



MedSeaRise

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BENCHMARKS ON EVALUATION OF SEA LEVEL RISE ANTHROPIC IMPACTS RISK ASSESSMENT



Deliverable D.2.3.1

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Deliverable ID

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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 anthropic activities, 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 insights to specific aspects of the work done. Deliverable indicators are reported too.



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 anthropic impacts 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:

$$S = (I(B) - I(A)) / (GWL(B) - GWL(A))$$



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 anthropic impacts

MedSeaRise activity 2.3 has produced several 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 anthropic activities.

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
A-01_PP6	PP6 - UM	Annex 8
A-01_PP2	PP2 – ARPA FVG	Annex 9
A-03_PP2	PP2 – ARPA FVG	Annex 10
A-01_LP1	LP1 – ANATOLIKI S.A.	Annex 11
A-02_PP3	PP3 – CCINCA	Annex 12
A-01_PP4	PP4 - UoM-IBMK	Annex 13
A-01_PP5	PP5 - BCC	Annex 14



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	7	Benchmarks focusing on anthropic 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.



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.



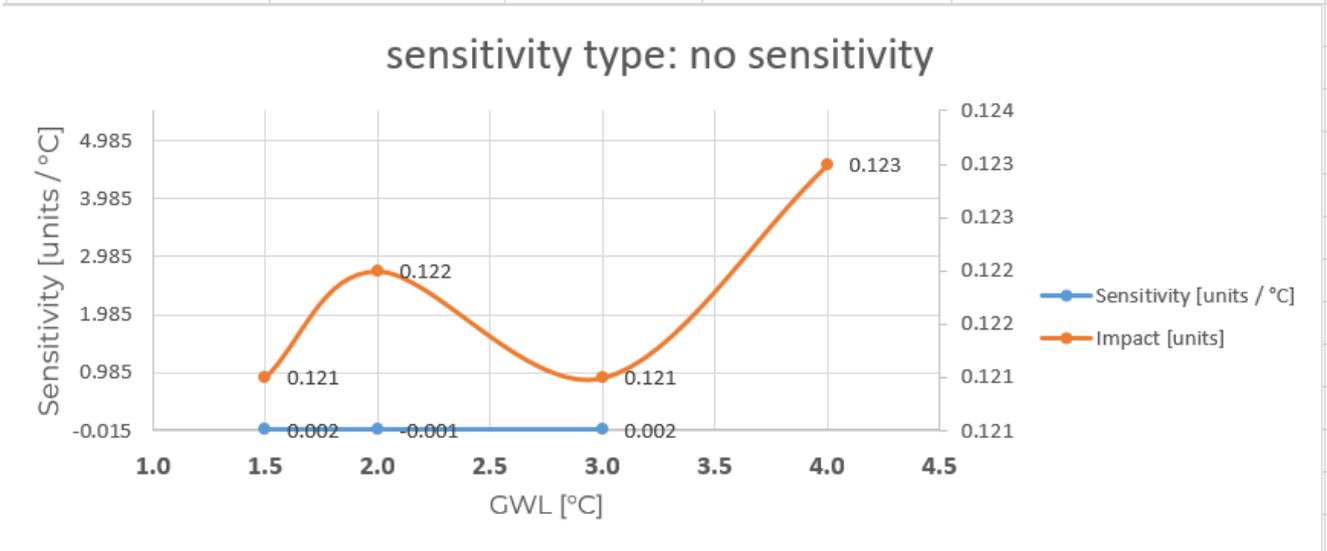
Annexes

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			



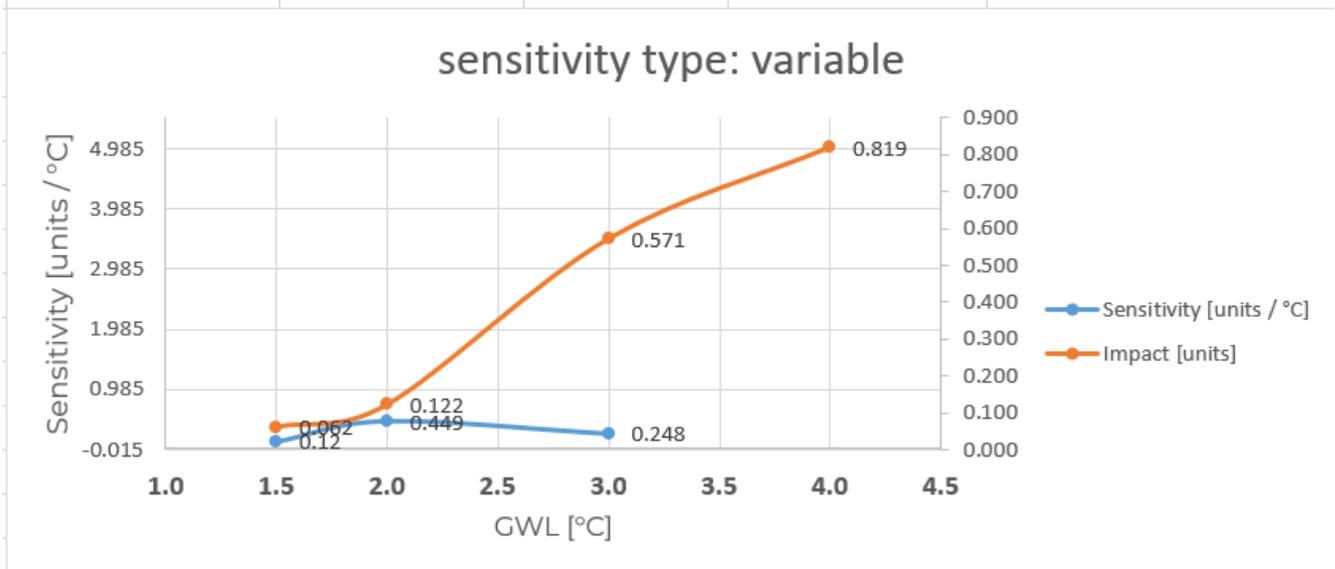


Annex 2 – Example of sensitivity type: variable

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			



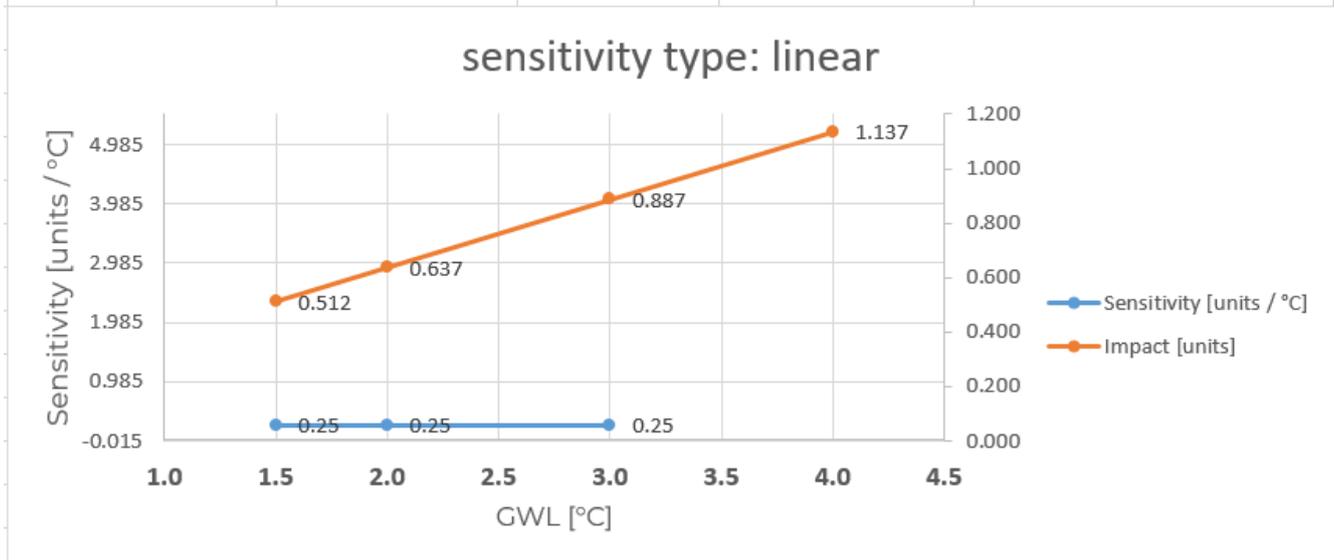


Annex 3 – Example of sensitivity type: linear

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			



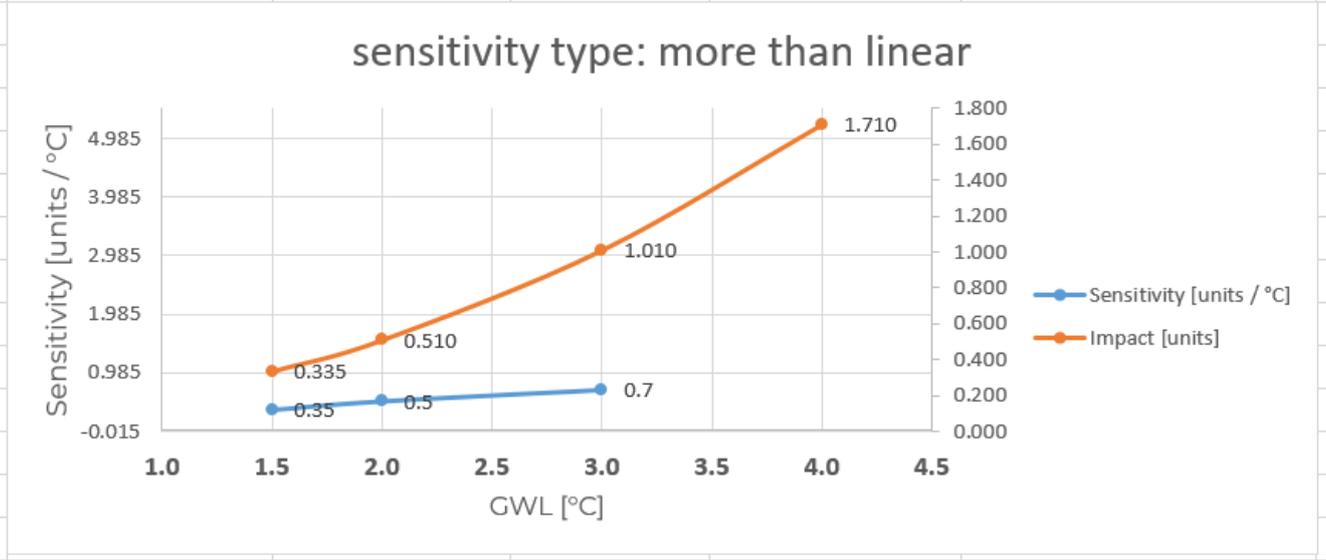


Annex 4 – Example of sensitivity type: more than linear

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			



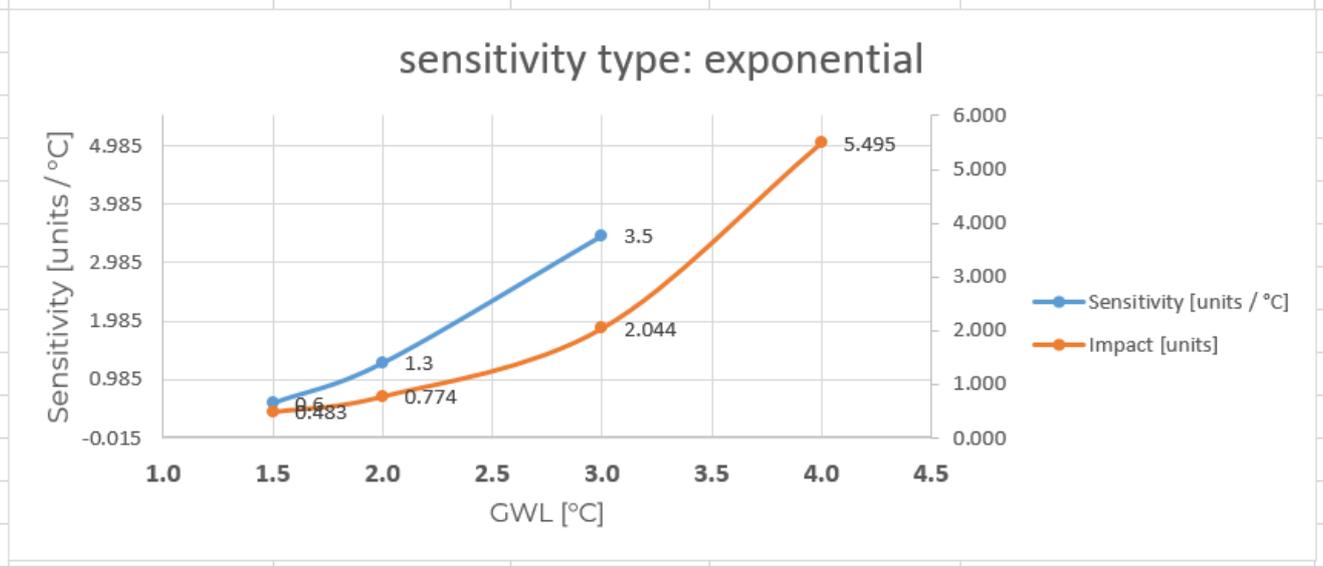


Annex 5 – Example of sensitivity type: exponential

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			



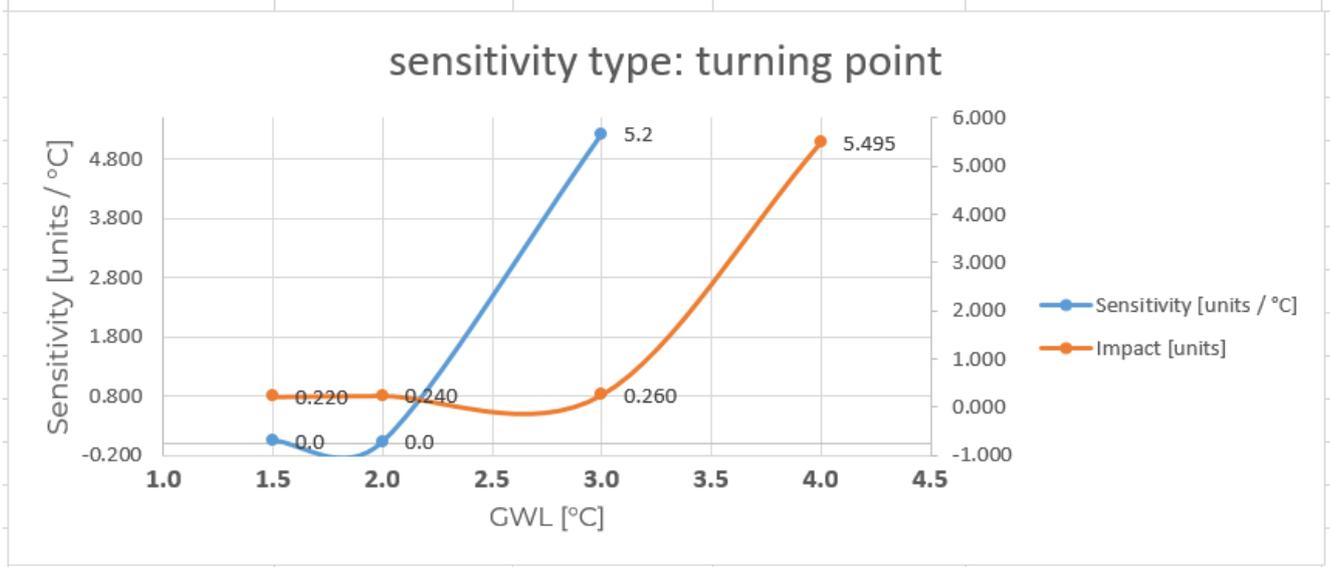


Annex 6 – Example of sensitivity type: turning point

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			



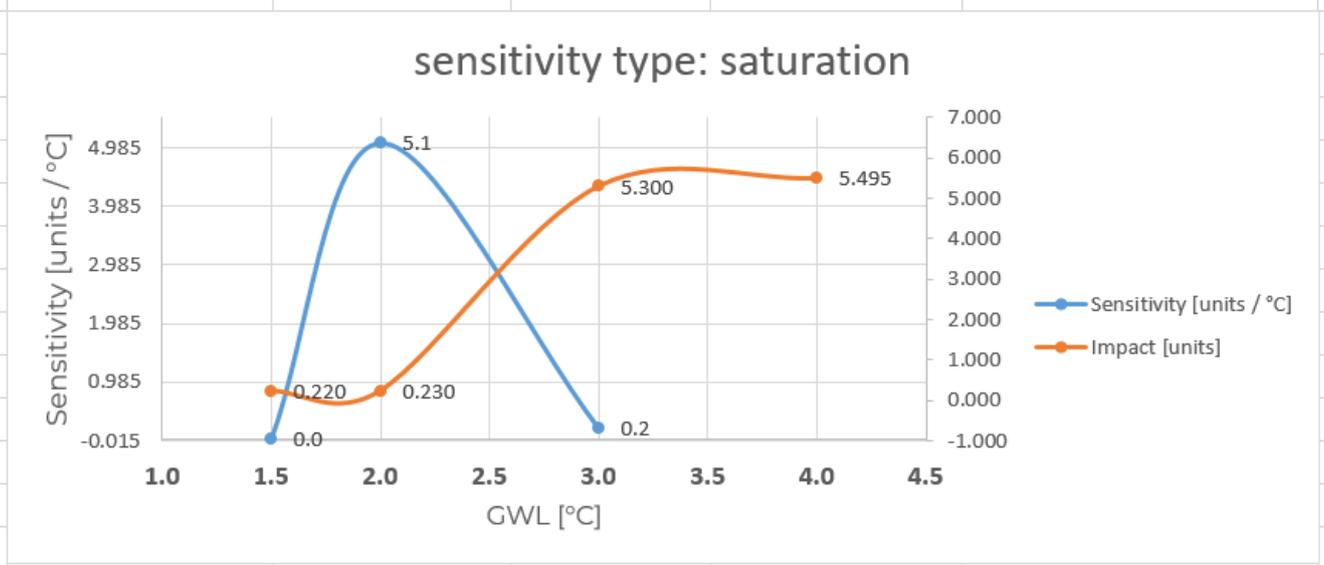


Annex 7 – Example of sensitivity type: saturation

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_A-01_PP6

MedSeaRise project partner PP6 benchmark A-01.

The case study will focus on Msida, a low-lying coastal town in Malta. Msida is already vulnerable to flooding, not only from heavy rainfall but also from temporary sea level increases caused by atmospheric pressure changes (seiches). These events are expected to become more problematic with long-term sea level rise, making Msida a valuable site for studying the combined impacts of climate change.

File: **Act_2.3_MedSeaRise_benchmark_A-01_PP6.zip**

Annex 9 – MedSeaRise_benchmark_A-01_PP2

MedSeaRise project partner PP2 benchmark A-01.

Flooding of archaeological assets within the UNESCO site of Aquileia. The city of Aquileia sits at the confluence of two rivers that merge before flowing into the lagoon as a single waterway. Located just 4 kilometers from the river mouth, Aquileia is directly affected by tidal fluctuations and sea level rise, which influence water levels in both rivers—particularly the Natissa, which runs closest to the city. The Natissa has already flooded archaeological areas and nearby portions of the city during extreme tidal and rainfall events, and rising sea levels are expected to increase both the frequency and severity of such flooding.

Stakeholders have also reported problems with rising groundwater levels, which are causing archaeological sites to flood from below. As water levels continue to rise, previously unexplored archaeological remains risk being submerged and deteriorating before they can be properly studied and documented.

These combined factors are projected to significantly increase the costs of protecting, maintaining, and restoring archaeological assets, while likely rendering some areas of archaeological potential permanently inaccessible before they can be explored.

File: **Act_2.3_MedSeaRise_benchmark_A-01_PP2.zip**

Annex 10 – MedSeaRise_benchmark_A-03_PP2

MedSeaRise project partner PP2 benchmark A-03.

Flooding of the urban area of Grado town. The city of Grado, situated on Italy's north-eastern coast, is especially vulnerable to sea level rise due to its low elevation, its proximity to tidal lagoons, and its exposure to the dynamics of the Adriatic Sea. As Mediterranean sea



levels continue to rise, the city is likely to experience more frequent and intense flooding. This could lead to the shrinking of beaches that are vital for the tourism and economy of the city, while also damaging urban areas and infrastructure. Consequently, maintenance costs would rise, and property values could decline, affecting both private owners and public administrations.

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

Annex 11 – MedSeaRise_benchmark_A-01_LP1

MedSeaRise project partner LP1 benchmark A-01.

Kalamaria Municipality comprises the broader metropolitan area of eastern Thessaloniki, the 2nd largest city in Greece (Central Macedonia), with its coastal waterfront comprising the most significant part of the northeastern Thermaikos Gulf littoral areas (northwestern Aegean Sea), i.e., the neighbourhoods of Karabournalki, Kodra Camp, Kouri, Aretsou, Nea Krini, Agios Georgios, and Mikra, which are administratively part of it.

Sea level rise and extreme storm surge or tidal events pose a significant threat to the coastal zone of the Kalamaria waterfront, with the potential to inundate critical littoral areas. This endangers not only urban assets but also natural habitats and essential infrastructure linked to air and maritime transport, water supply, and public utilities. The resulting socio-economic losses and associated costs are highlighted in this case study.

File: **Act_2.3_MedSeaRise_benchmark_A-01_LP1.zip**

Annex 12 – MedSeaRise_benchmark_A-02_PP3

MedSeaRise project partner PP3 benchmark A-02.

Saint-Laurent-du-Var is a coastal municipality located directly to the west of Nice, in the Alpes-Maritimes department of southeastern France. As one of the most urbanized sections of the coastline, it combines major economic infrastructures, such as the Cap 3000 shopping center located next to the Airport of Nice. There are recreational beaches, restaurants...

The area faces a unique set of challenges due to its low elevation, the influence of the Var River delta, and increasing human pressure linked to tourism and development.

Given its strategic importance and vulnerability, Saint-Laurent-du-Var was selected as a case study to better understand how sea level rise and related climate hazards could affect both economic activities and natural systems over the coming decades.



The study aims to combine environmental data from partners of MedSeaRise and local data, risk modelling, and stakeholder input to identify priority zones and assess potential impacts under different climate scenarios. The findings will contribute to the broader goal of MedSeaRise: benchmarks and Mediterranean coastal adaptations plans with practical tools and knowledge.

File: **Act_2.3_MedSeaRise_benchmark_A-02_PP3.zip**

Annex 13 – MedSeaRise_benchmark_A-01_PP4

MedSeaRise project partner PP4 benchmark A-01.

Boka Kotorska Bay, a UNESCO World Heritage site, is a unique bay on the Adriatic, known for its specific natural characteristics, dramatic landscapes, rich cultural heritage, and centuries-old coastal towns. The entire area, including the bays of Kotor and Risan, is subject to impacts due to the sea level rise, as detailed in the following sections.

Four likely future impacts due to following causes are considered: sea level rise, increase of seawater temperature, increase of salinity and a change in aquatic fish distribution due to more intensive immigration rate of tropical fish.

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

Annex 14 – MedSeaRise_benchmark_A-01_PP5

MedSeaRise project partner PP5 benchmark A-01.

In the framework of the MedSeaRise project, the Barcelona case study focuses on the Delta del Llobregat. The area combines high ecological value with critical socio-economic infrastructure, including the Port of Barcelona. Sea level rise and extreme marine events may flood key areas of the Delta del Llobregat, threatening natural assets and key infrastructure related to transport. This could result in economic losses analysed under this case study.

File: **Act_2.3_MedSeaRise_benchmark_A-01_PP5.zip**



References

Bibliography and Sitography

- [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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