

1. Introduction

This report presents a structured methodology for assessing climate vulnerability and resilience in the Po Delta and Lamone River pilot site, within the framework of the ACTION – Increasing coastal ecosystem resilience to climate change project.
The Po Delta and Lamone River basin constitute a socio-ecological system of strategic relevance for the northern Adriatic coast of Emilia-Romagna. This area includes highly valuable and fragile ecosystems, agricultural landscapes, important coastal tourism destinations, traditional fisheries and aquaculture activities, and industrial activities. The region is highly vulnerable to climate change, facing increasing hazards and threats such as flooding, storm surges, saltwater intrusion, land subsidence, drought, as detailed described in the project deliverables D.1.2.1. and D.1.3.1.
The study adopts a common assessment matrix, agreed upon by project partners, which combines considers sensitivity, exposure, and adaptive capacity across relevant sectors - biodiversity, tourism, agriculture, fisheries and aquaculture. Two climate scenarios are considered: SSP2-4.5, which represents a moderate mitigation pathway, and SSP5-8.5, describing a high-emission trajectory where adaptation capacity becomes ineffective.
This integrated approach allows identifying the most critical risks for each sector, thus providing evidence for prioritizing adaptation strategies at the local scale.

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.
For the analysis of hazards and threats and local scenarios of the Po Delta and Lamone River pilot site the following stakeholders were involved: i) PP3 UNIBO, as research organization; ii) the LM Ravenna Municipality, as local public administration; and iii) the PP2 PDP, as environmental management body.

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

AREA: BIODIVERSITY			Area of protected habitats	Species richness	Ecosystem services
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, drougth) 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: TOURISM			Tourism infrastructure and services	Economic development and employmen	Preservation of tourist attractions
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, drougth) 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: 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, drougth) 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, drougth) 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 (Calvin et al., 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_2 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_2 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.

Current climate exposure				
Season	*Thermal risk and climate extremes*	*Hydraulic and hydrogeological risk*	*Wind and weather storm risk*	*Geological and land degradation risk*
Spring				
Summer				
Autumn				
Winter				

Future climate exposure: SSP2-4.5 scenario - "Middle of the Road" world where trends largely follow their historical patterns				
Season	*Thermal risk and climate extremes*	*Hydraulic and hydrogeological risk*	*Wind and weather storm risk*	*Geological and land degradation risk*
Spring				
Summer				
Autumn				
Winter				

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				
Season	*Thermal risk and climate extremes*	*Hydraulic and hydrogeological risk*	*Wind and weather storm risk*	*Geological and land degradation risk*
Spring				
Summer				
Autumn				
Winter				

LEGEND
HIGH: High probability of occurrence with potential significant impacts
MODERATE-HIGH
MODERATE: Medium probability of occurrence with manageable impac
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*	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*
	Adaptive Capacity				
Species richness	**Measures**	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*
	Adaptive Capacity				
Ecosystem services	**Measures**	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*	*List potential adaptation/prevention measures and their level*	*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:

*Residual Vulnerability = Sensitivity * Exposure / 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:

- 1–2: Low residual vulnerability
- 3–5: Moderate vulnerability
- 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: 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: 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: 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 and discussion

3.1. Exposure

3.1.1. Current and Future Climate Exposure

As described in the deliverable D.1.3.1, the Po Delta-Lamone River pilot site is a fragile area where hydraulic, thermal, storm-related, and land degradation risks interact with subsidence, salinization, and human pressures.

The pilot area is currently exposed to significant hydraulic and hydrogeological risks. These include riverine flooding, as evidenced by the events of 2023 and 2024 (Arrighi and Domeneghetti, 2024; Brath et al., 2023; Cremonini et al., 2024; Valente et al., 2025), which affected extensive areas along the Romagna coast, causing considerable damage to infrastructure, agricultural land, and urban settlements. The complex hydrological network (river and drainage system) combined with flat and low topography, make the pilot area particularly vulnerable to overflow during periods of heavy rainfall. Coastal flooding, particularly during strong wind and winter storm surges, also represents a major hazard (Ciavola et al., 2007; Salerno et al., 2012), affecting extensive areas of both coastal urban settlements (e.g., Casalborsetti, Marina Romea), damaging coastal dunes and natural habitats such as the Piallassa Baiona and nearby wetlands.

The region also faces saltwater intrusion into aquifers and wetlands, driven by a combination of factors including land subsidence, sea level rise, intensive drainage, and reduced aquifer recharge (Antonellini et al., 2008; Colombani et al., 2017; Cozzolino et al., 2017; Giambastiani et al., 2021; Mollema et al., 2013) . This phenomenon threatens freshwater resources, agricultural productivity, and the ecological integrity of sensitive wetland areas. Over time, these combined pressures can intensify soil salinization, compromise groundwater quality, and undermine the sustainability of local water management systems.

Overall, the hydrogeological and hydraulic risk profile of the pilot area is high-moderate high, resulting from the interplay of natural processes, human-induced modifications, and climate change impacts, which collectively pose serious challenges for both environmental conservation and socio-economic development.

Regarding thermal risks and climate extremes, the pilot site is exposed to more frequent heatwaves in summer compared to the past, increased drought episodes (i.e. the most recent and severe in 2022 (Bonaldo et al., 2023; Montanari et al., 2023), and reduced water availability, with cascading effects on ecosystems, agriculture, and tourism.

The exposure of the pilot area to geological risks is currently moderate, moderate-high, mainly related to subsidence, shoreline retreat, and soil erosion, which affect both natural and agricultural systems.

3.1.2. Future exposure under SSP2-4.5

Under the SSP2-4.5 scenario, the Po Delta and Lamone River pilot site, as well as the whole territory of Ravenna, is expected to face an intensification of the abovementioned risks. Thermal extremes are projected to become more frequent and prolonged, with longer and more intense heatwaves affecting urban areas, and rural agricultural zones in the surrounding plains.

The mean projections for the Emilia-Romagna region, provided by the Climate Change Knowledge Portal (https://climateknowledgeportal.worldbank.org/country/italy/climate-data-projections) and based on the CMIP6 – Coupled Model Intercomparison Project Phase 6 (https://pcmdi.llnl.gov/CMIP6/), which supports the IPCC's Sixth Assessment Report, indicate a marked increase in the frequency and duration of heatwaves. The number of hot days (T > 35 °C) is projected to rise consistently, especially during the summer months (June–August, Fig. 5), with mean annual temperatures increasing by approximately +1.5 °C by mid-century compared to the reference period 1995–2014 (Fig. 6). These changes are expected to intensify the urban heat island effect in densely urbanized areas, leading to higher energy demand for cooling and greater health risks for vulnerable populations. In addition, rising temperatures will exacerbate water scarcity and increase water demand, both for irrigation in agriculture and for the preservation of natural ecosystems.

Exposure to hydraulic hazards, including riverine floods, coastal storm surges, and saltwater intrusion, is likely to remain consistently high throughout the year due to the combined effects of rising temperatures, altered precipitation patterns, and ongoing land subsidence. In addition, wind- and storm-related risks are expected to intensify in autumn and winter, leading to more frequent episodes of coastal erosion along the Adriatic coast. These processes threaten both coastal settlements and wetland habitats, while also damaging existing coastal defence infrastructures, thereby reducing its effectiveness and increasing the vulnerability of the territory.

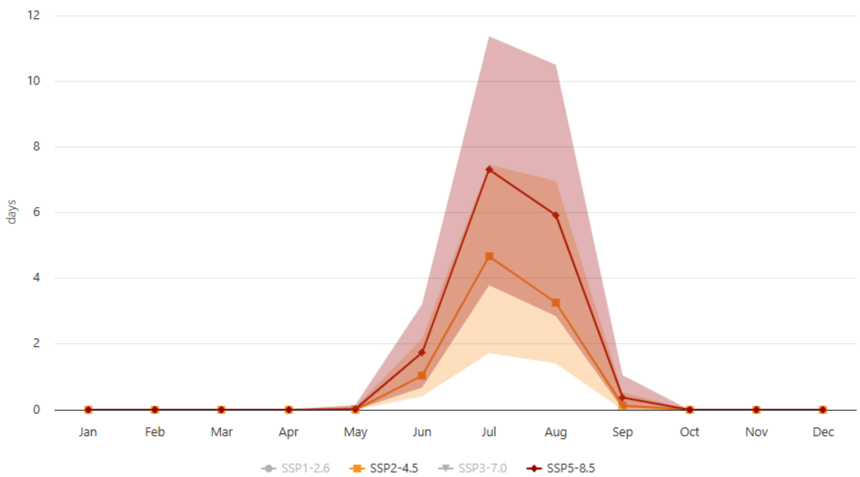

Fig. 5 - Projected anomaly of number of hot days (T-max > 35°C) to 2040-2059, under SSP2-4.5 and SSP5-8.5 scenarios, relative to a reference period 1995-2014. The p10 and p90 shading indicate the 10th and 90th percentile ranges among the different climate models in the ensemble, providing insight into the uncertainty or spread of monthly projections.

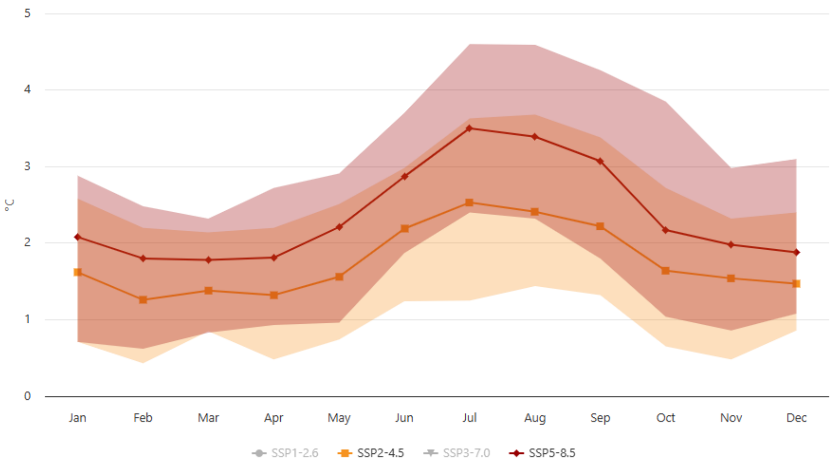

Fig. 6 – Projected changes of average mean surface air temperature (°C) to 2024-2059 under SSP2-4.5 and SSP5-8.5 scenarios, relative to a reference period 1995-2014. The p10 and p90 shading indicate the 10th and 90th percentile ranges among the different climate models in the ensemble, providing insight into the uncertainty or spread of monthly projections (data from Climate Change Knowledge Portal; https://climateknowledgeportal.worldbank.org/)

3.1.3. Future exposure under SSP5-8.5

Under the high-emission SSP5-8.5 pathway, all risk categories in the pilot area are projected to escalate to critical levels. Sea-level rise, projected for the northern Adriatic coast of Italy at approximately +0.33 m by 2060 relative to the 1995–2014 baseline (according to NASA's IPCC AR6 Sea-Level Projection Tool: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?type=global; Fig. 7), will substantially increase the frequency and severity of both riverine and coastal flooding. In parallel, it will intensify saltwater intrusion into aquifers and promote saltwater encroachment along rivers and canals, further undermining freshwater availability and increasing pressure on water management systems.

Prolonged high temperatures and extreme heatwaves (Fig. 5 and Fig. 6), combined with recurrent droughts, will place severe pressure on agriculture—particularly on crops sensitive to water stress—and threaten the availability of freshwater for human use and ecological needs. The combination of these thermal and hydraulic stresses will also impact biodiversity, including endangered wetland species, and compromise the ecological functioning of the Po Delta and adjacent coastal lagoons. Under this scenario, the pilot site, and Ravenna itself, effectively becomes a climate hotspot, where cascading and interconnected hazards pose systemic risks to both human settlements and natural ecosystems.

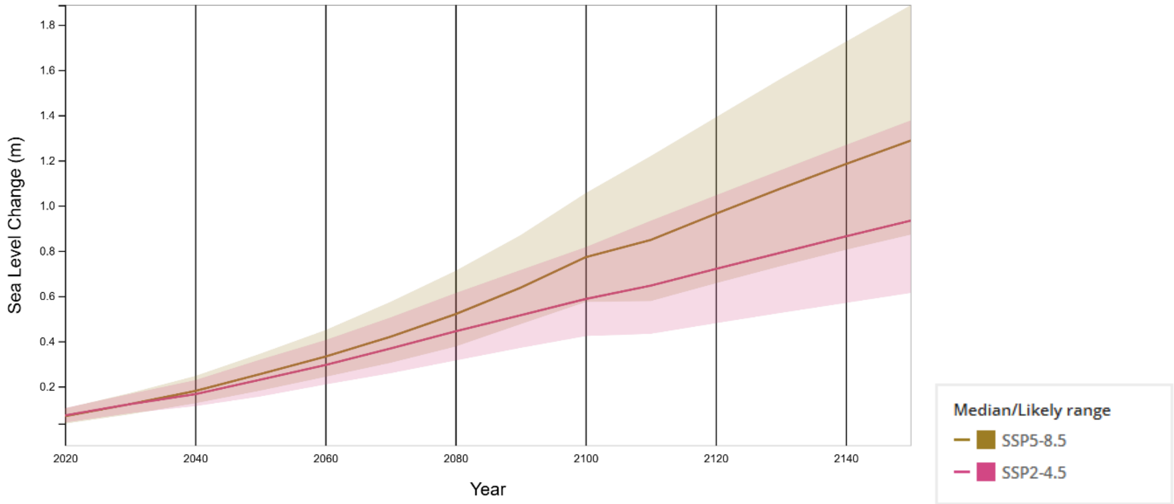

Fig. 7 – Projected sea level rise under SSP2-4.5 and SSP5-8.5 scenarios for the Norther Adriatic Sea. Projections are relative to a 1995-2014 baseline (data by NASA – Sea Level Change https://sealevel.nasa.gov/)

3.2. Adaptation strategies and adaptive capacity

The analysis of adaptation strategies for the Po Delta–Lamone River pilot site reflects both the ecological fragility of the area and the heterogeneous level of preparedness to face climate risks. Across all thematic areas, adaptive capacity under the SSP2-4.5 scenario is uneven: measures exist and in some cases are already implemented, but gaps remain in financial resources, institutional coordination, and public awareness.

3.2.1. Biodiversity

Protected habitats could benefit from a wide range of proposed ecosystem-based and infrastructural measures (forest canopy increase, dune protection and restoration, shoreline stabilization). Adaptive capacity is generally medium, indicating that while management instruments and technical know-how are available, implementation depends on financial and institutional resources. Species richness shows lower adaptive capacity, particularly against hydraulic and storm-related risks, due to the high sensitivity of indicator species and the limited feasibility of rapid interventions. By contrast, ecosystem services exhibit stronger potential for adaptation (medium to high capacity) thanks to the nature-based solutions already partially embedded in local policies. Overall, biodiversity adaptation depends heavily on long-term ecosystem management and the ability to maintain connectivity among habitats, especially under scenarios of saltwater intrusion and water stress.

3.2.2. Tourism

Tourism infrastructure displays contrasting levels of adaptation. While measures against thermal extremes (e.g. shading vegetation, cooling areas, urban green, etc.) are feasible and supported by governance (high capacity), hydraulic risks reveal major weaknesses. The territory is highly exposed (see paragraph 3.1. above) and securing tourist infrastructures against these risks requires costly interventions (e.g., reinforcing embankments, updating water drainage systems), which are often beyond the financial capacity of local administrations and operators. Furthermore, although rapid alert systems and evacuation plans exist in some areas, their coverage is partial, and awareness campaigns targeting tourists remain limited. As a result, adaptive capacity to hydraulic risks is considered low; strengthening it would require not only infrastructural investments but also long-term planning to align tourism development with climate resilience goals.

Economic development and employment in the tourism sector are moderately adaptable to climatic extremes but remain vulnerable to hydraulic risks, as compensation mechanisms and safety planning are not enough. The preservation of cultural and natural tourist attractions presents the lowest adaptive capacity overall, reflecting the difficulty of protecting heritage assets from extreme events.

3.2.3. Agriculture

Adaptive strategies include a mix of agroforestry, resilient crops (including less water-demanding options and salt-tolerant plants), flood-tolerant land zoning, and insurance schemes. Flood-tolerant land zoning involves dividing areas based on flood risk by implementing tailored development strategies: high -risk zones should be restricted to low-occupancy uses like recreation, while in low-risk areas, more development would be permitted with the aim of reducing flood impacts and ensuring buildings can withstand or adapt to flood events.

The adaptive capacity of agricultural income and employment cannot be considered uniformly low, but it displays low to medium capacity. After the severe floods of 2023 and 2024, regional and national authorities mobilized substantial compensation schemes, emergency funds, and facilitated access to EU rural development instruments. These measures partly reduced the immediate economic losses for farmers and agricultural workers. However, access to subsidies and insurance coverage remains uneven, with small-scale farms often facing delays or difficulties in navigating bureaucratic procedures. This situation will worsen in case of an increase of extreme events.

In general, agriculture remains one of the most exposed sectors, requiring structural investment in innovation and governance support.

3.2.4. Fishing and Aquaculture

Adaptive capacity in this sector is highly variable: some activities are better prepared to adapt to climate change, while others are much less resilient. The use of resources and income/employment dimensions are constrained by low to medium capacity, as traditional fishing and small-scale aquaculture (e.g., clams, mussels, eel farming in coastal lagoons) show limited diversification, strong dependence on a few climate-sensitive species (often affected by heatwaves or harmful algal blooms), and almost no access to insurance or financial tools for extreme events. However, multifunctionality shows relatively strong adaptive potential (medium to high capacity), with opportunities to integrate aquaculture into offshore renewable energy projects, eco-tourism (e.g., recreational fishing tourism, already established in Marina di Ravenna, Cervia, and Goro), and ecosystem restoration (i.e. oyster reefs as promoted by the LIFE NatuReef project - https://site.unibo.it/life-natureef/en, or wetland buffering). These multifunctional approaches can enhance resilience, diversify income sources, and raise climate awareness, but they will only succeed if supported by adequate governance frameworks and public and private investments.

3.3. Residual vulnerability assessment

The residual vulnerability assessment and the summary of scores highlights sector-specific criticalities under the 2 selected climate scenarios SSP2-4.5 and SSP5-8.5.

Highest residual vulnerability (score >5) is associated with hydraulic and hydrogeological risks (8.40) and thermal risks and climate extremes (7.94) under SSP5-8.5. This is due to high exposure (flooding, salinization, climate extremes and higher temperatures) combined with limited adaptive capacity, particularly regarding habitat protection. This indicates extreme fragility of ecosystems in the pilot site, where adaptation capacity collapses under high-emission scenarios.

Tourism and agriculture show to be highly vulnerable to hydraulic and hydrogeological risks (6.40 and 5.80 under SSP5-8.5, respectively), with infrastructures highly exposed to floods and storm surges. Additionally, agriculture is highly exposed to geological and land degradation risk (5.50), reflecting the strong impact of soil erosion, subsidence, and salinization on agricultural productivity. In this sector adaptive strategies exist but remain fragmented, with uneven access to resources and limited protection for small farms. Also fishing and aquaculture are vulnerable to hydraulic risks associated with salinization, lagoon flooding, change in water regime and availability, storm surges.

Moderate to high vulnerability also appears for thermal extremes (4.89 under SSP5-8.5), impacting aquaculture species and ecosystem balance.

Lower vulnerability (scores 1–2) is associated to geological risks and wind and weather storm risks, generally, less critical under SSP2-4.5, but still increasing in the extreme scenario.

4. Conclusions

The residual vulnerability assessment for the Po Delta–Lamone River pilot site highlights the structural fragility of the territory and the uneven distribution of adaptive capacity across sectors.

Across the pilot area, hydraulic and thermal risks consistently represent the most critical drivers of residual vulnerability, especially for biodiversity and agriculture. Geological degradation and land degradation risks, linked to subsidence, erosion, and water and soil salinization, are particularly relevant for agriculture, while storm-related risks remain comparatively less severe. Tourism is strongly exposed to hydraulic hazards, with infrastructures and cultural/natural assets threatened by floods and storm surges. Fisheries and aquaculture are severely affected by hydraulic risks and moderately by thermal extremes, with cascading effects on local livelihoods.

Under SSP2-4.5, vulnerabilities remain moderate to high but can be partly mitigated through diversified and well-implemented adaptation strategies. Under SSP5-8.5, however, adaptation capacity collapses, and vulnerabilities rise severely across all sectors, confirming the site as a climate hotspot.

The complete analysis underlines the urgency of strengthening water management measures; diversifying adaptation pathways; investing in ecosystem-based and nature-based solutions (wetland restoration, dune protection, agroecological practices); and enhancing governance, financial instruments, targeted investments, and community awareness to ensure effective adaptation.

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Annexes

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

2 - Exposure, Adaptation and Residual Risk assessments, resulting from the integration of the analyses completed by PP3 UNIBO, LP MR, and PP2 PDP on threats and related impacts for the Po Delta and Lamone River pilot site.

ANNEX 2- The Exposure, Adaptation and Residual Risk assessments, resulting from the integration of the analyses completed by PP3 UNIBO, LP MR, and PP2 PDP on threats and related impacts for the Po Delta and Lamone River pilot site

The matrix below shows the results of the Exposure analysis, the assessment of the adaptation solutions, and the residual risk assessment developed for the Po Delta and Lamone River pilot site under different climate scenarios (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.

Current climate exposure				
Season	*Thermal risk and climate extremes*	*Hydraulic and hydrogeological risk*	*Wind and weather storm risk*	*Geological and land degradation risk*
Spring	Moderate	High	Moderate-High	Moderate-High
Summer	High	Moderate-High	Low	Moderate
Autumn	Moderate-Low	High	Moderate-High	Moderate-High
Winter	Moderate-Low	Moderate-High	High	Moderate

Future climate exposure: SSP2-4.5 scenario - "Middle of the Road" world where trends largely follow their historical patterns				
Season	*Thermal risk and climate extremes*	*Hydraulic and hydrogeological risk*	*Wind and weather storm risk*	*Geological and land degradation risk*
Spring	**Moderate-High**	High	Moderate-High	Moderate-High
Summer	High	Moderate-High	Low	Moderate
Autumn	Moderate-Low	High	Moderate-High	Moderate-High
Winter	Moderate-Low	Moderate-High	High	Moderate

Future Climate Exposure: Scenario SSP5-8.5 - Fossil-fueled Development "Taking the Highway", a world characterized by rapid and unlimited growth in economic production and energy use				
Season	*Thermal risk and climate extremes*	*Hydraulic and hydrogeological risk*	*Wind and weather storm risk*	*Geological and land degradation risk*
Spring	High	High	High	High
Summer	High	High	Low	Moderate-High
Autumn	Moderate-High	High	High	High
Winter	Moderate-High	High	High	Moderate-High

LEGEND
HIGH: High probability of occurrence with potential significant impacts

MODERATE-HIGH
MODERATE: Medium probability of occurrence with manageable impacts

MODERATE-LOW

LOW: Limited probability and low impacts

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 favorable (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**	*Increase forest canopy* *Create water retention ponds* *Control water releases to match phenology of species* *Monitor climatic conditions*	optimize hydrological network and water management; fix hydraulic infrastructure (i.e. sluice gates) Buffer zones to slow runoff and collect water Reduce artificial drainage in sensitive zones	Maintain and restore coastal dune Reinforce embankments in wetlands and lagoons	Stabilize and revegetate eroding shorelines; Promote sediment trapping measures; Reduce land subsidence through sustainable groundwater and gas extraction;
	Adaptive Capacity	*Medium*	*Medium*	***Medium***	*Medium*

Species richness	**Measures**	Adjust management of breeding timing and habitat water levels Monitor indicator species' stress responses	Restore water connectivity between wetland units	Monitor vulnerable nesting sites Avoid forest over-fragmentation to reduce blowdown risk	Create refuges or corridors for species migration; Restore degraded habitats to support ecosystem resilience
	Adaptive Capacity	*Medium*	*Low*	*Low*	*Medium*
Ecosystem services	**Measures**	Protect wetland buffer vegetation Avoid land change and consumption Encourage agroecological practices in buffer areas	Improve drainage systems - Enhance water storage capacity during wet seasons - Apply water-sensitive agriculture	Grow natural windbreaks and vegetative buffers to reduce storm damage; Diversify agroecosystem functions including long rotation crops	Prevent soil compaction and erosion in agricultural and wetland areas; Apply conservation tillage and native vegetation cover
	Adaptive Capacity	*Medium*	*Medium*	*High*	*Medium*

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**	Increase shading vegetation along nature trails; Improve microclimatic resilience of protected coastal areas; Adjust timing of tourist access based on seasonal extremes. Implement rapid alert systems to inform tourists of real-time natural hazards.	Restore wetlands as natural buffers; Improve infrastructure to cope with flooding in natural parks and lagoon trails; Maintain boardwalks and elevated paths in vulnerable areas. Implement rapid alert systems to inform tourists of real-time natural hazards.	Strengthen natural dune systems protecting visitor areas; Design wind-resistant structures for info points and shelters. Implement rapid alert systems to inform tourists of real-time natural hazards.	Stabilize hiking paths and coastal lookout points; Control tourist access in erosion-prone zones; Manage compaction and footpath erosion

	Adaptive Capacity	*High*	*Low*	*Medium*	*Medium*
Economic development and employment	**Measures**	Regulate tourist access based on forecasts of extreme weather events. Educate visitors about newly introduced or dangerous species and increase the availability of potable water sources.	Increase connectivity of habitats to preserve mobile species (e.g., birds, amphibians) as well as restore and maintain small freshwater bodies within tourist nature parks. Implement rapid alert systems to inform tourists of real-time natural hazards. Establish safety points in elevated areas to minimize flood risks for both tourists and employees.	Implement rapid alert systems to inform tourists of real-time natural hazards. Develop resilient infrastructure in tourist areas to protect both visitors and employees from major storms and extreme weather events.	Rehabilitate degraded tourist natural sites and maintain the existing one to increase attractivity; Monitor and manage human impact on touristic ecosystems.
	Adaptive Capacity	*Medium*	*Low*	*Medium*	*Low*
Preservation of tourist attractions	**Measures**	Introduce heat-resilient vegetation in and around attractions; Use reflective or breathable materials in conservation areas; Limit access during extreme heat conditions.	Develop water drainage systems near historical/cultural sites; Protect attractions from floods with barriers and water diversion methods; Elevate or relocate vulnerable features.	Use wind-resistant barriers and shelters to protect open-air attractions; Stabilize structures and artifacts exposed to windstorms; Use temporary covers during extreme weather.	Restore eroded landscapes and features; Restrict access to fragile geological formations; Use sustainable materials and techniques in conservation to minimize human impact.
	Adaptive Capacity	***Low***	*Low*	*Medium*	*Low*

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**	Promote agroforestry and shaded cropping systems; Shift sowing and harvesting calendars; Introduce heat-resilient crops; Expand use of mulching and precision irrigation.	Restore and conserve wetlands to regulate water cycles; Design flood-tolerant cropping zones; Create buffer zones near water bodies as flooding areas; Improve and maintain drainage infrastructures.	Use shelterbelts and windbreaks; Apply storm-resilient land zoning practices; Reinforce protective field infrastructure like greenhouses and fencing.	Enforce zoning in erosion-prone areas; Implement soil stabilization and reforestation projects. Increase the carbon storage against soil erosion.
	Adaptive Capacity	*Medium*	*Medium*	*High*	*Medium*
Agricultural income and employment	**Measures**	Provide subsidies for climate-resilient farming; Support income diversification (e.g., agritourism); Develop early warning systems for heatwaves and crop loss.	Promote insurance for flood-related crop loss; Offer financial aid for farm recovery; Train farmers on adaptive irrigation methods and water conservation.	Strengthen access to social safety nets post-storm events; Provide infrastructure protection grants; Support local cooperatives for emergency response.	Invest in land restoration programs with labor components; Encourage sustainable farming to prevent land degradation; Fund educational programs for soil health practices.
	Adaptive Capacity	*Low*	*Low*	*Medium*	*Medium*
Agricultural biodiversity	**Measures**	Conserve and promote drought- and heat-tolerant crop varieties; Enhance seed banks with local species; Support mixed cropping and polyculture systems.	Protect wetland and riparian habitats for wild species; Maintain genetic diversity of flood-tolerant crops; Promote landscape connectivity for agro-ecosystems.	Establish emergency seed reserves post-storm events; Enhance resilience through crop diversification; Design biodiversity corridors protected from storm damage.	Preventing monoculture in erosion-prone areas; Encourage crop rotation to maintain soil structure and species richness; Restore degraded agro-ecosystems with native species. Encourage the use of shelterbelts as biodiversity hot-spot.

	Adaptive Capacity	***Low***	*Medium*	*Low*	*Medium*

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**	Shift toward farming thermally resilient species; Adjust fishing seasons and times to avoid heat stress; Monitor oxygen levels and harmful algal blooms in aquaculture sites.	Improve lagoon and estuarine management to prevent salinity intrusion; Install water-level regulation systems; Create buffer zones around aquaculture sites.	Reinforce fishery structures and aquaculture tanks against storm surges; Design floating or submersible aquaculture systems; Create mobile units for harvesting.	Prevent overexploitation of benthic habitats; Promote sustainable dredging practices; Monitor seabed and lagoon floor erosion.
	Adaptive Capacity	*Low*	*Medium*	*Medium*	*Medium*
Income and employment	**Measures**	Provide financial incentives for species diversification; Offer training in climate-resilient fishing and farming practices; Promote cold storage and processing infrastructure to reduce heat-related losses.	Establish insurance schemes for damage; Support emergency income programs; Diversify livelihoods linked to wetland-related processing.	Provide risk reduction training for fishers; Develop storm compensation funds; Support collective safety nets for fishery workers.	Invest in skills transition toward sustainable marine practices; Support circular economy initiatives to reduce resource pressure; Introduce land-sea integration planning for employment security.
	Adaptive Capacity	*Low*	*Low*	*Medium*	*Medium*
Multifunctionality	**Measures**	Encourage integration of aquaculture with renewable energy (e.g., floating solar); Promote recreational and educational uses of aquaculture systems that are heat resilient.	Develop nature-based solutions (e.g., aquaculture-wetland integration); Use multi-use platforms combining flood mitigation and fish	Promote marine ecotourism with storm-resilient infrastructure; Create multipurpose docks and floating hubs that combine fishing, tourism, and monitoring.	Support erosion-resilient multifunctional areas (e.g., oyster reefs); Integrate aquaculture with dune or sediment stabilization efforts; Use multifunctional

			farming; Restore natural filtration ecosystems.		coastal zones to reduce degradation pressure.
	Adaptive Capacity	*Medium*	***Low***	*Medium*	*High*

Residual vulnerability analysis

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

Based on 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.

AREA: BIODIVERSITY	*Scenario*	*Sensitivity*	*Exposure*	*Adaptation*	***Residual vulnerability***
Thermal risk and climate extremes	**SSP2-4.5**	2.89	2.13	2.00	**3.07**
	SSP5-8.5	2.89	2.75	1.00	**7.94**
Hydraulic and hydrogeological risk	**SSP2-4.5**	2.80	2.75	1.67	**4.62**
	SSP5-8.5	2.80	3.00	1.00	**8.40**
Wind and weather storm risk	**SSP2-4.5**	2.00	2.25	2.00	**2.25**
	SSP5-8.5	2.00	2.50	1.00	**5.00**
Geological and land degradation risk	**SSP2-4.5**	2.42	2.25	2.00	**2.72**
	SSP5-8.5	2.42	2.75	1.00	**6.65**

AREA: AGRICULTURE	*Scenario*	*Sensitivity*	*Exposure*	*Adaptation*	***Residual vulnerability***
Thermal risk and climate extremes	**SSP 2-4.5**	2.00	2.13	1.33	**3.19**
	SSP 5-8.5	2.00	2.75	1.00	**5.50**
Hydraulic and hydrogeological risk	**SSP 2-4.5**	1.93	2.75	1.67	**3.19**
	SSP 5-8.5	1.93	3.00	1.00	**5.80**
Wind and weather storm risk	**SSP 2-4.5**	1.83	2.25	2.00	**2.06**
	SSP 5-8.5	1.83	2.50	1.00	**4.58**
Geological and land degradation risk	**SSP 2-4.5**	2.00	2.25	2.00	**2.25**
	SSP 5-8.5	2.00	2.75	1.00	**5.50**

AREA: TOURISM	*Scenario*	*Sensitivity*	*Exposure*	*Adaptation*	***Residual vulnerability***

AREA: FISHING AND AQUACULTURE	*Scenario*	*Sensitivity*	*Exposure*	*Adaptation*	***Residual***

Thermal risk and climate extremes	SSP2-4.5	2.00	2.13	2.00	**2.13**
	SSP5-8.5	2.00	2.75	1.00	**5.50**
Hydraulic and hydrogeological risk	SSP2-4.5	2.13	2.75	1.00	**5.87**
	SSP5-8.5	2.13	3.00	1.00	**6.40**
Wind and weather storm risk	SSP2-4.5	1.50	2.25	2.00	**1.69**
	SSP5-8.5	1.50	2.50	1.00	**3.75**
Geological and land degradation risk	SSP2-4.5	1.75	2.25	1.33	**2.95**
	SSP5-8.5	1.75	2.75	1.00	**4.81**

					vulner ability
Thermal risk and climate extremes	SSP 2-4.5	1.78	2.13	1.33	**2.83**
	SSP 5-8.5	1.78	2.75	1.00	**4.89**
Hydraulic and hydrogeological risk	SSP 2-4.5	2.20	2.75	1.67	**3.63**
	SSP 5-8.5	2.20	3.00	1.00	**6.60**
Wind and weather storm risk	SSP 2-4.5	1.33	2.25	2.00	**1.50**
	SSP 5-8.5	1.33	2.50	1.00	**3.33**
Geological and land degradation risk	SSP 2-4.5	1.83	2.25	2.33	**1.77**
	SSP 5-8.5	1.83	2.75	1.00	**5.04**

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