SEA LEVEL RISE IN EUROPE

BROCHURE OF THE SUMMARY FOR POLICYMAKERS

KNOWLEDGE HUB SEA LEVEL RISE
JPI OCEANS
JPI Climate
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

This brochure provides an overview of the Summary for Policymakers from 'Sea Level Rise in Europe: 1st Assessment Report of the Knowledge Hub on Sea Level Rise'.

It is designed as a guide to the key findings, projected sea level rise, impacts, adaptation measures, and policy recommendations, supporting informed decision-making and strategic planning across European coastal regions.

For a more in-depth understanding, the full Summary for Policymakers paper is available on the Copernicus journal, State of the Planet: https://sp.copernicus.org/articles/3-slre1/1/2024/

The full assessment report published on the State of the Planet can be accessed here: https://sp.copernicus.org/articles/3-slre1/index.html

STATE OF THE PLANET

Copernicus Publications
The Innovative Open Access Publisher

Introduction

The European Knowledge Hub on Sea Level Rise (KH-SLR), a collaborative effort by the Joint Programming Initiatives for "Connecting Climate Knowledge for Europe" (JPI Climate) and for "Healthy and Productive Seas and Oceans" (JPI Oceans), has developed the 1st Assessment Report (SLRE1) to address the challenges posed by SLR in Europe.

The report was preceded by a series of targeted surveys and workshops with stakeholders such as coastal decision-makers, from six the European sea basins: Mediterranean Sea, Black Sea, North Sea, Baltic Sea, Atlantic, and Arctic. It synthesizes the current scientific knowledge on SLR drivers, impacts, and policies at local, national, and European basin scales provides basin-specific analyses on local sea level changes, compared with relevant global assessments such as those of the Intergovernmental Panel on Climate Change (IPCC). In addition, it identifies critical knowledge gaps needed to support the development of actionable information.

Bart van den Hurk, co-chair of the Knowledge Hub on Sea Level Rise

"There are many different areas exposed to sea level rise consequences, each with its own history, culture, and impacts. Our challenge is to make information accessible to people dealing with sea level rise, keeping that diversity and specificity in mind.

Nadia Pinardi, co-chair of the Knowledge Hub Sea Level Rise

"Assessment reports are a fundamental component of actionable science for climate mitigation and adaptation.

ASSESSMENT SCOPE AND STAKEHOLDER NEEDS ON EUROPEAN SEA LEVEL INFORMATION

SCOPE OF THE ASSESSMENT

Despite the global threat of sea level rise, Europe faces disparities in understanding and applying sea level science, evaluating its impacts, and devising effective adaptation strategies.

The European Knowledge Hub on Sea Level Rise has started by conducting an extensive scoping process defining its outline and identifying critical knowledge gaps. It aims to provide easy access to usable knowledge specifically on regional to local sea level change in Europe and enable policymakers to make well-informed decisions about installing protective and adaptive measures.

STAKEHOLDER CONSULTATION ON AVAILABLE AND REQUESTED INFORMATION

Online Survey

Responses were received from 200 stakeholder participants, from 23 European and 8 non-European countries; categorized into two groups:

1 "government" - potential users of SLR information for policy design and implementation, professionals in public or private sector, or with advisory roles

2 "research" - information providers and academic research staff

a) Availability of SLR information

Approximately 32% of respondents indicated a lack of essential regional to local data and information on SLR, with disparities across different sea basins.

- Respodents reported that mostly *global* sea level projections were used.
- Information gaps primarily revolve around regional SLR projections, uncertainties, and ice sheet mass loss contributions,
- Better understanding and projections related to long-term SLR are needed.

Identified gaps varied slightly in perspectives and priorities between respondents from government and research categories.

Government respondents prioritised precise regional projections as the ultimate product, crucial for fulfilling their responsibilities, with uncertainty estimation being a significant concern.

Scientists prioritized a comprehensive understanding of factors influencing regional projections, considering these insights as the final goal, with a strong focus on the factors contributing to uncertainty. Improving local SLR projections, understanding the impact on extreme water levels, and addressing coastal erosion were all deemed important.

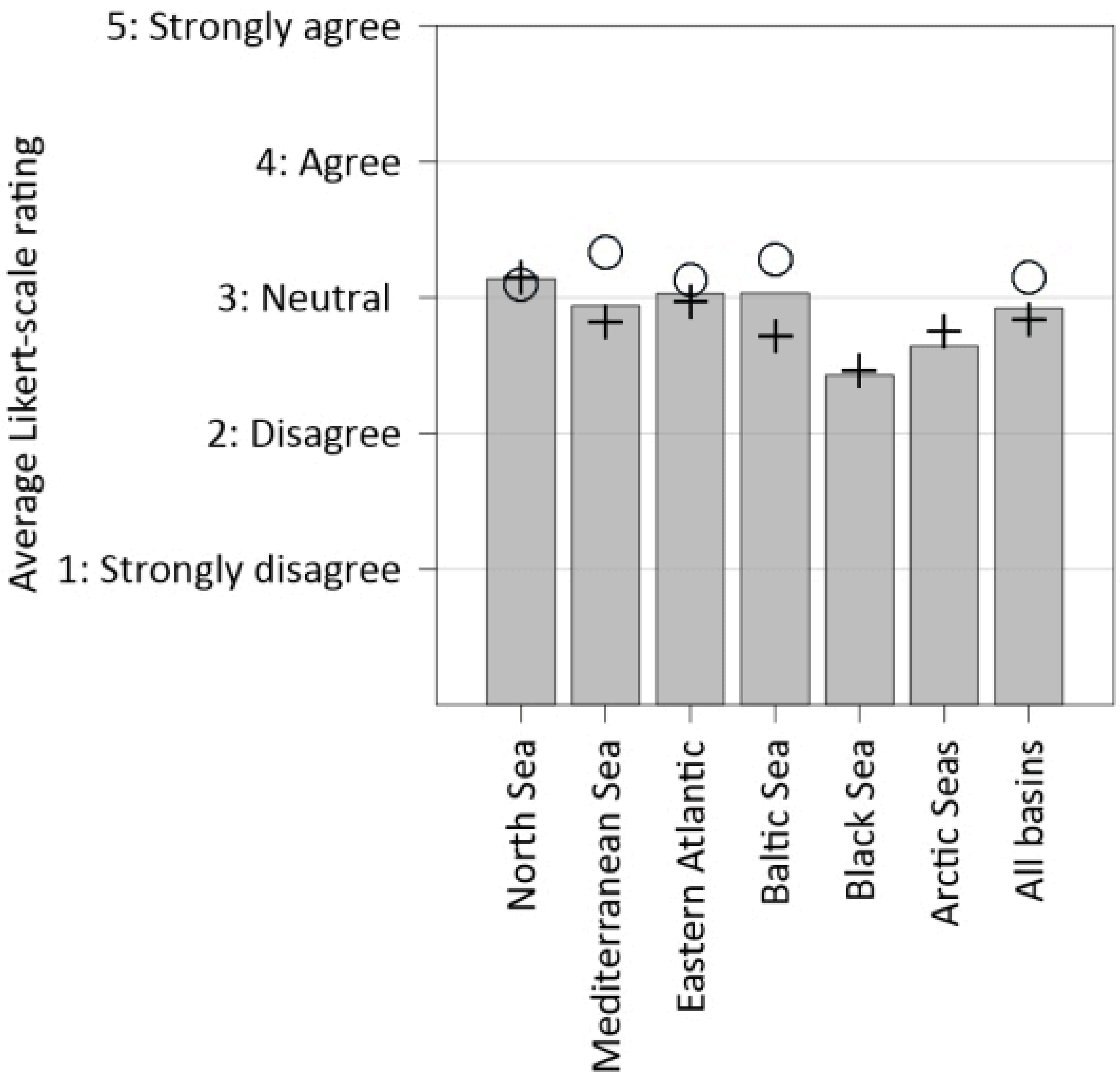
b) SLR Impacts

Shoreline erosion emerged as a dominant concern in all basins except the Arctic, highlighting the critical role of beaches in regional economies.

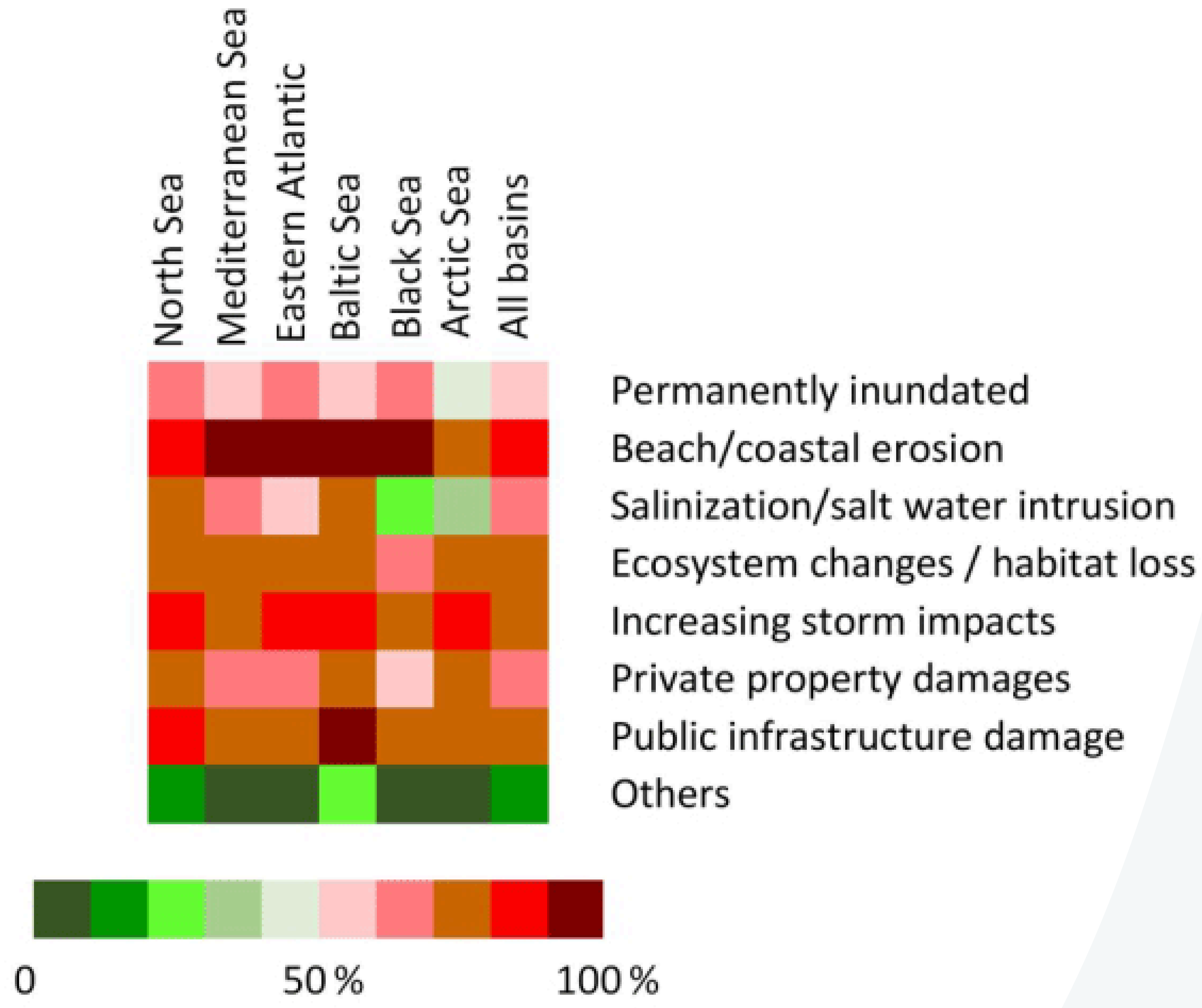
Other significant impacts included flooding, damage to infrastructure, and groundwater salinization, with notable disparities across sea basins.

Challenges persist due to the absence of high-quality impact assessments, particularly in the Black Sea and Arctic basins.

Knowledge gaps: SLR Impacts



Average rating on the Likert-scale to the statement "High-quality and up-to-date assessments of SLR-induced impacts are available for making decisions on planning" (o is for government; + is for scientists; the grey bar shows the total; the values for government representatives from the Black and Arctic seas are excluded due to their low representation with only two respondents each).



Relevance of specific SLR-induced impacts in each sea basin indicated by the percentage of respondents who identified these impacts.

c) Adaptation to SLR

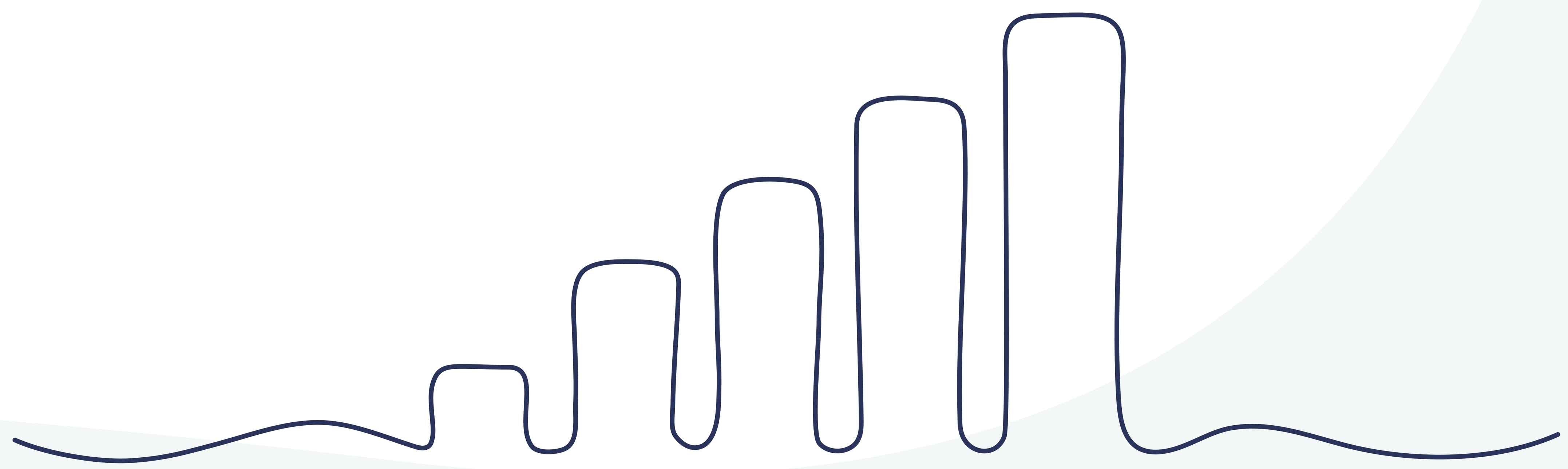
Many stakeholders deem existing adaptation plans to be inadequate, with scientists being more critical than government respondents. Flexibility of existing adaptation strategies in the face of SLR-induced impacts is considered insufficient, highlighting the need for adaptive planning approaches.

Respondents unanimously agree on the usefulness of IPCC reports for informing policy and decision-making.

However, they identified needs for:

- periodic updates to SLR projections,
- comprehensive impact assessments,
- enhanced exploration of adaptation strategies to mitigate SLR impacts on coastal communities and ecosystems,
- allocation of resources for research and data collection to improve evidence-based and adaptive policymaking.

Collaboration among government agencies, research institutions, and stakeholders to develop and implement effective adaptation measures was emphasized. Policy implications include the recognition of the value of incorporating nature-based solutions in coastal adaptation plans, although their implementation requires rigorous evaluation and evidence of long-term sustainability under site-specific circumstances.

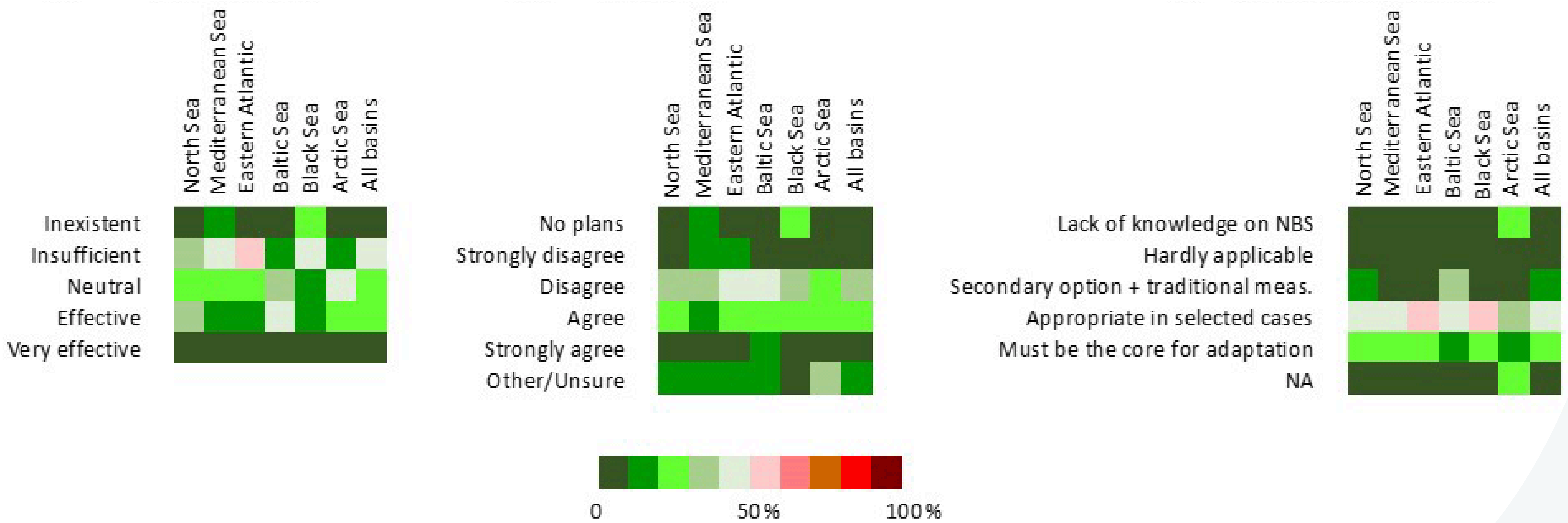


Knowledge gaps: SLR Adaptation

(a) "How effective do you consider the present adaptation strategy to SLR in your country/region?"

(b) "Existing adaptation strategies/plans are flexible enough to adapt to future updates in SLR-induced impacts or to cope with the inherent uncertainty in their assessment"

(c) "Nature-based solutions (NBSs) are appropriate as adaptation measures to SLR in your country/region



Online Workshops

Four online scoping workshops focusing on specific European sea basins gathered insights from stakeholders, policymakers, and experts, furthering the understandings from the survey. The following shows the number of participants for each workshop:

- North Sea and Arctic Ocean - 65
- Eastern Atlantic - 42
- Mediterranean and Black Seas - 70
- Baltic Sea - 70

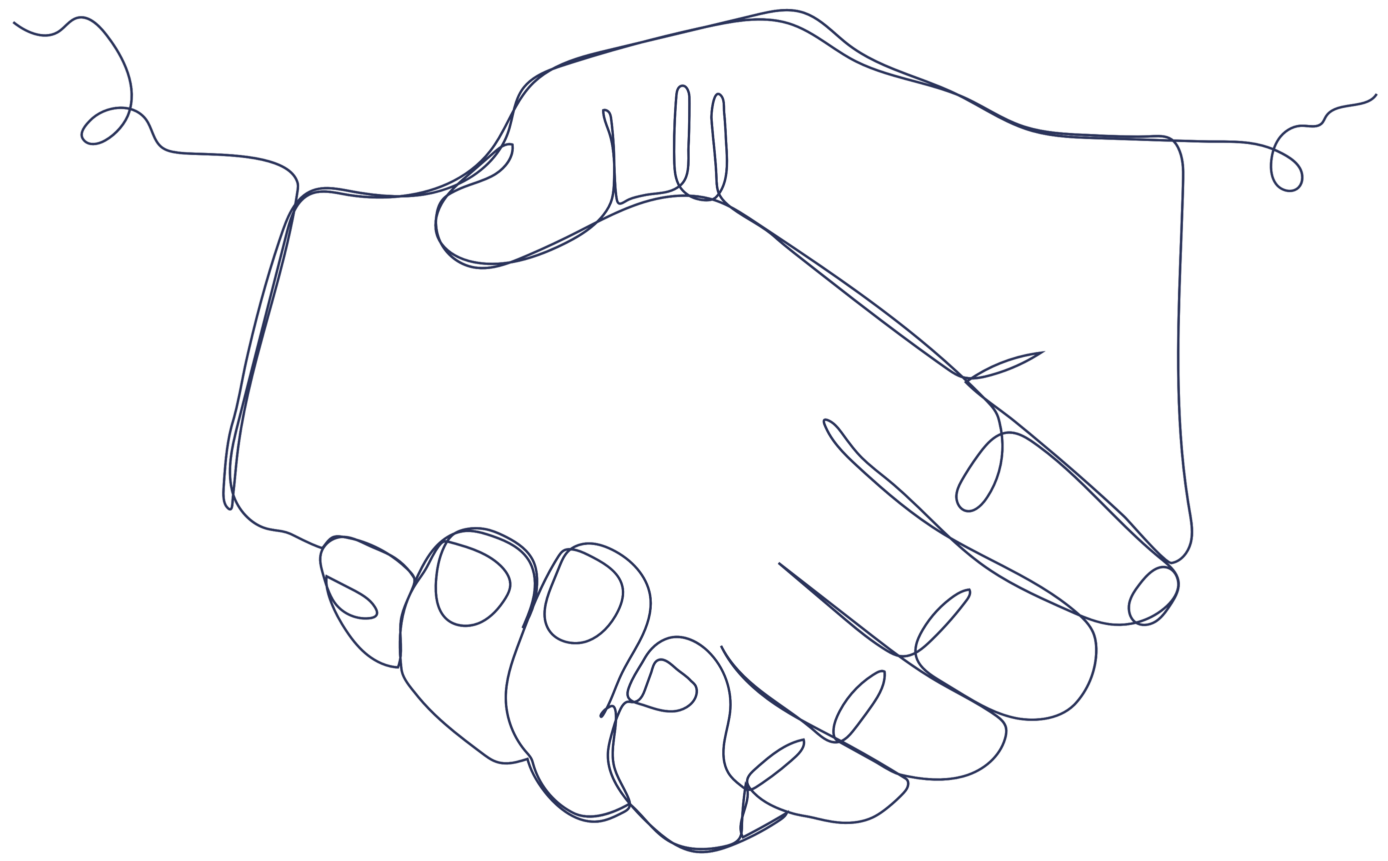
For all European sea basins, the workshops identified data and information gaps, particularly in climate projections that capture local processes and coastline details:

- Data resolution in estuaries is insufficient.
- There is a general lack of data on human activities.
- We need a robust data delivery and quality control system.

The workshops also highlighted the need for a solid methodology to assess the effectiveness of coastal adaptation measures and to develop integrated coastal zone management and/or maritime spatial planning that incorporates sea level rise policies.

Both scientists and policymakers emphasized the importance of community engagement and effective communication strategies.

More details on the specific needs for each European basin are given in Jiménez et al. (2024), in the report.



access the full chapter here

KEY MESSAGE ON OBSERVATIONS AND PROJECTIONS

The mean rate of European sea level rise slightly exceeds the global mean trend and is accelerating. Regional variability is large, with lower (or negative) sea level rise in some Baltic regions due to vertical land movements and effects of loss of land ice masses. Future sea level rise rates are very uncertain and depend greatly on emission scenarios. Higher rates are expected in the southern European areas.

PAST, PRESENT AND FUTURE SEA LEVEL

The Assessment Report delves into observed and projected SLR and extreme sea level in European basins.

Despite some variability in SLR trends between European basins, satellite altimetry shows a consistent upward trend in the basin averaged sea level for the past 30 years, slightly above the global mean SLR.

Relative sea level (which considers human-induced subsidence, and vertical land motion) will rise throughout the 21st century over European seas, except in the northern Baltic Sea and parts of the European Arctic.

Under a very high emission scenario, a 1 m SLR is projected to occur over most European coasts south of 60° N during the first half of the 22nd century.

Because of the large inertia of ice sheets and of the deep ocean, sea level is committed to rise for centuries to millennia in European seas.

A major uncertainty for SLR projections relates to the Greenland and Antarctic ice mass loss and related tipping points.

The frequency at which historical centennial water levels are reached is projected to amplify along most European coasts in the coming decades, especially in southern Europe, implying the need for more adaptation measures.

Higher-resolution sea level projections are needed, along with information on local drivers of extreme sea levels, including tides, waves, and storm surges.

NORTH SEA

Drivers of Past Mean and Extreme Sea Level

The North Sea receives warm, saline water from the North Atlantic, and cooler, fresher water from the Baltic Sea, resulting in complex dynamics. Relative SLR in the North Sea is largely driven by temperature, salinity, and current changes. Spatially varying rates of relative SLR are also influenced by ice mass loss and subsidence. The highest rates of relative SLR are found in the south-eastern North Sea.

Interannual variations in sea level are mostly driven by variability in local winds and surface atmospheric pressure. Sea levels in the North Sea are known to experience large changes over time. Astronomical tides significantly influence water levels, with the largest tidal ranges observed along the UK east coast. Changes in waves, tides, and storm surges have been observed, influenced by historical trends in mean sea level, changes in ocean stratification, and non-linear interactions between water level components.

Projections of Mean and Extreme Sea Level

Relative SLR in the North Sea will vary spatially in the 21st century, with higher rates in the southern parts of the basin and spatial differences influenced by factors like past and present terrestrial ice mass loss. Changes in SLR, due to temperature, salinity, and currents, are projected to be relatively uniform across the North Sea. However, uncertainty stemming from factors like the resolution of global climate models and local dynamics are still large. Extreme sea level events are likely to become more frequent, which will affect coastal communities. The impact of SLR on storm surges, tides, and waves is significant, particularly in shallow areas, necessitating adaptive coastal management strategies (see Sect. 6.2 in Melet et al., 2024, in the report).

EUROPEAN ARCTIC

Drivers of Past Mean and Extreme Sea Level

Vertical land motion is a significant driver of relative sea level change in the European Arctic, bordering Iceland and parts of Norway, attributed to past ice mass loss. Ongoing ice mass loss in Iceland and on Svalbard also contributes to local land uplift. Recent studies highlight widespread vertical land motion in the European Arctic due to ice mass loss from Greenland, and an overall rising trend in sea level. Sea level observations are challenging due to the remote location of the European Arctic, the limited number of tide gauges, and hampered satellite measurements.

Projections of Mean and Extreme Sea Level

Projections suggest that the European Arctic will experience a below-global-average SLR, mainly due to land uplift effects from Arctic glacier and ice sheet melting (see Fig. 11, in Melet et al., 2024, in the report). However, temperature-, salinity-, and current-driven SLR in the Arctic is expected to be larger than the global average, primarily due to ocean freshening. Projections indicate uncertainties regarding changes in storm surges and waves, but future wave climate projections generally indicate a lower mean significant wave height in the north-eastern Atlantic sector. Receding sea ice cover will result in higher waves in the north-western part of the Norwegian and Barents seas (see Sect. 6.3 in Melet et al., 2024, in the report).

MEDITERRANEAN AND BLACK SEA

Drivers of Past Mean and Extreme Sea Level

Sea level changes at basin scale in the Mediterranean Sea, are primarily driven by mass contributions, while temperature and salinity components explain a significant portion of variance at the subbasin scale. Regional deviations result from ocean circulation, heat redistribution, and air–sea momentum fluxes. Storm surges, due to North Atlantic atmospheric cyclones and medicanes, and seiches are especially important for extreme sea level events. Vertical land motion can be locally important.

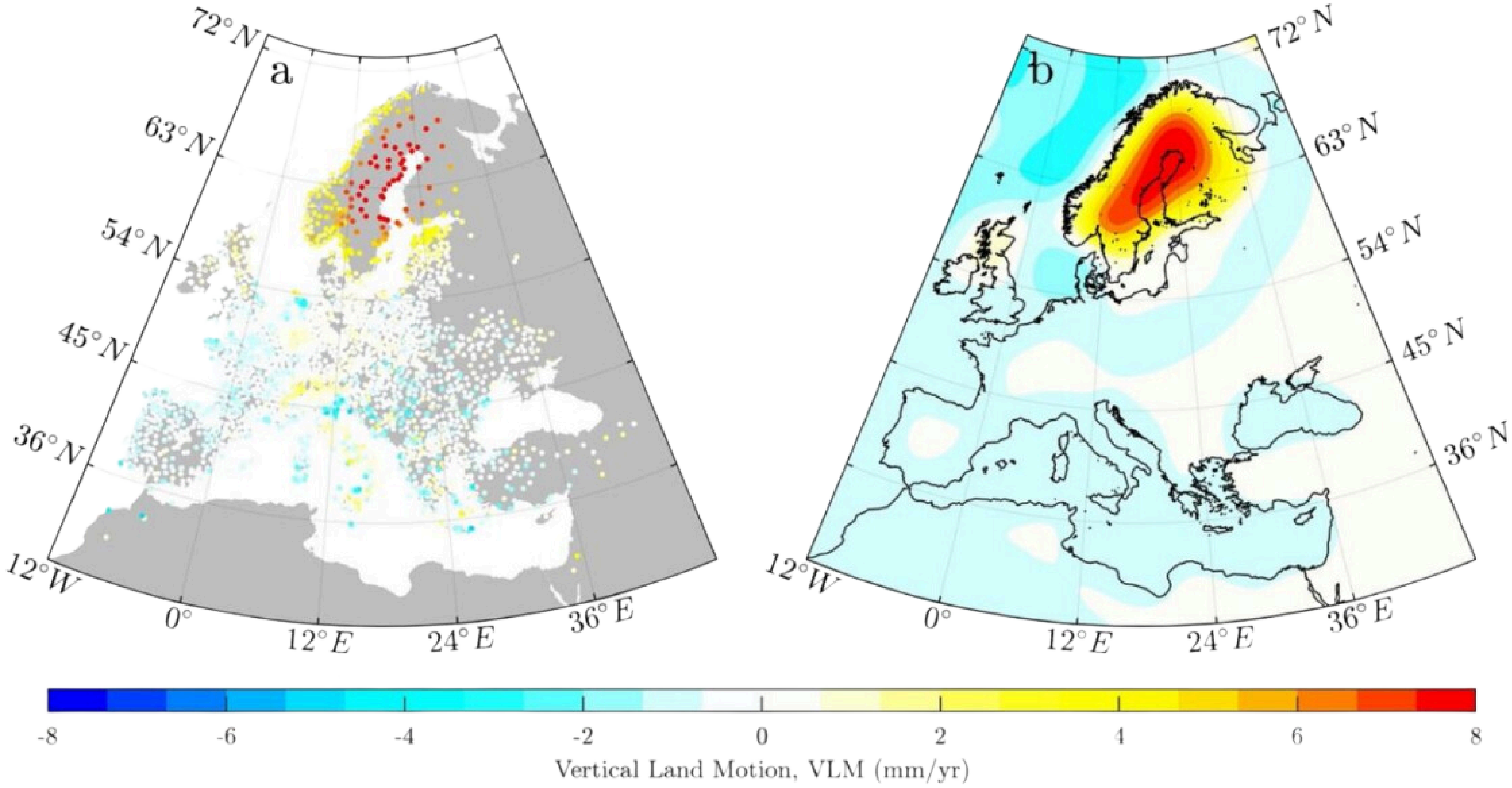
The Black Sea, primarily receiving freshwater from the Danube, Dnieper, and Don basins, presents much lower salinity than the Mediterranean. Most of the SLR in this basin appears to be primarily related to salinity reduction, rather than temperature increases. Coastal vertical land motion is a relatively minor contributor to relative SLR in the Black Sea compared with other basins.

Projections of Mean and Extreme Sea Level

Projections for the Mediterranean Sea suggest average rates of SLR by 2100 that are amongst the highest for European seas (see Table 3, in Melet et al., 2024, in the report). The Black Sea's projected relative SLR has been scarcely assessed, but it is expected to be within a range of ±20 % of global mean SLR. Mean SLR will be the dominant driver of increasing coastal extreme sea levels during the 21st century. Changes in medicanes (extratropical cyclones) and meteotsunamis (high-frequency oceanic waves due to rapid atmospheric-pressure changes) are anticipated due to increased sea surface temperatures and altered atmospheric-circulation patterns, with potential implications for coastal hazards. The projected increase in the frequency and amplitude of extreme sea levels is the largest in the Mediterranean Sea among the European seas (see Fig. 12 and Sect. 6.4 in Melet et al., 2024, in the report).

Observations and Projections

Ongoing ice mass loss on Iceland and Svalbard contributes to local land uplift. Recent studies highlight widespread elastic Vertical Land Motion (VLM) in the European Arctic due to ice mass loss from Greenland.



(a) Preferred filtered and smoothed present day VLM field from Piña-Valdés et al. (2022) and based on data from ~4000 GNSS stations in Europe.

(b) Present day VLM from the Glacial Isostatic Adjustment inversion model from Caron et al. (2018).

EASTERN ATLANTIC

Drivers of Past Mean and Extreme Sea Level

The northeastern Atlantic Ocean, concerning Portugal, Spain, France, the UK, and Ireland, features strong bathymetric gradients, energetic tides, waves, and storm surges, notably due to the North Atlantic mid-latitude storm track. Rates of SLR have accelerated over the past century. Regional patterns of relative SLR are mostly explained by ocean current changes and mass loss from the Greenland ice sheet and mountain glaciers. Climate variability, such as the North Atlantic Oscillation affects storminess and atmospheric-pressure patterns, thereby impacting the frequency and intensity of extreme sea level events. The highest extreme water levels of European seas are reached in the northeastern Atlantic.

Projections of Mean and Extreme Sea Level

In Europe, relative sea level will rise fastest along the coasts of the north-eastern Atlantic (see Table 3 in Melet et al., 2024, in the report). Relative SLR in this region will closely track the global mean. Thermal expansion, salinity, and ocean circulation changes, remains the primary contributors to relative SLR along the European Atlantic coast. Changes in ocean circulation, are projected to influence mean and extreme wave conditions, affecting coastal flooding and erosion. Projections indicate a decrease in wave height and period along European coasts, leading to a reduction in wave set-up and run-up. Non-linear interactions between SLR, tides, and storm surges can be substantial in the northeastern Atlantic and are anticipated to impact coastal water levels, with implications for coastal resilience and adaptation (see Sect. 6.1 in Melet et al., 2024, in the report).

BALTIC SEA

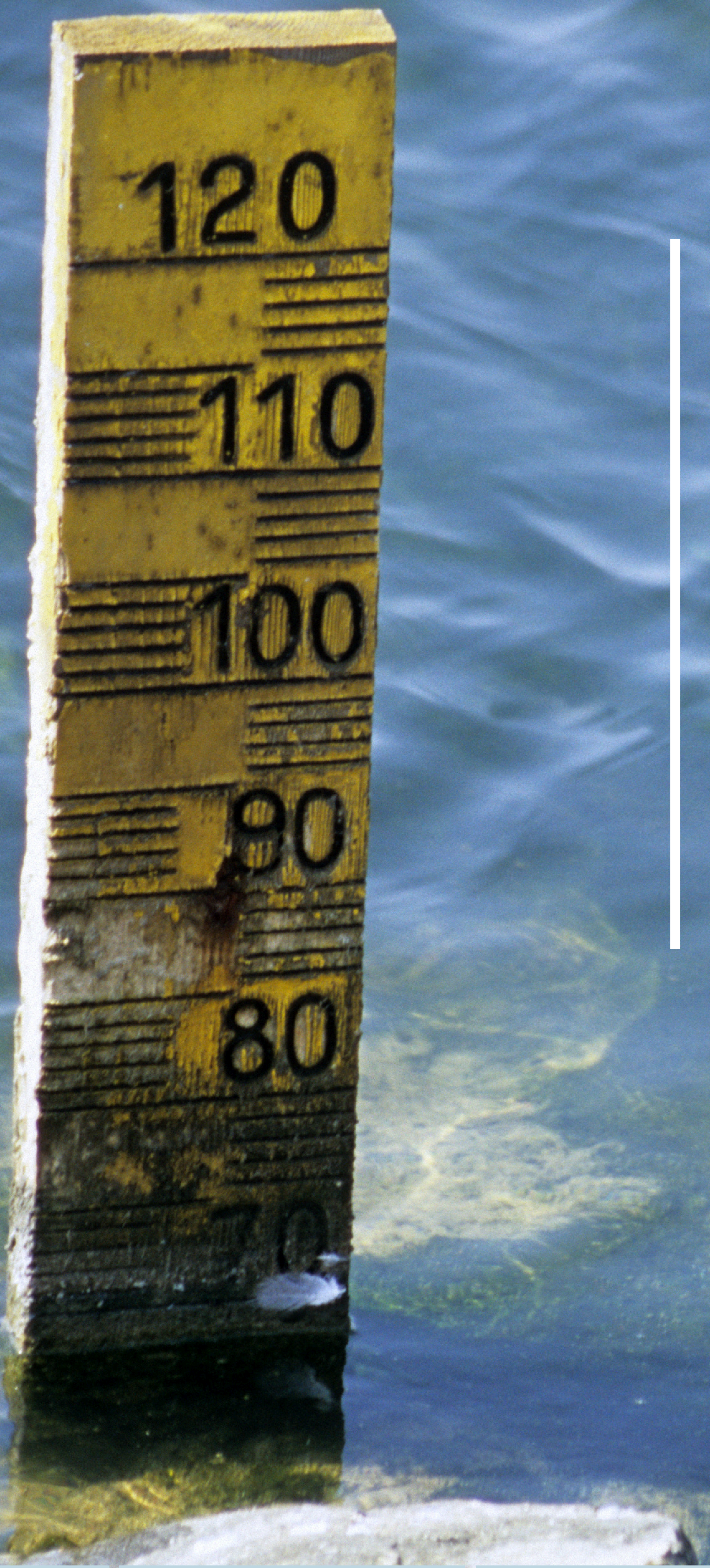
Drivers of Past Mean and Extreme Sea Level

The Baltic Sea is characterized by its semi-enclosed and shallow nature. The North Atlantic Oscillation is impacting wind patterns and sea level fluctuations. The Baltic Sea experiences pronounced seasonal variations in sea level. At timescales longer than a month, the mean sea level in the Baltic Sea approximately follows the sea level in Kattegat, outside the Baltic Sea, but with larger variance at the northernmost and easternmost bays. SLR in the southern Baltic Sea approximately follows the projected global mean SLR, but land uplift due to ice mass loss is particularly significant in northern subbasins, leading to a relative fall of mean sea level there. Storm surges, amplified by westerly winds, pose threats to low-lying coastal areas. Extreme sea levels in the Baltic Sea are caused by pronounced atmospheric cyclones that sometimes interact with seiches on daily timescales and with volume changes on weekly timescales.

access the full chapter here

Projections of Mean and Extreme Sea Level

Projections of 21st-century sea levels in the Baltic Sea require high-resolution regional climate models due to the complex coastline and topography of the basin. Available projections suggest mean SLR in the Baltic Sea under medium- and high-emission scenarios, slightly below the global mean SLR. Relative sea level will continue to exhibit a clear north–south gradient during the 21st century, with a relative sea level fall in the northernmost Baltic Sea due to the effects of ice mass loss (see Fig. 10 in Melet et al., 2024, in the report). Future changes in extreme sea levels will depend on mean SLR, atmospheric circulation patterns, and wind changes. Sea ice loss is expected to increase sea level extremes in previously ice covered regions, leading to higher wave heights, coastal erosion, and sediment resuspension. Confidence in projections for extreme sea levels remains limited due to inconsistencies between global climate model projections. Due to land uplift, the lowest amplification factors of the frequencies of extreme sea levels in Europe are found in the northern Baltic Sea (see Sect. 6.5 in Melet et al., 2024, in the report).



KEY MESSAGE ON IMPACTS

Sea level rise causes several coastal impacts, including increased likelihood of floods, shoreline retreat by coastal erosion, and freshwater shortages by saltwater intrusion. Other human interventions can exacerbate these impacts, such as reduced sediment supplies due to streamflow obstructions, urbanization and habitat loss in exposed coastal areas, lack of sustainable groundwater strategies, or ageing coastal infrastructure.

COASTAL FLOODING, EROSION, AND SALTWATER INTRUSION IN EUROPE

COASTAL FLOODING

Coastal flooding, influenced by rising sea levels and various factors like storms, has social, economic, and environmental consequences. Despite high flood-defence standards, significant populations and assets remain vulnerable, especially on low-lying coastal flood plains. The risks are further escalated by ageing infrastructure, urbanization, and habitat loss. Compound flooding, from combined factors like heavy rainfall, river overflow, and storm surge, exacerbates these challenges.

The interplay of drivers like extreme coastal water levels, tides, storm surges, and waves is receiving increasing attention in the development of early-warning and decision support tools.

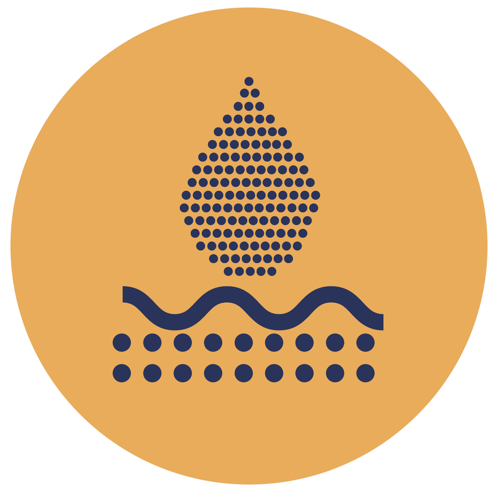
Climate change intensifies coastal flooding, primarily through SLR, altering flood dynamics and increasing the likelihood of compound events. Efforts to address flooding involve a multi-faceted approach, including coastal defences, habitat restoration, and enhanced flood forecasting.

Incorporating SLR risk assessments into policy directives can help to improve flood management strategies. While extensive flood management infrastructure exists, challenges persist, especially with accelerating SLR. Effective adaptation measures and investments in flood resilience are essential to mitigate the growing risks posed by coastal and compound flooding in Europe (see Sect. 4 in van de Wal et al., 2024, in the report).

EROSION

Extreme waves, storm surges, and human activities influence coastal erosion, which governs over 8200 km of European sandy beaches, causing shoreline change. SLR and the reduced river sediment supply due to human developments and dams are main drivers of erosion. While local sediment budgets and climate patterns (winds and atmospheric-pressure changes) determine the specific sign and magnitude of shoreline changes, rising sea levels will negatively impact all coastlines by adding an erosion component to existing trends. Coastal erosion challenges coastal communities, leading to habitat loss, infrastructure damage, and increased flood risk as well as compromising the sustainability of recreational beach use and, thus, impacting the tourism sector.

Europe’s coastline is heavily influenced by human activities and infrastructure. Human development along coastlines exacerbates erosion. Effective coastal management strategies must consider the complex interplay of drivers contributing to erosion and shoreline change (see Sect. 5 in van de Wal et al., 2024, in the report).



SALTWATER INTRUSION

Saltwater intrusion is the encroachment of saltwater into freshwater resources, affecting both surface waters and groundwater. It poses significant challenges to agriculture, freshwater availability, and coastal communities' livelihoods due to salt damage to crops and health risks associated with saline drinking water. Saltwater intrusion reduces freshwater storage and impacts soil fertility, vegetation, freshwater species, and ecosystem services, especially in deltaic regions and estuaries.

Human activities, including reduced river flows and urbanization, exacerbate saltwater intrusion. Climate change intensifies its drivers, including SLR and reduced freshwater supply, affecting hydrogeological interactions between groundwater, surface water, and marine water. Consequences encompass reduced drinking water reserves, agricultural losses, habitat degradation, and land subsidence. Anthropogenic interventions, such as flood barriers and managed aquifer recharge schemes, aim to mitigate the impacts by limiting saltwater intrusion and enhancing freshwater resources. However, challenges persist, including the effectiveness of engineered solutions during extreme events and the need for sustainable groundwater management strategies.

Future projections indicate increasing groundwater salinization and drinking water loss, underscoring the importance of integrated coastal management and adaptation measures to address saltwater intrusion's multifaceted impacts on Europe's coastal regions (see Sect. 6 in van de Wal et al., 2024, in the report).

REGIONAL IMPACTS

Eastern Atlantic

Flooding: The Eastern Atlantic coastline is affected by coastal flooding due to SLR. Flood-defence standards in many European countries along the Eastern Atlantic are among the highest in the world, indicating high importance of protection measures in this region.

Coastal Erosion: Projections under different emission scenarios indicate a shoreline retreat along the Basque coast of 10–66 m by the year 2100.

Saltwater intrusion: Along the Atlantic coasts, various cases of increased saltwater intrusion in the groundwater system have been reported. Specifically, the Minho and Lima estuaries on the northern coast of Portugal have been affected by SLR, leading to a transgression of the saltier front over several kilometres.

North Sea & Arctic

Flooding: The North Sea coastline is significantly affected by coastal flooding due to SLR. Coastal cities, such as Rotterdam, Hamburg, and London, are vulnerable to compound flood events arising from storm surges, waves, river discharge, and heavy precipitation. Port operations may also be negatively affected by SLR.

Saltwater intrusion: Enhanced salinization is projected to be induced by SLR and climate change in several coastal locations in the North Sea. For instance, coastal locations in the Netherlands and Belgium, are facing increased saltwater intrusion due to SLR.

Mediterranean Sea and Black Sea

Flooding: The Mediterranean Sea coastline is highly vulnerable to SLR-induced coastal flooding. Specific locations such as the Gulf of Valencia, north-west Algeria, the Gulf of Lion, and the Adriatic coast of the Balkan Peninsula present an increased flood risk due to compounding features characterizing hydrometeorological hazards and coastlines.

Coastal Erosion: Mediterranean beaches are particularly susceptible to SLR due to their relatively narrow width. Studies project significant erosion of Mediterranean beaches, such as those in the Balearic Islands, with projections of at least 20% of beaches losing more than 50% of their area by the end of the 21st century

Saltwater intrusion: Mediterranean Basins are significantly impacted by saltwater intrusion, including through increased seawater infiltration in coastal aquifers. This has pronounced consequences for agricultural productivity and threatens coastal ecosystems, including the potential loss of subtidal seagrass meadows.

Baltic Sea

Flooding: The vulnerability of coastal subtidal seagrass meadows and intertidal salt marshes to SLR is particularly high in microtidal areas in parts of the Baltic Sea coast.

While not all SLR impacts have been systematically assessed for each basin, an inventory of the main impacts are presented in the report; any impacts not covered for a specific basin are a possible scope for future assessments to fill these gaps.

access the full chapter here

KEY MESSAGE ON ADAPTATION

Selection of options against adverse sea level rise impacts usually has to strike a balance between multiple objectives, available time windows, and long term implications. Uncertainty in future sea level rise and socio-economic developments require long-term flexibility by adopting an iterative decision process and monitoring progress in reaching policy objectives.

Adaptation Measures and Decision-Making Principles

Types of Adaptation Strategies

A wide range of measures and decision-making principles can be applied to adapt to sea level rise and coastal hazards. Interventions and measures are classified into four main adaptation strategies:

Accommodation Measures

'Accommodation' refers to measures that enable coping with the consequences of sea level rise, such as floodproofing buildings and increasing resilience of critical infrastructure, which reduce the vulnerability of coastal communities to SLR impacts.

- Flood-proofing and raising buildings
- Adaptation measures to increase resilience of critical infrastructure
- Adaptation of groundwater management
- Sustainable fisheries and aquaculture management
- Climate risk insurance schemes
- Consideration of climate change in credit risk and project finance assessments
- Integration of climate change adaptation in coastal zone management plans
- Early-warning systems and flood preparedness
- Develop a risk culture within the population

PROTECT MEASURES

'Protect' measures aim to reduce coastal hazards through hard and soft defence mechanisms, as well as the restoration and management of coastal ecosystems. Examples include dams and seawalls, artificial reefs, restoring marshes, and other forms of nature-based solutions.

- Hard defence for coastal management (dams, dikes, levees, etc.)
- Restoration and management of coastal ecosystems
- Beach and shoreface nourishment
- Other soft defence measures for coastal management (reloading littoral strips, cliff reshaping, polymer grids)

ADVANCE MEASURES

'Advance' measures involve creating or advancing new land to address coastal flooding and erosion, often through conservation and restoration efforts.

- Rising and advancing coastal land

RETREAT MEASURES

'Retreat' measures focus on reducing exposure to coastal hazards by relocating human activities, infrastructure, or cities from high-risk to less-exposed areas. Relocation strategies involve complex trade-offs between effective risk reduction and societal and economic costs.

- Planned relocation
- Restricting new developments in flood-prone areas
- Managed realignment

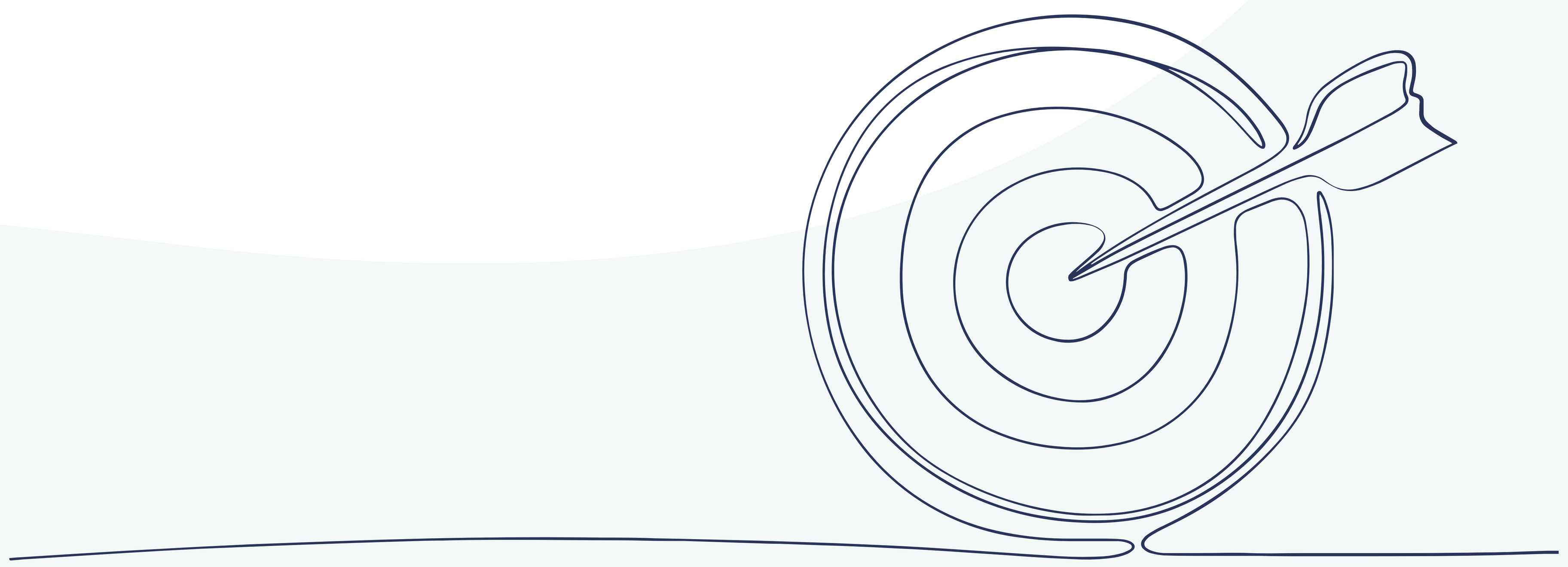
APPROACHES FOR DECISION MAKING

Decision-making about coastal adapation is complex, demanding thoughtful approaches to address uncertainties about climatic and societal developments. It involves the selection of various options planned for implementation at different moments in the future. Policy analysis methods exist that systematically examine the sequential ordering and timing of adaptation decisions in the future, including their potential triggers, alternatives, and long-term implications.

A combination of participatory and analytical methods is crucial in the process of identifying suitable options. Coastal adaptation decisions usually have to strike a balance between multiple objectives, available measures, and uncertainties about future conditions and policy implications. Methods such as multi-criteria decision analysis help manage this complex balance by organizing decisions and highlighting preferences and priorities.

Low-regret measures can offer immediate benefits with minimal costs, including awareness campaigns and preservation of landscapes with high societal support. Inherent SLR uncertainties require the flexibility and adaptability of strategies. Keeping future options strategically open involves postponing long-term decisions where possible and implementing flexible measures that can be adjusted to changing conditions and available information.

SLR affects current decisions with long-term consequences, particularly in the domains of critical infrastructure and urban planning. Iterative revision of decisions and monitoring progress enable timely adjustments as well as the adoption of new policies as needed. Adopting a systematic approach to coastal adaptation decision-making ensures resilient and sustainable outcomes amidst evolving challenges (see Sect. 2.2 in Galluccio et al., 2024, in the report).



ASSESSMENT OF REGIONAL ADAPTATION DEVELOPMENTS

In Europe, adaptation to SLR varies across different sea basins and often includes a combination of strategies of different types.

All basins display examples of the integration of traditional (hard) engineering solutions with ecosystem-based (soft) measures and community involvement in decision-making processes.

Eastern Atlantic

Across the Atlantic Ocean basin, countries are implementing a variety of adaptation measures. Ecosystem-based protection measures, such as cliff strengthening and sand nourishment, are prominent, alongside advanced strategies like the regeneration of beaches and artificial-dune systems.

Retreat measures, including the removal of constructions in flood-critical areas, are also being considered at various locations.

North Sea

At the North Sea, most countries have integrated SLR information into coastal planning, employing a combination of hard and soft protection measures, such as dike upgrades, sand nourishment, and managed retreat.

Comprehensive strategies combine flood protection with the maintenance of a healthy freshwater system, while also enhancing societal and ecological values.

Mediterranean Sea

Mediterranean countries have advanced the mainstreaming of SLR information into national adaptation planning, e.g. in Italy and Spain. Soft protection measures, including sand nourishment, coastal reforestation, and the restoration of dunes and marshes, are emphasized along with large-scale adaptation initiatives in urban areas like Venice and Barcelona.

Insurance is emerging as an accommodation measure to address SLR, e.g. in Spain and France.

Black Sea

Efforts are being directed towards developing monitoring and early-warning systems, alongside upgrading coastal infrastructure to manage SLR and associated flood risks.

Initiatives combining sand nourishment, cliff stabilization, and artificial reef building are being implemented with the aim of reducing erosion risks and enhancing resilience in the tourism sector.

Baltic Sea

Several countires have integrated SLR projections into spatial planning and land use regulations. Protection measures, including upgrading coastal defences and implementing nature-based solutions, are contributing to marine environment conservation and the enhancement of living marine resources.

access the full chapter here

KEY MESSAGE ON GOVERNANCE

Sea level rise is a chronic hazard that is addressed in the governance of environmental and economic development of European coastal regions in all surrounding sea basins.

GOVERNANCE CONTEXT AND CHALLENGES

The governance of coastal adaptation includes institutional organization, stakeholder engagement, and the practice of decision-making. It also includes the management of scientific knowledge, conflicting interests, and the incorporation of a diversity of perspectives.

For this report, Bisaro et al., 2024 reviewed relevant European coastal adaptation policy frameworks in place at regional and national levels.

EASTERN ATLANTIC

The eastern Atlantic region encompasses several vital economic sectors, such as maritime tourism, shipping, renewable energy and green-port infrastructures. However, the basin also faces militarization and competition over natural resources and trade routes.

With the rise in maritime activities, challenges related to sustainable development and resource management emerge.

Policy interventions are necessary to balance economic growth with environmental conservation.

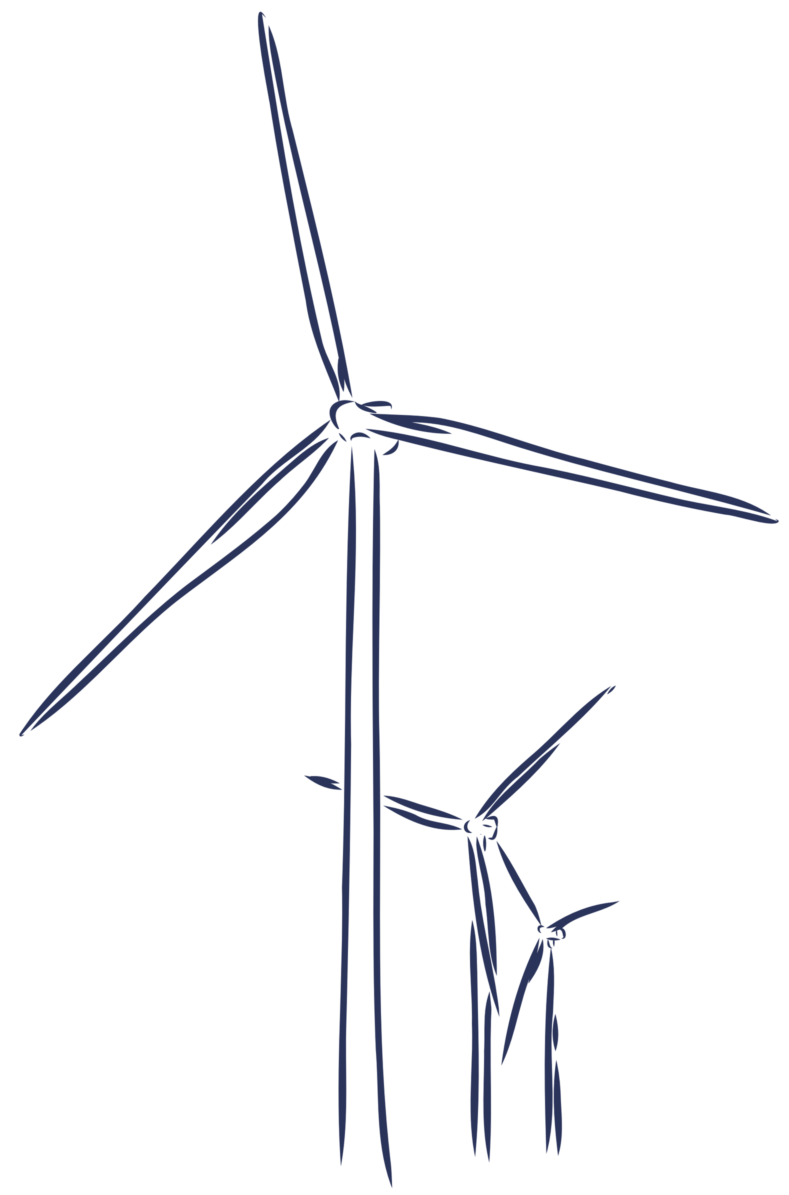
Some countries incorporate SLR into their maritime spatial planning, whereas others lack specific measures.

NORTH SEA

The North Sea basin hosts significant economic sectors like shipping, oil, and gas and is witnessing heightened attention due to its vast energy reserves and potential for renewable energy, notably offshore wind. Europe aims to leverage these resources for its energy transition to enhance economic growth and stability.

Countries in the North Sea basin have reported SLR as a chronic hazard and have adopted adaptation policy strategies. Coastal adaptation measures and funding approaches vary substantially among countries.

Governance challenges include maintaining environmental sustainability amidst economic growth while ensuring safe maritime activities and transitioning towards renewable energy production.



EUROPEAN ARCTIC OCEAN

The Arctic Ocean has become a geopolitical hotspot due to its rich energy resources and strategic geopolitical positioning. The EU and non-EU countries are actively engaged in Arctic policy, focusing on sustainable development, climate resilience, and cooperation with indigenous populations amidst growing global competition.

The European Arctic faces economic opportunities in traditional sectors, like oil, gas and fishing, and in emerging sectors, including data centres and raw-material extraction. Governance challenges include balancing economic development with environmental conservation and addressing demographic shifts and indigenous peoples' rights alongside industrial growth. Norway considers mid-range SLR scenarios in planning approaches, highlighting a proactive stance towards coastal adaptation.

MEDITERRANEAN AND BLACK SEA

The Mediterranean and Black Sea regions host crucial traditional economic sectors, like tourism, fisheries, and mariculture, and emerging sectors, like offshore energy. In addition, complex challenges are present, including migration, territorial disputes, and energy security concerns. In its policies and recommendations, the EU emphasizes partnership and cooperation to address conflicts, promote stability, and mitigate environmental degradation in these seabasins.

Governance challenges include sustainable tourism management, ensuring seafood security, and transitioning towards renewable energy sources to mitigate environmental degradation.

The Mediterranean Basin has regional instruments addressing coastal adaptation, albeit with limited effectiveness due to the absence of specific measures for SLR. In the Black Sea, regional instruments lack provisions for SLR and coastal adaptation.

BALTIC SEA

The Baltic Sea basin features significant traditional sectors, such as shipping and fishing, and emerging sectors, like offshore wind energy. However, the region also faces security challenges exacerbated by Russia's invasion of Ukraine, further aggravated by issues of energy dependence. Efforts focus on diversifying energy sources, enhancing maritime security, and promoting sustainable development through innovation and cooperation.

Other governance challenges involve addressing pollution concerns, sustainable resource management, and promoting green technologies to reduce environmental impact.

Countries in the Baltic Sea basin show varying levels of adoption of adaptation policies and measures addressing SLR. Maritime spatial planning is enforced across the basin, with some countries incorporating SLR into their plans.

access the full chapter here

THE KNOWLEDGE HUB ON SEA LEVEL RISE

The Knowledge Hub on Sea Level Rise *is a joint effort by JPI Climate* & *JPI Oceans*. *It provides* a networking platform promoting the generation, synthesis, exchange and integration of knowledge on local, regional and global, historic and future sea level rise. *Its aims to inform policy making at local, national, and European levels.*

The Knowledge Hub connects research and policy experts from different disciplines, facilitating communication of latest scientific and socio-economic developments, aligned with ongoing policy and public debates.

PARTICIPATING COUNTRIES

The report was made possible through the financial support of Belgium, Ireland, Spain, Germany, and Italy, with additional in-kind contributions from all member countries of the Knowledge Hub on Sea Level Rise.

Sponsoring organisations:

KNOWLEDGE HUB SEA LEVEL RISE

JPI OCEANS

JPI Climate

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

learn more about the Knowledge Hub on Sea Level Rise here