December 2025

BENCHMARKS ON EVALUATION OF SEA LEVEL RISE ECOSYSTEM IMPACTS RISK ASSESSMENT

Deliverable D.2.3.2

https://medsearise.interreg-euro-med.eu/

Deliverable ID

Project acronym	MedSeaRise
Project title	Supporting Adaptation to Mediterranean Sea Level Rise
Project mission	Protecting, restoring and valorising the natural environment and heritage
Project priority	Greener MED
Specific objective	RSO2.4 Promoting climate change adaptation and disaster risk prevention, resilience, taking into account eco-system based approaches
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Project duration	01/01/2024 – 31/03/2026 (27 months)

Deliverable title	Benchmarks on evaluation of sea level rise ecosystem impacts risk assessment
Deliverable number	D.2.3.2
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Work package title	Information analyses, methodology development and tools generation
Activity name	Comparative analyses and benchmarking
Activity number	2.3
Partner in charge (author)	UM
Partners involved	ANATOLIKI S.A., ARPA FVG , CCINCA, UoM-IBMK, BCC, UM

Document history

Versions	Date	Document status	Delivered by
Version 0.1	23/10/25	Draft	PP2
Version 1.0	19/12/2025	Final	PP2

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Abbreviations

ANATOLIKI   Organisation for Local Development, Anatoliki S.A. – Project Partner - LP1

ARPA FVG   Regional Environmental Agency of Friuli Venezia Giulia Region- Project Partner - PP2

CCINCA   Chamber of Commerce and Industry Nice Côte d'Azur - Project Partner - PP3

UoM-IMBK   Public institution University of Montenegro - Institute of Marine Biology - Project Partner - PP4

BCC   Barcelona Chamber of Commerce - Project Partner - PP5

UM   University of Malta - Department of Geosciences- Project Partner - PP6

PP   A Project Partner, in general. Nobody specifically indicated

PPs   All Project Partners

D.2.2.1   Project deliverable 2.2.1: Case studies for evaluation of sea level rise anthropic impacts risk

D.2.2.2   Project deliverable 2.2.2: Case studies for evaluation of sea level rise ecosystem impacts risk

D.2.4.1   Project deliverable 2.4.1: Methodology and the best practices

Output 2.1   Project output 2.1: Methodology for an effective use of sea level rise scenarios in climate change impact risks assessment

GWL   Global Warming Level

WPs   MedSeaRise Work packages

Executive summary

This is a deliverable of the project MedSeaRise. The project contributes to the Natural Heritage mission of the Euro-MED Programme and it belongs to the Study Project class.

The document summarizes the work done in the frame of the project activity 2.3, describing how the project partners have generated a set of analyses on the impacts expected to affect the ecosystems, as a consequence of the progressive increase of the sea level , in the Mediterranean basin.

First, an outlook on the needs and the objectives that have stimulated the generation of specific case studies and their organization as benchmarks is presented. Furthermore details of the benchmark structure are detailed in addition with the methods specifically created to assess the sensitivity of the sea level rise related impacts to the increase of the global temperature of our planet.

The document is completed with a summary of the available benchmarks and appendixes that give further

The benchmarks aim

Introduction and Objectives

This document presents a specific contribution in the achievement of the general MedSeaRise WP2 objective, namely the evaluation of the likelihood of Mediterranean Sea level trends scenarios, to develop a methodology for a proper use of such data in the risk assessment processes and to provide guidelines and benchmarks for the methodology application.

Specifically, one of the results expected from the Activity 2.3 is the generation of benchmarks suitable to evaluate the sensitivity of the risk assessment, which has been conducted applying the MedSeaRise methodology on case studies. Case studies are described in detail in project deliverables D.2.2.1 [1.1] and D.2.2.2 [1.2].

The sensitivity of the sea level rise risk analysis is explored and quantified, for each of the identified impacts. A metric was developed as part of this activity. Benchmarking has been conducted evaluating the sensitivity of the risk assessment using that metric.

Benchmarking is conducted also with the aim to support the best practices definition, furthermore benchmarks are included in the methodology as examples for a best use of data on future sea level scenarios. Then, benchmarks are an essential component of the project Output 2.1.

In summary, a benchmark is a standard example of risk assessment for an impact, due to the increase of the sea level rise, that has to be considered as a tool for the evaluation and comparison of the risk sensitivity from the input data on the sea level trends, according to a specific metric.

To generate the benchmarks, PPs have defined a guideline, which has been applied to a selection of the case studies to enrich them and then produce the benchmarks.

This deliverable describes how benchmarks for impacts on ecosystems have been generated, and how many they are. Each benchmark is composed of a document and supplemental files that are part and parcel of this document. The benchmarks are annexes of this deliverable and are available as archive files attached to the document.

Guideline for benchmark generation

Benchmark generation

In MedSeaRise project a benchmark is defined as standard example of risk assessment for an impact, real or ideal, due to the increase of the sea level rise, that has to be considered as a tool for the evaluation and comparison of the risk sensitivity from the input data on the sea level trends, according to a specific metric.

So, a benchmark has to be characterized by some mandatory information. Those information relate to the impact caused by the increase of the sea level, its assessment and quantification, a description of the procedure and the data involved in the impact assessment, the sensitivity of the impact to the input data. Anyway the format of the information presentation through the benchmark is not strictly defined.

Since project activity 2.3 foresees a comparison of the benchmarks sensitivity, it is straightforward all the benchmarks have to share a common set of core data on impacts sensitivity on inputs.

Starting from the above considerations, it is suggested to generate a benchmark extending a case study conducted in the frame of the activity 2.1.

In fact, case studies have been generated and presented according to a shared set of elements, which have been described in the case study guidelines document and that have been also included in the template document for the case study reporting.

To a case study document, it is important to add a further section reporting elements useful and sufficient to support the best practices application, which are presented in the MedSeaRise methodology for an effective use of sea level rise scenarios in climate change impact risks assessment (D.2.4.1 and project Output 2.1) [2.1]. We need to recall that benchmarks will be included in the methodology for a best use of data on future sea level scenarios.

In the next paragraph a template of that section is presented.

Finally, to allow the comparison of the impacts sensitivity to the inputs describing the future sea level condition, in the frame of the present climate change, it is important the benchmark summarizes the impacts as a function of the GWLs.

Since each benchmark has its own specific inputs, according to the area and the kind of impact, a common way to assess the sensitivity is by means of the variation of the impact with respect to the GWLs. In fact, all the case studies, thus the benchmarks, link the impacts to the GWLs.

The last section describes how each benchmark sensitivity to the sea level will be compared.

How to evolve a case study into a benchmark

Starting from the document detailing a case study, that is one of those realized in the frame of the project activity 2.1, see deliverables D.2.1.1 [1.1] and D.2.1.2 [1.2] the benchmark have to bring all the analyses and the results produced for the case study and to include a further section reporting information suitable to understand how to reproduce the study of the sea level rise related impact, step by step.

This specific section, whose title is named "Description of the tools and data used to carry on the case study", is composed of key points with a brief description of the essential elements one has to consider in reproducing the case study or to use it as an example for another similar case.

Here below each of the key points are reported together with a guide on how to fill in the information on each of them.

Description of the tools and data used to carry out the case study

In the benchmark, explain in a very summary what was done, once identified the impact to be studied. The information has been retrieved and how they were processed. Here are guidelines on how to proceed.

Data on future sea level used for the case study

(*Describe what inputs on future mean sea level you have retrieved from those let available in the frame of the project. Furthermore, describe what further data of sea level you have used, for example tides simulations, sea level gauges measurements, etc. including their sources too.*)

Data on the exposed subject used for the case study

(*Describe what are the inputs concerning the subject the case study has considered for the impact, including the sources of those data too. For example the Digital Elevation Model of the coast, the database of commercial assets potentially impacted, scientific papers and datasets reporting data on ecosystems, etc.*)

Resources used to conduct the case study

(*Describe what kind of resources you have employed to conduct the risk assessment in the case study. For example, personnel internal to the PP, external experts, specific software, computational resources, etc..*)

Procedure adopted to employ data and resources to generate the impact

(*A very brief description on how data and resources have been involved in the case study to assess the impact. It is advised to use a presentation by points or an image with a sketch of steps followed to compute the impacts.*)

Notes of results presentation

(*A very summary on the motivations led you to adopt the presentation of the results accessible in the case study. For example unique table which is part of the document, a series of plots and images, a set of separate files attached to the case study document, etc.*)

Preparation of case study outputs suitable for sensitivity analysis

The comparison of the benchmarks sensitivity, which in turn means the sensitivity of the impact to the input data, requires the benchmark outputs be presented as a function of the GWLs. This means that the quantity describing the impact has to be linked to the GWLs of the input. The most simple way is a tabular form. See annexes from 1 to 7.

Benchmark sensitivity method

To the highest extent, the sensitivity analysis of the risk assessment, conducted by means of the benchmark results, requires a shared metric linking the sea level hazard uncertainty and reliability with the impacts. Thanks to the MedSeaRise activities, conducted analysis shows that it is hard to define such a metric meaningful for all the possible classes, at least before the project conclusion.

Instead, it is possible to classify the sensitivity of the impact with respect to the GWLs. In fact, all the case studies, thus the benchmarks, link the impacts to the GWLs.

Using the sensitivity of the impact on the variations of the GWLs allows the comparison of sensitivity among classes of impacts very different from each other, in addition to impacts inside the same class. Of course, it is a sensitivity of the impact with respect to the GWL evolution and it is not respect the uncertainty and the reliability of the input data.

In addition, this kind of sensitivity adds more information to those available for the decision making. In fact, it is helpful to know the response of the impact to the increase of the GWL, in the frame of decisions to be taken to enhance the resilience of the coastal areas or to choose adaptation solutions to reduce the vulnerability or even the exposure to the sea level hazard.

For this reason the following metric has been defined. It allows placing the impact response to the GWL change into one of the classes representing the spectrum of responses. The classes are common to all kinds of impacts and this means that it is possible to compare impacts having quite different features and dependencies.

Consider **I** to indicate the impact and **GWL** the Global warming level. Then the variation of the impact with respect the change in the GWL is named the sensitivity **S**; it is defined as follow:

$$\mathbf{S} = (\mathbf{I}(B) - \mathbf{I}(A))/(\mathbf{GWL}(B) - \mathbf{GWL}(A))$$

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A and B are two different simulations of the impact. Each of them are associated to the corresponding GWL.

The sensitivity has the meaning of impact for units of GWL, that is it tells you how fast the variation of the impact is when our planes move from one Global Warming Level to the next.

In the MedSeaRise project, we have generated input data belonging to four GWLs, namely 1.5 °C, 2.0 °C, 3.0 °C and 4.0 °C, so it is possible to compute three values of sensitivity. Specifically, the sensitivity to the change from GWL 1.5 °C to 2.0 °C, that from 2.0 °C to 3.0 °C and finally from 3.0 °C to 4.0 °C. In case of less sensitivity values it is still possible to associate a sensitivity class to the impact.

Once the sensitivity **S** is computed, the evolution of the sensitivity with respect to the GWLs allows to assign a class to the impact **I** according to seven classes. They are:

1. not sensitive,
2. variable,
3. linear,
4. more than linear,
5. exponential,
6. turning point
7. saturation

Classes are independent from the type of impact, because they have been built on the behaviour of the sensitivity **S** with respect to the increase of the warming of our planet.

To find the suitable class for the impact explored through a benchmark, it is necessary to look at the evolution of both the sensitivity and the impact when the GWL increases.

In the annexes from 1 to 7 each class is described with the aid of a table and a graph. With these tools it should be easy to link the class to the benchmark.

The comparison of the benchmarks through the classes they belong to implement the comparative analyses and benchmarking foreseen by activity 2.3

Benchmarks

Summary of benchmarks on ecosystem impacts

MedSeaRise activity 2.3 has produced two benchmarks, with the objective to complement the methodology developed in the frame of the project and to give examples of the best practices application on the selection and use of sea level rise data for the risk assessment of impacts affecting ecosystems.

They are listed here below. For each benchmark essential information is presented, whereas in the appendixes it is available a short summary of the impact the benchmark is focused on together with the reference to the associated file storing all the details.

Benchmark ID	Project Partner	Appendix
E-03_PP2	PP2 – ARPA FVG	Annex 8
E-01_PP4	PP4 - UoM-IBMK	Annex 9

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Indicators of deliverable achievement

Deliverable indicators

The achievement of the objective described in this deliverable is summarized by means of the indicators reported here below. For each of them the expected indicator value and the actual one are presented. In addition, comments are reported too, if any.

Indicator	Expected value	Actual value	Comments
Number of benchmarks	1	2	Benchmarks focusing on ecosystem impacts

For each benchmark, a specific document is available as appendix. Furthermore, benchmark includes files and or reference do access files that are suitable to reproduce the benchmark.

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Conclusions

Conclusions

One of the most intensive and work demanding tasks, carried on by each MedSeaRise project partner, was the identification of the sea level rise impacts and their analysis in detail, applying the methodology developed in the frame of the project.

Such individual work, which was coordinated at Work Package level thanks to the efforts made by the WPs leaders, results in a set of case studies sharing the same conceptual approach to assess the consequences of the progressive increase of the sea level, due to climate change.

A selection of case studies is presented in detail and, each of them, with a schematic guideline that leads to the reproduction of the case study as it is or the application of the scheme to other similar impacts.

This presentation of a selected case study makes it a benchmark against which to compare further applications of the MedSeaRise methodology.

Furthermore the sensitivity method used in the benchmark, to assess the response of the impact to the increase of global warming, supports the stakeholders in making decisions on possible adaptation or resilience solutions aimed to minimize the risk to get the impact.

The benchmark sensitivity to the variations of the GWLs, which is described in this deliverable, is expected to stimulate the comparison of the impact sensitivity among classes of impacts very different from each other, besides those belonging to the same type.

Finally, the benchmarks collected in this deliverable have the ambition to enrich the set of studies focused on some of the issues the Mediterranean coastal areas are going to face in a rapid change of the climate. Furthermore, following the purposes of the Natural Heritage study project type, it is expected the benchmarks make the amplification of the results achieved in the frame of the MedSeaRise project easier.
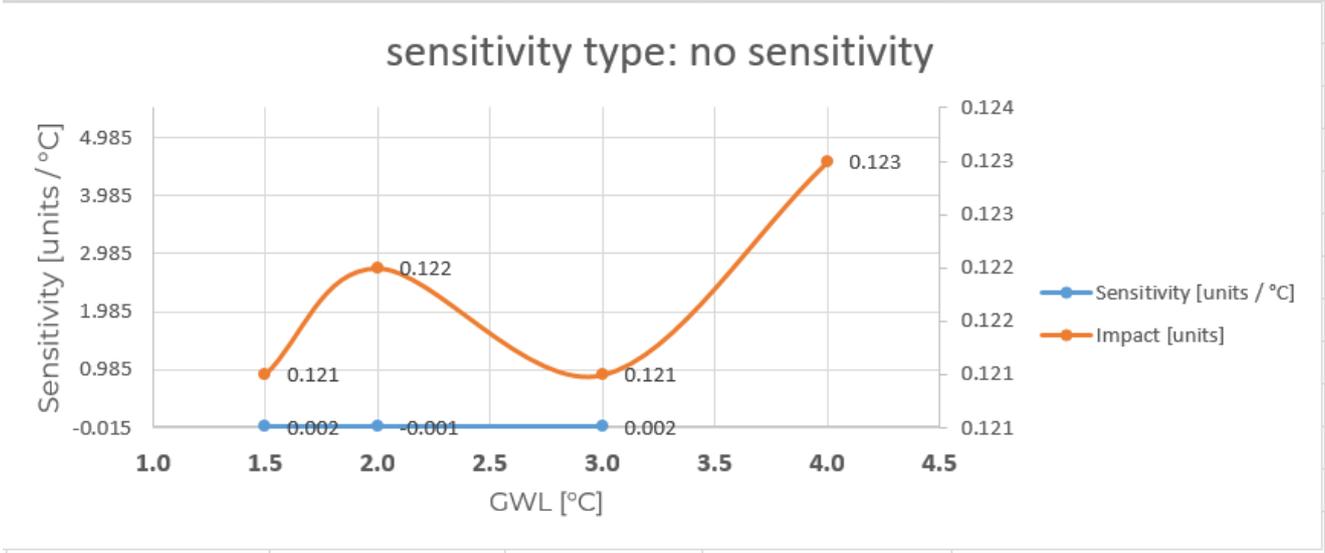
Annexes

Annex 1 – Example of sensitivity type: no sensitivity

Example of impact not sensitive to the GWLs change.

Sensitivity (**S**) is almost zero. Impact (**I**) changes without any trend.

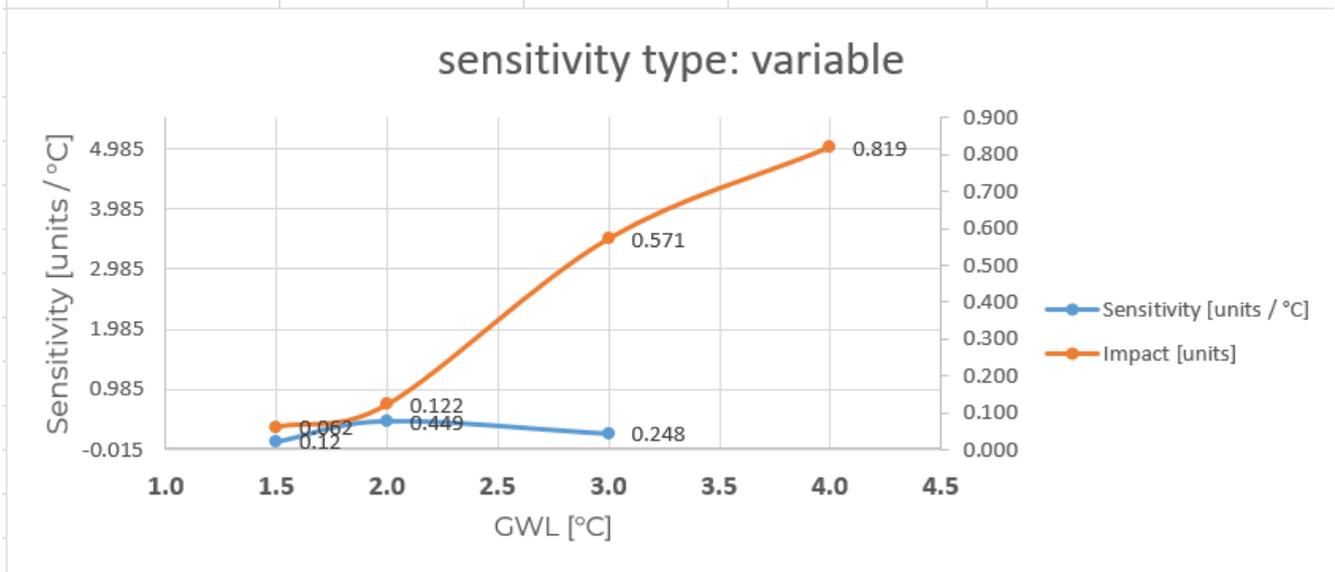| Sensitivity type:	no sensitivity			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.121	0.5	0.001	0.002
2.0	0.122	1.0	-0.001	-0.001
3.0	0.121	1.0	0.002	0.002
4.0	0.123			

Annex 2 – Example of sensitivity type: variable

Example of impact variable with respect to the GWLs change.

Sensitivity (**S**) is positive and smoothly changes. Impact (**I**) changes with a no clear trend.

Sensitivity type:	variable			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.062	0.5	0.060	0.12
2.0	0.122	1.0	0.449	0.449
3.0	0.571	1.0	0.248	0.248
4.0	0.819			

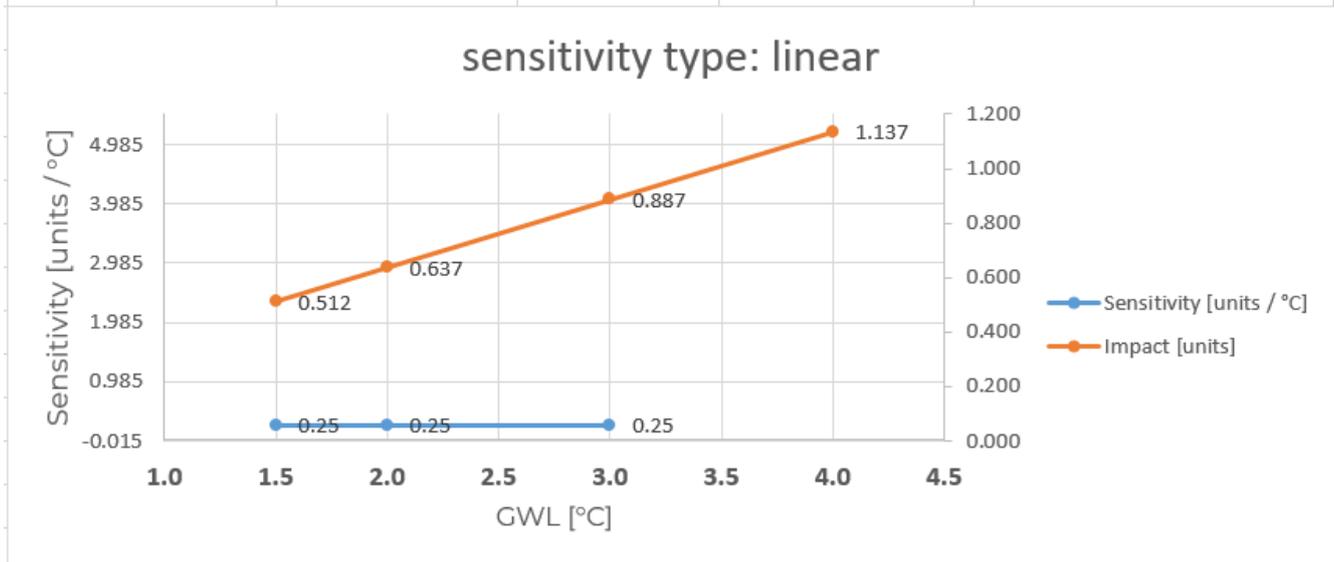sensitivity type: variable

Annex 3 – Example of sensitivity type: linear

Example of impact linear with respect to the GWLs change.

Sensitivity (**S**) is constant and different from zero. Impact (**I**) changes according to a linear trend.

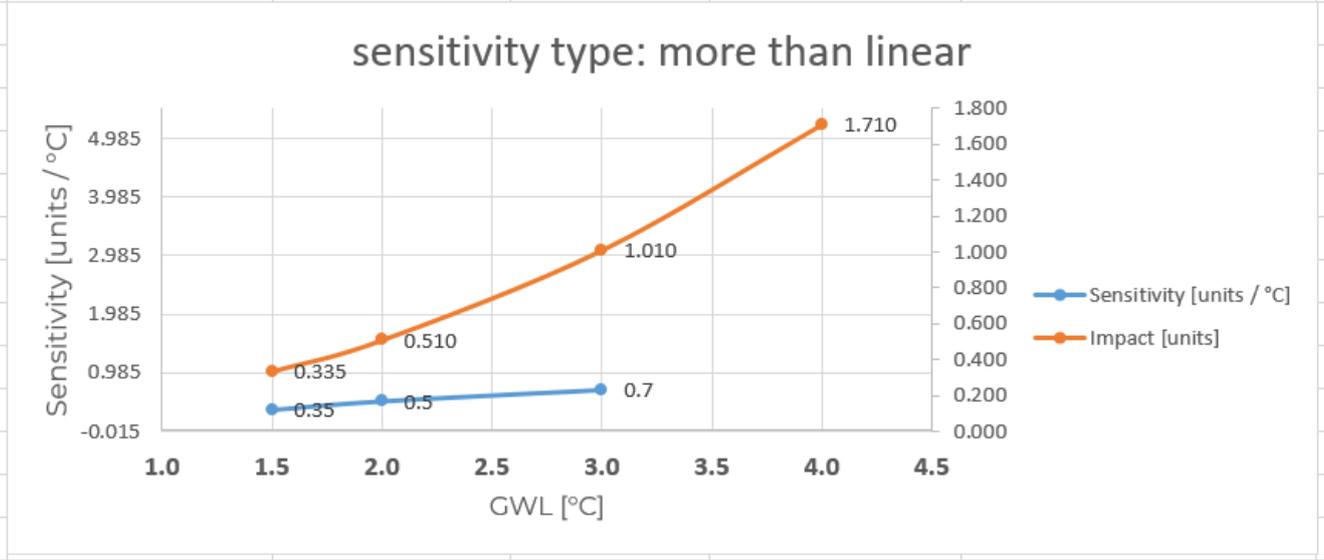| Sensitivity type:	linear			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.512	0.5	0.125	0.25
2.0	0.637	1.0	0.250	0.25
3.0	0.887	1.0	0.250	0.25
4.0	1.137			

Annex 4 – Example of sensitivity type: more than linear

Example of impact more than linear with respect to the GWLs change.

Sensitivity (**S**) is increasing. Impact (**I**) changes according to a power of GWL.

| Sensitivity type:	more than linear			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.335	0.5	0.175	0.35
2.0	0.510	1.0	0.500	0.5
3.0	1.010	1.0	0.700	0.7
4.0	1.710			

Annex 5 – Example of sensitivity type: exponential

Example of impact exponential with respect to the GWLs change.

Sensitivity (**S**) is rapidly increasing. Impact (**I**) changes according to an exponential law.

| Sensitivity type:	exponential			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.483	0.5	0.291	0.6
2.0	0.774	1.0	1.270	1.3
3.0	2.044	1.0	3.451	3.5
4.0	5.495			
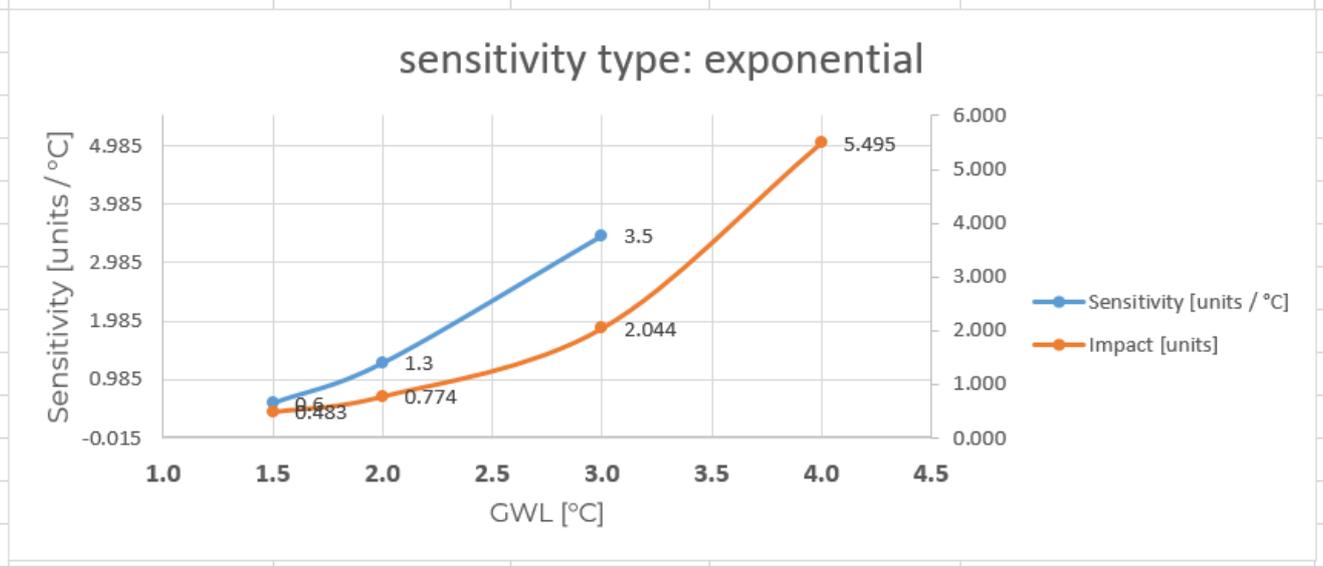
Annex 6 – Example of sensitivity type: turning point

Example of impact having a turning point with respect to the GWLs change.

Sensitivity (**S**) is almost zero up to the turning point, then has a jump. Impact (**I**) does not change much up to the turning point, then jumps up.

| Sensitivity type:	turning point			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.220	0.5	0.020	0.0
2.0	0.240	1.0	0.020	0.0
3.0	0.260	1.0	5.235	5.2
4.0	5.495			
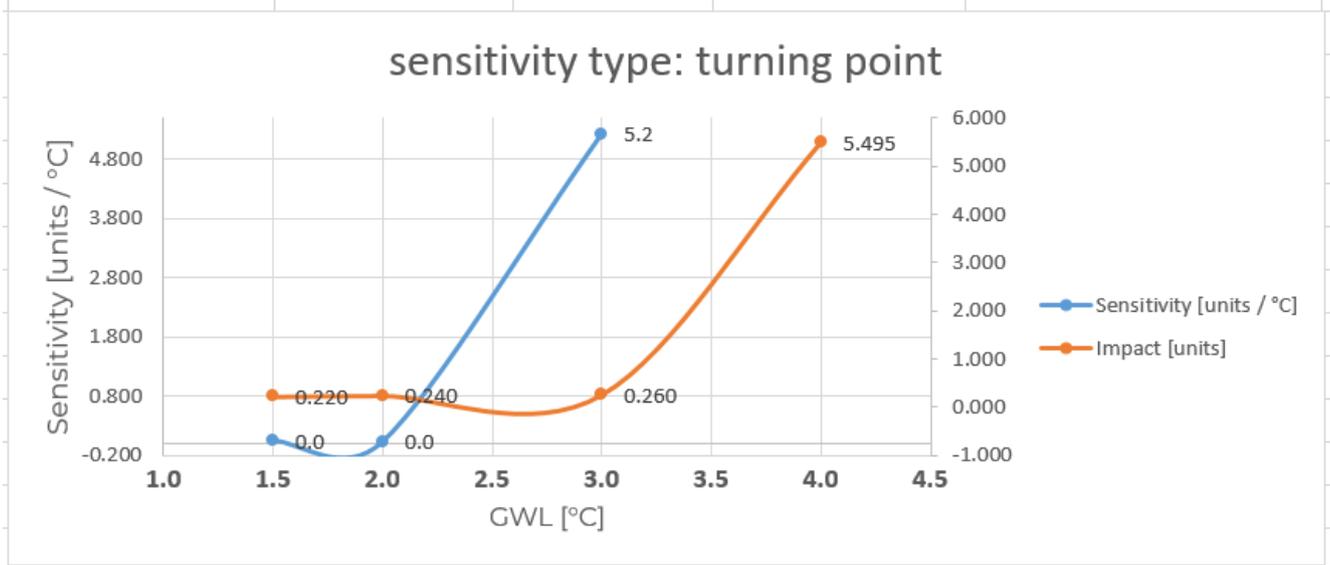
Annex 7 – Example of sensitivity type: saturation

Example of impact having a saturation with respect to the GWLs change.

Sensitivity (**S**) increases up to a point, then back to zero. Impact (**I**) increases rapidly up to a plateau, then does not change any more.

Sensitivity type:	saturation			
GWL [°C]	Impact [units]	Δ GWL [°C]	Δ Impact [units]	Sensitivity [units / °C]
1.5	0.220	0.5	0.010	0.0
2.0	0.230	1.0	5.070	5.1
3.0	5.300	1.0	0.195	0.2
4.0	5.495			
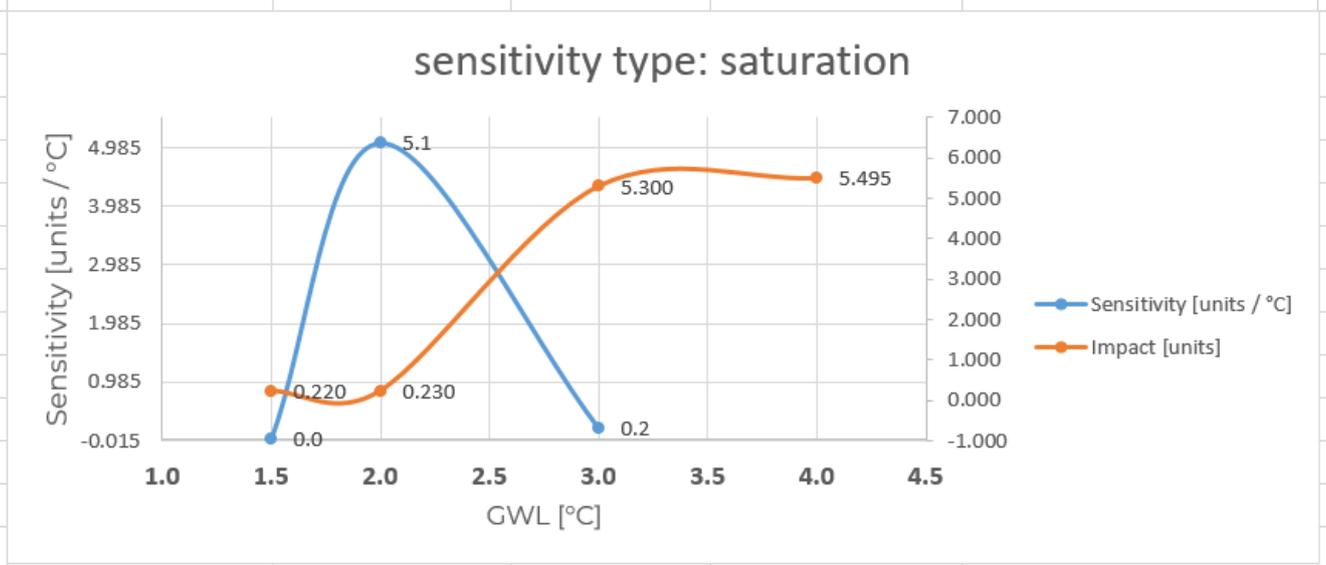
Annex 8 – MedSeaRise_benchmark_E-03_PP2

MedSeaRise project partner PP2 benchmark E-03.

The Grado and Marano Lagoon is undergoing a process of marinization, which refers to the transformation of a lagoon environment into a more marine-like system, primarily due to increased seawater inflow caused by sea level rise. This process alters the lagoon's salinity, water circulation, and sediment dynamics, furthermore it is impacting the vegetation and consequently the animals living in that area.

Biodiversity is particularly affected: the rising salinity and temperature of the lagoon waters are disrupting the ecological balance, making the environment more suitable for species adapted to marine conditions. As a result, species that once thrived in the lagoon are now struggling due to both the changes in the physical and chemical properties of the water and the increased competition from species better suited to the new conditions.

This is the case of the common reed, Phragmites australis. This species forms dense populations along the most natural and well-preserved shores of the Friuli Venezia Giulia Regional Authority (RAFVG) and represents a characteristic habitat of the region.

It is known that Phragmites australis is sensitive to high salinity and prolonged submersion, which lead to reduced growth and reproductive rates. The decline in reproduction is largely due to the depletion of carbohydrate reserves in the rhizomes and a lower success rate in seed germination.

File: **Act_2.3_MedSeaRise_benchmark_E-03_PP2.zip**

Annex 9 – MedSeaRise_benchmark_E-01_PP4

MedSeaRise project partner PP4 benchmark E-01.

This case study examines the impact of sea level rise on Tivat Solila. The impacts are affecting the historic salt evaporation farm. A wider environment around the farm with an area of 150 km^2 has been declared a special nature reserve. It is an area vulnerable to flooding that is often a result by meteo-tsunamis accompanied by heavy precipitation and strong persistent wind.

The impact will affect marsh vegetation and associated fauna. Seawater temperature will rise, which will induce faster decomposition of future submerged organic matter. Due to expected smaller precipitation and higher evaporation, salinity will rise which will favour more salinity tolerant plant and fauna species. Warmer and saltier seawater will change species distribution in the ecosystem which will have an impact on fishery.

File: **Act_2.3_MedSeaRise_benchmark_E-01_PP4.zip**

References

Bibliography

[1.1] MedSeaRise deliverable D.2.2.1 Case studies for evaluation of sea level rise anthropic impacts risk

[1.2] MedSeaRise deliverable D.2.2.2 Case studies for evaluation of sea level rise ecosystem impacts risk

[2.1] MedSeaRise deliverable D.2.4.1 Methodology and the best practices

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ANATOLIKI S.A. ORGANIZATION FOR LOCAL DEVELOPMENT | aRPa FVG AGENZIA REGIONALE PER LA PROTEZIONE DELL'AMBIENTE DEL FRIULI VENEZIA GIULIA | CCI NICE CÔTE D'AZUR | UCG 1974 INSTITUT ZA BIOLOGIJU MORA | Cambra de Comerç de Barcelona | L-Università ta' Malta