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SEA-LEVEL RISE IN THE MEDITERRANEAN REGION

The paragraphs below are adapted from three main relevant sources of information:

- "*UNEP/MAP 2019 State of the Environment and Development Report"* (SoED 2019) and its Summary for Decision-Makers (UNEP/MAP, 2019)
- MedECC booklet (2019): "*Risks associated to climate and environmental changes in the Mediterranean region"*, based on Cramer W., Guiot J., Fader M., Garrabou J., Gattuso J.-P., Iglesias A., Lange M.A., Lionello P., Llasat M.C., Paz S., Peñuelas J., Snoussi M., Toreti A., Tsimplis M.N., Xoplaki E. (2018) *Climate change and interconnected risks to sustainable development in the Mediterranean*, Nature Climate Change 8, 972-980, doi: 10.1038/s41558-018-0299-2
- *"Mediterranean Quality Status Report"* (UNEP/MAP, 2017)

1. Causes and effects

The Mediterranean Basin is one of the most prominent hotspots of climate and environmental change worldwide. The Mediterranean Region is warming 20% faster than the global average. Current change and future scenarios consistently point to significant and increasing risks during the coming decades.

Similar to worldwide trends caused by warming and loss of glacial ice, sea level in the Mediterranean Basin has risen between 1945 and 2000 at a rate of 0.7 mm per year[1] and between 1970 and 2006 at the level of 1.1 mm per year[2]. There has been a sharp increase during the last two decades as sea-level rise reached about 3 mm per year[3]. There are important uncertainties concerning global mean sea-level rise in the future. Future projections range goes from 52 to 190 cm global mean sea level increase by 2100 depending on the method used. These uncertainties will largely influence the Mediterranean Sea level rise, because of the connection to the global

[1] Calafat F.M., Gomis D. (2009) Reconstruction of Mediterranean Sea level fields for the period 1945-2000. Global and Planetary Change, 66(3-4), 225-234.
[2] Meyssignac B. et al. (2010) Two-dimensional reconstruction of the Mediterranean Sea level over 1970–2006 from tide gage data and regional ocean circulation model outputs. Global and Planetary Change, 77(1-2), 49-61
[3] Tsimplis M.N. et al. (2013) The effect of the NAO on sea level and on mass changes in the Mediterranean Sea. Journal of Geophysical Research: Oceans, 118, 944-952

ocean through the Strait of Gibraltar. The accelerating ice loss in Greenland and Antarctic ice sheets implies a significant risk for additional sea-level rise even if global warming was limited to 1.5°C, with a potential of multi-meter rises in sea level[4]. The situation may be further compounded by non-climatic factors such as the subsidence of coastal land, subsurface resource extraction, and tectonic movements.

Regional projections of relative sea-level change are more uncertain than global projections, because of the reduced skills of global models and interactions between the Atlantic Ocean and the Mediterranean Sea. For Mediterranean coasts, regional changes in river runoff, provoking salinity changes and also significant land movements in the eastern parts of the basin need to be considered additionally. In addition to the impacts of global sea level change, circulation patterns in the Mediterranean may also be modified and generate changing regional sea level patterns[5], with local differences in sea surface height of up to 10 cm. In southern Italy, substantial coastal inundation is expected by 2100[6]. Significant shoreline modifications are also expected in other areas, like the Balearic Islands[7].

When considering sea-level rise, one should consider in the same time coastal flooding occurring along the Mediterranean coasts already today. Extreme weather events, storm surge, waves and tide are often combined and causing coastal flooding. Flash floods are becoming more and more frequent. Combined with other factors, such as for example soil subsidence, coastal floods can already reach substantial size. During such an event in Venice, Italy, in December 2019, the sea reached the level of 1.87m above the ground.

2. Impacts and challenges:

- ***Coastal risks resulting from rising sea level, storm-surge, flooding, and local land subsidence - Half of the 20 global cities set to suffer most from sea-level rise by 2050 are in the Mediterranean.***

For Mediterranean economies and societies, the coastline has long been an area of concentration with an increasingly high population density and related infrastructure, as well as touristic,

[4] Schleussner C.F. et al. (2016) Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C. Earth System Dynamics, 7, 327-351
[5] Adloff F. et al. (2015) Mediterranean Sea response to climate change in an ensemble of twenty first century scenarios. Climate Dynamics, 45(9-10), 2775-2802
[6] Aucelli PPC et al. (2017) Coastal inundation risk assessment due to subsidence and sea level rise in a Mediterranean alluvial plain (Volturno coastal plain–southern Italy). Estuarine, Coastal and Shelf Sciences, 198, Part B, 597-609
[7] Enríquez A.R., Marcos M., Álvarez-Ellacuría A., Orfila A., Gomis D. (2017) Changes in beach shoreline due to sea level rise and waves under climate change scenarios: application to the Balearic Islands (western Mediterranean). Natural Hazards and Earth System Sciences, 17, 1075-1089

commercial and industrial stakes, many of these situated close to mean sea level. This intensification of coastal uses is at the origin of many impacts that alter the invaluable capital that is the Mediterranean, leading to increased fragmentation of landscapes and disrupting ecological continuity. It also makes coastal zones highly vulnerable to sea-level rise, storm-surges, flooding and erosion.

Mediterranean coastal environments (soft sediment coasts, muddy environments, rocky and soft shores and cliffs) provide important ecosystem services, such as shoreline stabilization and buffering, coastal defense, groundwater storage, and water purification. They suffer from accelerated erosion rates and substratum loss of rocky shores due to urbanization and coastal infrastructure expansion, sea-level rise, and reduced river sediment inputs.

Due to a limited tidal range, Mediterranean coastal infrastructures and settlements are often closer to the mean sea level, than in most regions of the world[8], which makes them highly vulnerable to sea-level rise, storm-surges, flooding, erosion and local land subsidence. Considering the high concentration of human population and activities in the Mediterranean coastal zone, exposure is high, potentially leading to high economic, social and cultural losses, and increased risks of disasters. Sea-level rise also causes salinization of coastal wetlands and aquifers and, combined with a disturbed sediment balance on Mediterranean shores, they lead to erosion. In addition, salinization affects water security in a region particularly vulnerable to water scarcity and drought.

The particularly high density of coastal population and infrastructure on the shoreline, linked to a limited tidal range, make the Mediterranean coast particularly vulnerable to changes in climate and sea level. Extreme rainfall and droughts, combined with sea-level rise, will contribute to higher risks of coastal flooding and erosion, with increasing damage to key infrastructure and highly populated and growing coastal cities. The effects of sea-level rise are expected to be high for most low-lying coasts of the Mediterranean basin. These risks may be even higher along the southern and eastern shores, where monitoring systems are limited, and the adaptive capacity is generally lower than in the north. Coastal erosion and flooding will generate loss of coastal land where important cultural heritage sites are located with 85% of the 49 low-lying World Cultural Heritage sites being at risk of flooding and 75% at risk of coastal erosion, already today.

[8] Becker et al. (2012), Climate change impacts on international seaports: knowledge, perceptions, and planning efforts among port administrators. Climatic Change, 110(1), 5-29

3. **Opportunities and responses (solutions)**

- ***Integrated marine and coastal zone management***

The Protocol on Integrated Coastal Zone Management (ICZM) of the Barcelona Convention, in its article 8, provides that Contracting Parties (i.e. 21 Mediterranean States and the European Union) shall establish in coastal zones, a zone of at least 100 m in width where construction is prohibited. However, the built-up area within the first 150 m wide belt along the coastline is above 20% in almost half of Mediterranean countries (in 2015). The built-up area in the Mediterranean coastal belt has continued to increase in all Mediterranean countries throughout the last decade; and between 1965 and 2015, three out of four Mediterranean countries doubled or more than doubled the built-up area in the coastal belt of 1 km from the coastline. This leaves less space for natural coastal ecosystems, diminishing the services they provide, and increases coastal risks for the people living in the coastal zone.

Article 18 of the ICZM Protocol invites Mediterranean countries to prepare National Coastal Strategies, Plans and Programmes. It is at the local scale that concrete action for risk reduction, conservation and management of natural resources for human wellbeing are taken. A successful integrated approach requires prioritization of challenges. For the coastal zones, climate crises and the consequent sea-level rise or actual coastal flooding during extreme weather events, represent a major threat and as such should be central to any coastal plan or strategy.

Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) offer coherent responses to current challenges that Mediterranean coasts face. The ICZM Protocol to the Barcelona Convention has been supplemented in 2017 by a "Common Regional Framework" to introduce MSP into the delivery of the ICZM Protocol. Both ICZM and MSP deal with land-sea interactions and address conflicts between human uses and coastal and marine ecosystems and advocate for coherent policy mixes. Avoiding further degradation of Mediterranean coastal zones and, where possible, restoration of ecosystems, require urgent implementation, enforcement and follow-up of these approaches and tools.

- ***Foresight and adaptation: Anticipating the transformation of coastal and marine areas, activities and landscapes***

Mitigation efforts are essential to reduce the rate and magnitude of climate change impacts, however, under current scenarios, mitigation efforts alone will not be enough to manage the adverse effects of climate change. Adequate adaptation policies and measures at the regional and local levels will be essential to anticipate and respond to a wide range of potential climate-related risks, including those associated with sea-level rise.

Climate change adaptation in agricultural, urban and coastal areas is expected to require major investment. Anticipating adaptation, choosing no-regret solutions including nature-based

solutions, and effectively involving the private sector (including banks and insurance) can minimize funding needs.

Protecting the coastal zone from urban sprawl and economic pressures: As highlighted in the Common Regional Framework for ICZM in the Mediterranean, protecting the coastal zone from cumulated pressures in both land and marine sides of the land-sea interface requires an integrated set of complementary and coordinated policy instruments. Besides a legal framework, critical instruments include monitoring and assessment, coordinated planning processes and governance mechanisms, dedicated funding mechanisms (e.g. economic or fiscal instruments), land policy instruments (e.g. land acquisition, concession, separation between ownership and right of use, land stewardship, etc.), training, communication and information, and efficient enforcement systems.

With an expected increase in sea-level rise, coastal erosion and coastal extreme events, **adaptive strategies will be required** for organising where needed strategic retreat, and ensure when appropriate a sustainable transition in economic activities and human settlements. These transformations are projected to become game-changers and need to be mainstreamed into new and existing policies.

The "maritimization" of human activities is an emerging trend adding on to the impact on a continued "littoralization". This phenomenon requires extending the approach and practices of ICZM towards more offshore waters through maritime spatial planning. Human activities are increasingly moving towards the sea, with both a continued growth of existing maritime activities and the emergence of new activities rendered possible by technological development at sea. The coastal zone, already subject to a continued pressure from land-based activities and urban development, and saturated by build-up areas in some parts, is an unavoidable base for these new maritime activities, expected to generate additional pressures on fragile ecosystems, in particular in shallow coastal areas. Avoiding, reducing or compensating these impacts is expected to be a major challenge for the upcoming decades.

- ***Local action: Translating national and international commitments into local action, adapted to the territorial context***

The gap between the ambition of international agreements and their implementation at the local level needs to be closed while taking into account local specificities. It is at the local scale that concrete action for conservation and management of natural resources for human wellbeing can be taken. This is particularly true for adaptation to environmental and climate change. Clear mechanisms to mainstream international commitments into local planning often lack effective tools. Coordination between local administrations and central and decentralized sectoral technical services, as appropriate, requires further capacity building and implementation support to become more effective.

Strengthening the Science-Policy Interface at the regional and sub-regional level is also important; the Mediterranean Workshop in the framework of the United Nations Decade of Ocean Science for Sustainable Development 2021-2030 (Venice, Italy, 21 - 23 January 2020) aims to provide a substantive contribution to strengthening the Science Policy Interface in the Mediterranean and to support development and uptake of policy-oriented research.

Mediterranean islands. While the issues of sustainable management of resources, limitation of destruction of natural habitats, control of invasive alien species and mitigation and adaptation to climate change are not specific to islands, they are particularly exacerbated in these isolated territories where resources are scarce, space limited and technologies restricted. Islands should not be reduced to vulnerable territories, as they represent resilience laboratories for innovation for biodiversity conservation and sustainable development. The networking among these territories needs to be encouraged in the Mediterranean Region and beyond, and policies recognizing the singularity and value of these territories should continue to be implemented (in line with the efforts made under the Rio+20 declaration, the Aichi targets and working group on insular biodiversity, the resolution XII.14 of the Ramsar Convention and the ICZM Protocol).

Promote innovative local-level systems and governance models, around emerging (or re-emerging) value chains. **Collective organization and citizen-led innovations in sustainable agriculture, aquaculture, fisheries and eco-tourism sectors, creating jobs and diversifying the economy, should be further strengthened and supported**. The value chain approach promotes the participation of local producers which individually are “vulnerable”, to group and act collectively to overcome market barriers and increase revenue. The value chain approach can also help identify opportunities towards a more circular economy. Mechanisms to value local products, i.e. labelling, should be further implemented to value sustainable practices and protect consumer health.