MedSeaRise

Interreg Euro-MED

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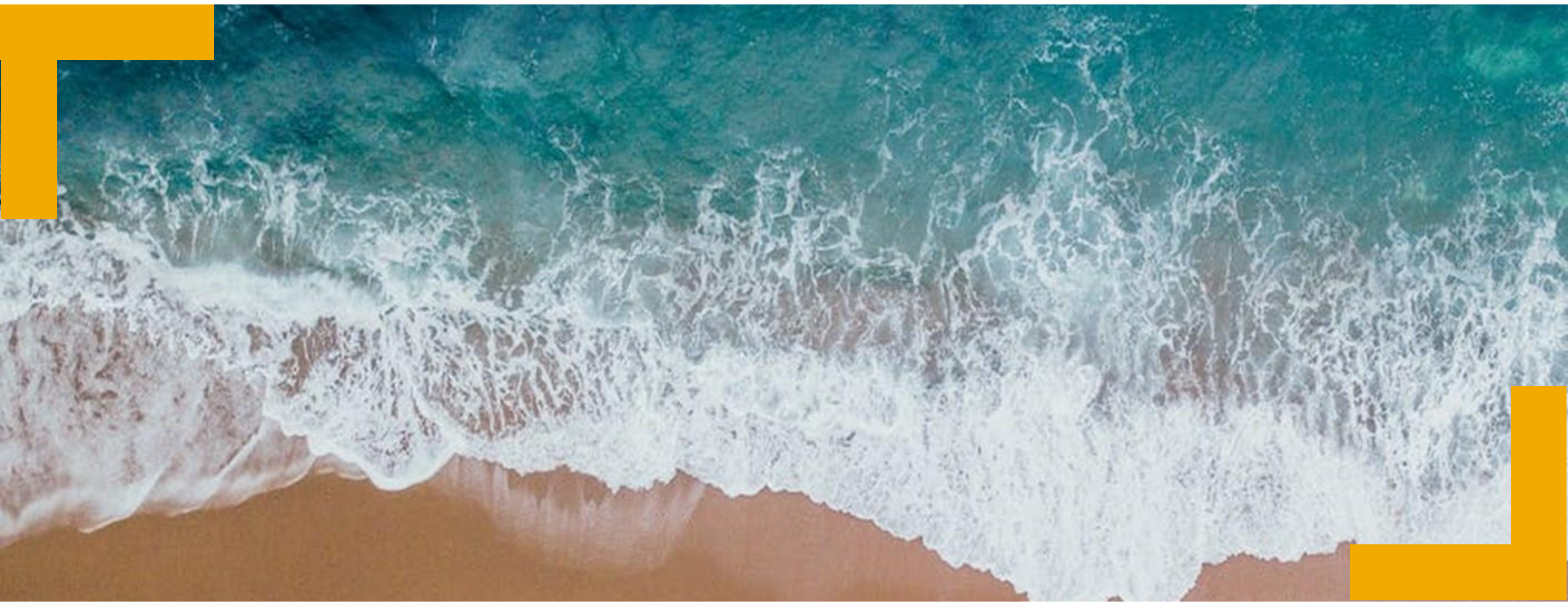

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# GREEN PAPER

Deliverable D.3.4.2

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

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## Deliverable ID

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| **Project priority** | Greener MED |
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# Table of contents

## 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.2.4.1** | 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 |
| **GrP** | The MedSeaRise Green Paper. Project deliverable 3.4.2 |
| **WhP** | The MedSeaRise White Paper. Project deliverable 3.4.1 |
| **SLR** | Sea Level Rise |

# Executive summary

This is the MedSeaRise Green Paper, which analyzes the potentials and issues of a large-scale testing of the MedSeaRise methodology and its application to an extended set of sea level rise related risks. Furthermore, the content of this document reports the main thoughts the MedSeaRise partnership has elaborated on regarding project results capitalization and achieved knowledge sharing besides its maintenance in the Programme cooperation area.

The information and the ideas exposed in this document have been collected thanks to the results of the MedSeaRise methodology application and the experience gained by project partners during the project implementation. In particular, the case studies conducted have played an essential role in that.

The structure of the document is single issue oriented; that means the issues and potentials are presented as self-contained paragraphs. Each paragraph deals with a specific aspect in which the core of the issue is presented, reporting evidence of the situation for the potential or the problem that is considered an issue. Then the elements of the hypothetical causes of the issue or motivations for the potential are described in summary. In addition, there are the consequences deriving from the topic that has been described.

Proposals on how to exploit the potentials or to work around the limits are included too.

The paper does not require a background in any topic related to the issues.

# Purpose of this document

## Introduction

MedSeaRise is a Euro-MED thematic project belonging to the class of study projects, whose aim is to better address a thematic issue, developing new instruments and approaches to face that issue.

The progressive increase of the mean sea level, due to climate change, is the issue MedSeaRise focuses on. The experience and the skills brought by the PPs into the project highlighted the need to generate easy-to-share knowledge on the available data describing the future evolution of the sea level and on their proper use.

MedSeaRise has elaborated a new point of view on how to use sea level climate scenarios. It is a methodology that starts from the available scenarios and leads the stakeholders towards the assessment of risks related to the impacts deriving from a progressive increase in sea level. It adopts the perspective of the Global Warming Levels (GWLs) and propagates the uncertainty affecting the hazard information.

In addition, to support the application of the methodology, the project has generated summary datasets of future climate scenarios, which have been derived specifically for the Mediterranean basin.

The output methodology and the datasets have the potential for further applications, in addition to those that have already been explored, subject to the necessary validation of the study.

It is worth noting that impacts coming from the increase of the sea level are widespread across the Mediterranean coasts, so the MedSeaRise methodology and practices deserve further application and validation that pave the way for the future implementation of their results through follow-up activities.

This Green Paper (GrP) collects the potential for large-scale testing of the methodology and its extension to a wider spectrum of risks, together with the capitalization of the knowledge, which has been achieved thanks to the project, in the Programme cooperation area and beyond.

It is expected that the contents of this document stimulate the discussion on how to blueprint the promotion and the sharing of the MedSeaRise methodology, implementing pilot activities within already existing and consolidated networks and creating new relationships.

Last but not least, the ideas collected in this GrP could serve to bring the concept of climate risk uncertainty, which is related to the ensemble climate scenarios, into the policies for climate change adaptation and resilience.

The contents of the paper are grouped in sections. Each section deals with key aspects of the challenges faced and the issues raised by activities carried out by the MedSeaRise study project.

# Issues and Proposals

## Scaling uncertainties into coastal planning is difficult

The core of the issue: The MedSeaRise methodology suggests a way to assess sea-level rise using many models and a 'global warming level' approach, but stakeholders still find it hard to use this method in the same way in different places and for different sectors. The main problems are practical. The data on what is exposed and how vulnerable it is are often missing, uncertainty is hard to explain clearly, and the workflow needs expert skills to turn results into something stakeholders can use.

The causes: Using the suggested method needs a mix of skills that many local authorities and small organizations do not have, so they often depend on outside experts. Moreover, the data needed to turn sea-level scenarios into real impacts are scattered, not at the same level of detail everywhere, and not easy to share.

The consequences: The method gets used only in a few pilot cases, and results can be difficult to repeat or compare among regions. Uncertainty is either reduced to a single number or seen as too complicated, which lowers trust in the results. This can lead to the wrong priorities, measures that are over or under designed, delays in action, and fewer chances to learn and apply the same good practice across the Mediterranean.

The proposal: Create a practical package that makes the MedSeaRise approach easy to repeat. Agree on a standard way to show and explain uncertainty and add short guides that link sea-level rise to the main impacts and indicators. Finally, support uptake with training, side-by-side tests across several sites, and more real case studies so the results can feed directly into policy.

## Translating SLR projections into understandable information for adaptation

The core of the issue: Translating sea-level rise (SLR) projections into understandable risk information for the adaptation and the resilience of critical coastal infrastructure. Assessing how SLR may affect complex coastal systems, such as port areas, requires linking climate projections with high-resolution spatial data and detailed infrastructure information. While methodologies such as MedSeaRise provide robust projections under different global warming levels, translating these scenarios into operational and economic risk indicators for specific infrastructures remains challenging. Taking as example one of the case studies carried out by MedSeaRise in areas such as the Llobregat Delta (Spain), where strategic assets coexist with natural ecosystems, highly urbanized settlement, and transport networks, the absence of harmonised approaches to combine climate projections, elevation data and asset-level information can limit the usability of results for planning and investment decisions.

The causes: Several factors contribute to this gap. First, infrastructure-level data (e.g. elevation of structures, breakwaters, or logistic platforms) is often incomplete, fragmented, or not easily accessible. Second, climate projections are typically produced at regional scales and require additional processing to be interpreted at the level of individual assets. Third, the integration of physical exposure with economic indicators involves methodological assumptions that may vary across studies, increasing accuracy and making the comparisons between locations more difficult.

The consequences: These limitations can generate uncertainty when estimating the potential magnitude of impacts on critical infrastructure. As a result, risk assessments may underestimate exposure or fail to capture the systemic nature of impacts across interconnected systems such as ports, transport corridors, and the regional markets that depend on them. This can complicate the integration of SLR considerations into long-term infrastructure planning, investment prioritisation, and adaptation strategies.

The proposal: To address this challenge, further development of operational guidance and practical tools could support the translation of climate scenarios into infrastructure-level risk indicators. This could include standardised workflows linking SLR projections with high-resolution elevation models and asset maps, building on the benchmarking work carried out in MedSeaRise. In addition, developing example indicators, together with their data requirements and calculation approaches, could help estimate potential economic disruption under different scenarios and assumptions. Expanding pilot applications across Mediterranean coastal infrastructures would also facilitate replication, support the validation of the methodology, and contribute to building a shared evidence base for climate-resilient coastal planning.

## Assessing risks, including uncertainty

The core of the issue: MedSeaRise study started from the well-known and widely used definition of risk, which is based on the three main elements, namely: the hazard, the exposure and the vulnerability. Each of these three contributions to the risk assessment introduces uncertainty that propagates through the quantitative evaluation of the risk.

The causes: In the case of impacts affecting human activities and coming from the progressive increase in sea level, due to global climate change, the prevailing source of uncertainty is associated with the hazard. However, for ecosystems, the exposure and the vulnerability are also very often sources of uncertainty. This is because of the lack of knowledge of cause/effect relations and the natural response of species to hazards through adaptation and an increase in resilience.

Furthermore, not all uncertainty sources have a random nature. In the case of deterministic but chaotic systems, the uncertainty stems from the approximation of the initial conditions of the system and those of the domain boundaries where the system evolves. On the other hand, for social and economic systems the uncertainty comes from random factors and human behaviour, often resulting in a spontaneous adaptation of the system according to the information it gets on its own behaviour. The widely accepted description of climate falls in the class of deterministic systems having low predictability.

The consequences: Uncertainty shall be considered an implicit element of risk assessment and therefore, a larger number of possible impact-reduction responses should be identified as the uncertainty increases. This awareness should be part of the risk management process. How the uncertainty propagates from the sources along the risk assessment process and consequently affects the results is not described by a universal law. Each sequence of forcing and response that describes the risk, from the hazard to the impact, requires a specific investigation of the sources from which uncertainty arises and the nature of such uncertainty. It is important to recall that not all uncertainty sources have a random nature. For deterministic but chaotic systems, the uncertainty stems from the approximation of the initial conditions of the system and those of the domain boundaries where the system evolves. On the other hand for social and economic systems the uncertainty comes from random factors and human behaviour, often resulting in a spontaneous adaptation of the system according to the information it gets on its own behaviour.

The proposal: The MedSeaRise experience suggests considering the whole risk assessment procedure as a unique model able to simulate the impact due to the hazard. Thus it is considered useful to generate a set of impact simulations, according to the available set of information on the hazard. Then the set of impacts is explored to study its properties and sensitivity on suitable parameters that describe the changes in the inputs. The Global Warming Level is an example of the sea level hazard.

## Interpretation of the ensembles of climate scenarios

The core of the issue: Simulations of the future climate evolution are clustered in classes that are called ensembles. Each ensemble aims to describe the evolution of a future climate scenario, so there is not one description only of the hazard tied to the scenario. Instead, there are many possible choices to be made inside the ensemble.

The causes: Climate evolution is simulated through numerical models. Those models have been developed and are maintained by different groups of scientists. There does not exist the best climate model that is considered to include all the achievements of cutting-edge research on future climate. Each model performs better in reproducing some process, not all, because of its development history, implementation and research group richness in terms of people involved, their skill and expertise and the availability of computational resources.

The consequences: The availability of more than one source of information, namely model outputs generating the evolution of the climate, specifically the future mean sea level, leaves one with a tough choice: which simulation among those available should I use to describe the hazard? In many cases this is a dilemma because the approach to the risks associated with the hazards stems from the probability of occurrence of hazardous situations. Return periods are widely used to present the likelihood of a dangerous event occurrence. If that is the way to deal with the sea level hazard it is straightforward to choose one set of data only, namely time series, to compute the return period and use it as input in the risk assessment procedure. Common choices are the worst (extreme) time series, or the average of all the available time series and so on and so forth. In those cases, the common shortcoming is that, for climate hazards, the events resulting in impacts are not determined by random processes that can be described by statistics. For a future climate scenario, each simulation available in the ensemble has the same probability to occur, because it reproduces the evolution of a dynamical system. Then all that information should be used, giving them the same chance to contribute to the risk assessment. Of course, the ensemble approach requires suitable knowledge on how to work with ensembles of data and skill in using the required computational tools and software.

The proposal: To exploit the full potential of an ensemble of climate simulation education is required first. So it is expected that training on the use of ensembles of future mean sea level scenarios is needed to make the ensemble approach a common practice among decision makers. Furthermore, it is necessary to train people in using strategies for ensemble time series handling to support decision makers with proper information tools. The basic consequence of the ensemble hazard logic, in risk assessment procedures, is the resulting ensemble impact outputs, which require the ensemble risk analysis for decision making purposes.

## Widening the applications and further testing the methodology

The core of the issue: The potential to extend the methodology to other sectors and other types of impacts is a key objective for scaling up the MedSeaRise methodology use and adoption of a standard approach to sea level rise related impacts. Furthermore, a wider set of applications, in addition to those already carried out in the frame of the project, would enrich the methodology testing.

The causes: The general aim of the MedSeaRise project was to define and promote a methodology supporting the assessment of risks and the adaptation actions related to sea level rise, due to climate change scenarios. Due to its study characteristics and the limited time for testing, the project generated a set of methodology applications. Anyway such a set is not exhaustive of all the many and possible applications. Furthermore, no method is perfect for all of the risk assessment areas and a continuous validation is the best way to identify weak points and strengths.

The consequences: Fostering the application of the method to a wider set of cases would refine the evaluation of the methodology capability to support the risk assessment for adaptation and resilience to the impacts deriving from the progressive increase of the mean sea level. Furthermore, a larger set of practical cases of methodology use enriches the support to the methodology understanding and diffusion as a best practice, thanks to the possibility of finding an application example close to the need of the stakeholder.

The proposal: The potential to extend the methodology to other sectors and other types of impacts depends on several key points. In applying the methodology it would first need to be aligned with existing planning instruments, in particular the Risk Prevention Plans. Just to give an example, in France the Plans de Prévention des Risques), the "Porter à Connaissance" on marine flooding, and the Territorial Coherence Scheme (Schéma de Cohérence Territoriale – SCoT), as well as the various ongoing studies carried out by municipalities and Public Establishments for Intermunicipal Cooperation (Établissements Publics de Coopération Intercommunale – EPCI). Stakeholders involved in the project also highlighted the need to better take into account existing coastal defense structures and the different types of flooding (inundation, surface run-off, river floods). Stakeholders consulted as part of the project are supportive of broadening applications along the coastline and on coastal islands. In their view, it appears more relevant to assess sea-level-rise risks at a broader scale rather than purely locally, as risk awareness is developed relatively evenly across France. Beyond assessing future impacts, the objectives would be to better understand the risks and to identify intervention needs for coastal protection structures. Back to the general aspects, adding application of the methodology to new case studies requires economical resources and human resources (skill, expertise, multidisciplinary teams), education, and formation of the next generation of experts.

## Improving analysis on ecosystemic impacts driven by sea level rise

The core of the issue: In the project MedSeaRise, mainly impacts on anthropic assets were investigated. Only two methodology applications focused on sea level rise impacts on ecosystems. This limits the experience gained in the methodology application climate issues involving the ecosystem response to sea level increase.

The causes: The few case studies on ecosystem impacts are due multiple reasons, the most relevant being the workflow complexity and the available data. In fact, whilst for anthropic assets the indices were computed by overlapping sea level projections with digital terrain models, for ecosystems the impacts yielded by increasing sea levels were not so straightforward to identify. In fact, plant species may tolerate and survive up to a certain degree of stress caused by a more frequent submersion rate, or on the contrary, the early dieback of sensitive species could lead to a sudden transformation of the coastal habitats. Those are a few examples of the reason why studying an ecosystem requires a great amount of data about its functioning and the relation between its species and the stressors that affect them.

The consequences: Even if only two, the MedSeaRise case studies on ecosystem impacts highlighted not only the complexity tied to biotic systems, but also yielded many questions about how the sea level rise can affect the natural capital. For example, the sea level rise is not going to affect only coastal areas, but the salt wedge ascent increase, driven by rising sea level, is thought to be significant and resulting in possible impacts for riverine habitats. All these are still open questions that require further methodology applications and analyses.

The proposal: To face this issue, a collaboration among many skills and expertise is needed. The most simple way to create the proper melting pot is to have funded projects focused on the issue. Anyway, also the collaborative activity carried on by different institutes, in the frame of their own institutional activities, is a possible approach, even if more difficult because it is based on a pure volunteer basis. It can be stated that while studying impacts on the ecosystems requires a case-by-case analysis and tailored approach based on the species relations with the impacted environment, requiring higher effort, it is also a great opportunity to broaden the knowledge between the ecosystems and the sea, making it an investment in better managing coastal environments as a whole.

## Partnership enlargement and methodology contamination

The core of the issue: The MedSeaRise project gave the opportunity to create a partnership strongly motivated to work on a multidisciplinary topic. At the beginning, partners felt some aspect of the project implementation was quite far from their consolidated skills and abilities. Working together has removed those distances and approaching the project end the partnership were able to increase competence and expertise, besides getting awareness of the possibility of dealing with complex problems through collaboration. This is considered an added value that goes beyond the MedSeaRise Partnership.

The causes: MedSeaRise partnership had the opportunity to put into practice what is conceptually well known, namely a motivated collaboration is more than the sum of the efforts; it is synergy creating added value into the partnership and into the cooperation area where the partnership operates.

The consequences: Starting from the MedSeaRise experience, it would be possible to consolidate and adjust existing networks or create new networks able to work on complex issues, taking benefit from the MedSeaRise organization, steering and conduction of the project activities. That would strengthen the presence of the Interreg Euro-MED cooperation area at transnational and European level too.

The proposal: New partnerships can reduce external barriers: the availability of experts, access to data, costs, and the integration of results into planning. Such partnerships are shaped by constraints linked to the implementation ecosystem. For example, in France, the partners identified operate at national and regional level, including: the Centre for Studies and Expertise on Risks, the Environment, Mobility and Planning (CEREMA); the French Geological Survey (BRGM – Bureau de Recherches Géologiques et Minières); the Departmental Directorate for Territories and the Sea (DDTM06); the Regional Directorate for the Environment, Planning and Housing (DREAL PACA); the Joint Syndicate for Flooding, Planning and Water Management (SMIAGE); the Mediterranean Institute for Environmental Risk and Sustainable Development (IMREDD); and the French National Centre for Scientific Research (CNRS). Local actors such as coastal intermunicipal authorities — the Cannes Pays de Lérins Agglomeration Community (CACPL), the French Riviera Agglomeration Community (CARF), the Sophia Antipolis Agglomeration Community (CASA), and the Nice Côte d'Azur Metropolis (MNCA) — also appear to be priority partnerships for strengthening local action networks.

## Legacy of the project and knowledge transfer

The core of the issue: The MedSeaRise project is a Euro-MED thematic project belonging to the study project class. This means that in addition to the deliverables produced through the implementation of project activities, the project contributes to enrich the overall knowledge in the Euro-MED cooperation area. This is a legacy the project leaves and that it is worth preserving and capitalising.

The causes: A study project explores new issues or already known topics with new approaches and tools. Each time a partnership works on innovation, there are problems to face and solutions adopted, which are not a pure application of already well-known methodologies and instruments. So, people that have spent time and resources studying a solution have gained experience and improved their skill in problem solving. That increase of knowledge on how-to is strictly tied to people involved in the project activities; in turn, this means the knowledge is inside the project partnership.

The consequences: When a project completes its lifecycle, the increase of partnership knowledge and skills does not have any more of the sharing environment suitable to transfer the gained know-how further in the cooperation area in which the project was born and conducted. This is a natural epilog of the project lifecycle facts. Besides spontaneous and often personal initiatives, what was not distilled in the project deliverable, for example the personal experience in solving problems and in steering a partnership through problems and making shared choices is hardly sharable outside each project partner people. As a consequence, after the project ends, the cooperation area can hardly benefit from a part of the knowledge and skills acquired thanks to the project resources.

The proposal: To continue to share project knowledge beyond the project end requires finding or creating conditions suitable to allow people to exchange ideas. Workshops and schools are the natural solutions, especially to make the knowledge transfer towards new generations of people involved in the area. Thus, it is warmly suggested that during the years getting closer to the project end, partners participate in events in which there is the opportunity to bring the project legacy.

## Contribution to rise risk awareness on sea level rise related risks

The core of the issue: The perception of the risks related to impacts coming from the progressive increase of the mean sea level as a consequence of global warming is not homogeneous across the public and stakeholders. Several times there is an underestimate of that risk too, and often there is no awareness about it.

The causes: For any person, there are more than one psychological aspect contributing to the reduction of the risk perception, assuming it has an excessive distance from the personal interests. Considering the impacts due to the progressive increase of the sea level, avoiding the physical distance (spatial distance) to all the potential impacts, the most common is the perception the problem manifestation will be far in the future (time distance). The perception there is a very low probability the sea level will increase by a significant amount (probability distance) is another key interpretation of the under-awareness of sea level rise impacts. Last but not least, there is the personal belief that, even if there will be impacts, the personal ability and skill to manage the problem will be enough to consider the impact negligible (social distance).

The consequences: The under-estimate of the risk or the lack of awareness leads to missing preparedness to face the impacts the sea level rise is bringing with. This means scarce ability to define and implement resilience and adaptation actions aimed to minimize the consequences of climate change.

The proposal: As a whole, the MedSeaRise project helps to raise awareness of coastal risks. However, carrying out the case study makes it possible to highlight tangible impacts on the ground and to enable local stakeholders and residents to grasp the hazards and risks affecting the spaces they use in their everyday lives. The case study proved highly relevant and was able to contribute to awareness-raising for several reasons. For example, in France, the perimeter selected for this case study, between the River Var and the port of Saint-Laurent-du-Var, was chosen with care. It is a strategic area, with a particularly high number of jobs and a wide range of coexisting activities: commercial and recreational economic activities, as well as residential areas, road infrastructure and coastal protection structures (breakwaters). This area also has an important morphodynamic feature. Unlike much of the French Mediterranean coastline, it is not an eroding zone but a perimeter where accretion processes are observed. This demonstrated the future impacts of sea-level rise, very concretely, including in areas that are currently considered relatively well preserved. This finding reinforces the idea that sea-level rise is a broad, overarching issue that concerns our entire coastline, without exception.

## Towards policies integrating the project methodology

The core of the issue: The integration of methodologies and best practices into policies makes them become a standard approach to the issue they are meant for. It is well known that there are very effective approaches that are not considered standards simply because they aren't specifically included in norms or planning documents.

The causes: The approaches to a complex issue, such as the assessment of the risks related to climate change, require cutting-edge techniques, advanced tools and continuously updated sources of data. In many cases, those approaches are far too difficult to be understood by people who are not insiders of the topic. So it is quite common that official documents, on adaptation and resilience against climate change impacts, lack to specify advices on the methods and source of data to be used by default to generate outputs to be compliant with the guidelines the documents declare to be mandatory.

The consequences: The gap between mandatory guidelines to face a problem and the identification of the set of tools considered suitable to generate the output, the guidelines aim to standardize or to make it have the required level of reliability, results in low effectiveness of the recommendations and the constraints. Furthermore, outputs regulated by the same guideline may differ a lot because they have been achieved through methods, data and their application not comparable. In the worst case, two results on the same issue can be quite different and potentially in contradiction even if they are compliant with the norm they had to respect.

The proposal: MedSeaRise has defined and tested a methodology supporting the correct use of scientific datasets on future climate scenarios when the assessment of risk related to sea level rise supports the definition of adaptation or resilience measures to reduce the impacts, especially on anthropic activities. It underlines the perspective of Global Warming Levels instead of the time evolution of the hazard. We do not know when and if we are going to reach those levels of warming, but for decision makers, it is more effective to relate the impacts with other conditions if impacts are a function of GWL. For example, if adaptation of floodable areas, due to SLR, shall be considered in conjunction with the touristic appeal of the areas and the appeal is a function of the maximum daily air temperature or fresh water availability, the sight based on GWL can link all these elements. Regardless of when they occur. Furthermore, the adaptation solution based on GWL may be reconsidered according to the speed of Global Warming increase and the time required to adopt the solution or the lasting period of the solution, up to the next level of impact, which is a function of GWL. The proposal is to stimulate a discussion on the MedSeaRise methodology application as a general approach and how to bring the core of its concepts, mainly of ensemble analysis of risk, into the policies for climate change adaptation and resilience.

## Synergies with new tools

The core of the issue: The MedSeaRise methodology for an effective use of sea level rise scenarios in climate change impact risks assessment was applied to case studies in the frame of the project. The tools to apply the methodology on those cases were selected among those pertaining to the skill and the expertise of the Project Partners. Certainly there are further ways to implement the methodology.

The causes: Because of the natural limits of resources, time and people involved in the MedSeaRise project activities, the ways explored to apply the developed methodology are not exhaustive.

The consequences: Surely there are possible applications of the methodology that results in being more efficient for a specific set of impacts, which have not been considered. Limits in the software used to transfer the hazard information towards impacts are among them.

The proposal: It would be worth making further use of emerging techniques of computation of the impacts related to sea level rise hazard. One of the most attractive areas is that of Artificial Intelligence (AI). AI can be used to assess the impacts and then approach complex impacts that are characterized by manifold interactions and feedback. Those impacts are typical on ecosystems, but there are many anthropic activities in which different assets are strongly related, generating mutual actions and responses, resulting in a very complex set of impacts related to climate change hazards.

## The external factors limiting the MedSeaRise Approach

The core of the issue: The MedSeaRise approach may be regarded as relevant, yet it can face limitations at the point of operational roll-out, as its uptake depends heavily on external factors: the availability of expertise, access to data, affordable costs, organisational maturity, and the ability of planning frameworks to incorporate its outputs. These constraints relate less to the methodology's intrinsic quality than to the real-world conditions in which stakeholders must apply it and use it to support decisions.

The causes: Several causes combine. First, the scarcity of external skills that can be mobilised (or their dispersion) can hinder uptake, particularly where implementation requires specialist profiles. Second, the overall cost of the application (time, data, consultancy, iterations) may exceed available budgets or compete with other priorities. Added to this are the perceived complexity of the approach in settings where planning and investment routines are not structured around probabilistic/uncertain analyses, as well as insufficient access to certain data needed to assess impacts (exposure, vulnerability, local reference datasets, etc.). Finally, even where an assessment exists, a major external factor remains: the possibility that the results are not genuinely integrated into adaptation decisions (institutional inertia, trade-offs, political timescales, regulatory frameworks).

The consequences: These constrains imposed by external factors translate into uneven adoption, sometimes limited to actors that are already “mature” or well-resourced. They can also lead to one-off applications rather than multi-site replication, with a risk of dependence on a small number of experts. Scientific quality may then fail to translate into operational impact: results remain peripheral to decision-making, or are over-simplified, reducing their usefulness for risk management and for anticipating the impacts of mean sea-level rise. In the longer term, the approach may be judged “too costly” or “too complex”, not because it is unsuitable, but because the implementation ecosystem does not provide the necessary prerequisites (data, skills, governance, funding).

The proposal: To reduce these external constraints, several complementary levers can be proposed: (i) support skills transfer through a “train-the-trainers” scheme, short modules and sector-specific application guides; (ii) reduce the marginal cost of replication by providing ready-to-use datasets, reproducible calculation models and packaged use cases; (iii) strengthen access to data through partnerships with data producers, interoperability standards and clarified data-sharing conditions; (iv) create demonstrators/pilots within established networks to show decision value (including where uncertainty is high); and (v) address the last mile of decision-making by aligning the method’s outputs with the formats expected in planning documents, cost–benefit analyses, investment frameworks and adaptation/resilience policies.

# Indicators of deliverable achievement

## Deliverable indicators

The achievement of the objective described in this deliverable is summarized usig the indicators reported below. For each of them, the expected indicator value and the actual one are presented. In addition, comments are reported where relevant.

| Indicator | Expected value | Actual value | Comments |
|---|---|---|---|
| Documents | 1 | 1 | The Green Paper |