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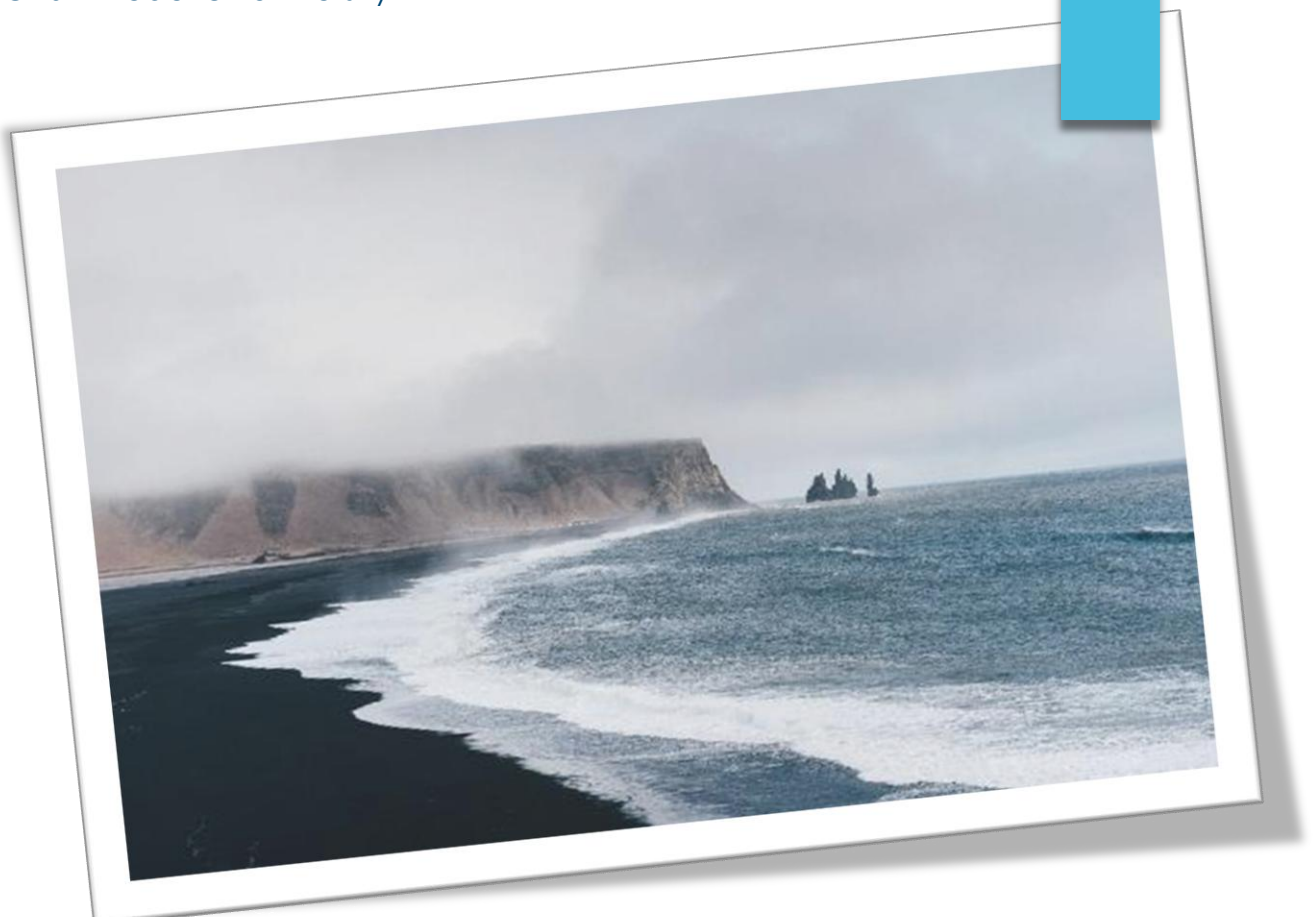
A PROactive approach for COmmunities to enAble Societal Transformation

D3.2 – Coastal ecosystem management data

T3.1 - Review Biodiversity State-of-the-art

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DISCLAIMER

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BACKGROUND: ABOUT THE PRO-COAST PROJECT

The PRO-COAST project tackles the challenge of biodiversity loss in Europe's coastal ecosystems. Coastal and marine ecosystems provide valuable ecosystem services to humans which are now threatened by different pressures, mainly due to climate change, anthropogenic activities, and human-induced pressures like pollution, coastal and dune degradation, and the spread of non-indigenous species. Different socio-economic realities strictly relate to coastal and marine ecosystem services, representing the most vulnerable groups facing degradation and loss of biodiversity, livelihoods, and ecosystem services degradation. The goal of PRO-COAST is to empower local communities to contribute to the restoration and preservation of biodiversity and ecosystem services across Europe, incorporating local knowledge into practical actions and policymaking. The project is now in progress, coordinating the efforts of 20 partners from 14 countries, focused on 9 unique case study areas (10 case studies). These studies explore a range of conservation methods across various coastal ecosystems, testing governance models and social incentives to engage local stakeholders in adopting technologies and practices for biodiversity conservation.

An important element of PRO-COAST is its holistic, interdisciplinary approach, based on a conceptual framework that treats social-ecological systems as interconnected. By mapping relationships between ecosystem components and uncovering feedback dynamics, the project seeks to identify leverage points for transformative change. PRO-COAST promotes integrated bottom-up decision-making, recognizing that environmental issues cannot be separated from social, economic, and political factors. Through extensive citizen engagement, guided by ecological and conservation science, the project aims to enhance community capacity for biodiversity conservation, offering scalable solutions that balance conservation needs with local socio-economic priorities. PRO-COAST aspires to shape adaptive, participatory governance approaches that prevent biodiversity loss and ensure sustainable, equitable access to coastal resources, and coastal and marine ecosystem services.

EXECUTIVE SUMMARY

This report is a key component of the PRO-COAST project, funded by the European Commission, which aims to review and analyse coastal ecosystem management practices across Europe. It provides a comprehensive analysis of the evolution of coastal management policies, highlights the driving factors behind these frameworks, and identifies the key characteristics of both successful and ineffective management practices. The report serves as a foundation for understanding the complexities involved in managing coastal ecosystems and identifying leverage points for transformative change that can address biodiversity loss, while balancing the socio-economic needs of human communities.

The report is structured into two main components.

The first component explores the development of coastal ecosystem management policies within the European Union (EU), tracing their evolution over time and examining how these policies, expressed through legislative frameworks, have influenced coastal management practices at various levels. The key legislative frameworks covered in this analysis include the Integrated Coastal Zone Management (ICZM) Strategy, the Maritime Spatial Planning Directive (MSP), the Water Framework Directive (WFD), and the Marine Strategy Framework Directive (MSFD), among others. This component also reviews the broader policy landscape and how the shift towards ecosystem-based and integrated management approaches is influencing coastal governance. Additionally, key messages from the 2024 IPBES Nexus Assessment and the thematic assessment on biodiversity loss and transformative change are integrated into the report.

These messages highlight the interconnected nature of global challenges - biodiversity loss, water availability, food security, health risks, and climate change - and emphasise the need for holistic and synergistic management approaches. The IPBES assessments identify opportunities for collaboration across sectors and scales to enhance coastal ecosystem resilience and mitigate biodiversity loss.

The second component of the report presents a scoping review of scholarly literature and previous relevant projects, focusing on management practices for coastal ecosystems, habitats and species implemented in Europe. It examines how management systems, consisting of interconnected practices, contribute to overall success or failure in coastal ecosystem management. This review identifies best practices and key challenges associated with current systems and highlights critical areas for improvement, including conservation and restoration efforts, governance structures, stakeholder inclusion, education and public awareness, and innovative technologies. The report underscores the importance of integrated and inclusive governance, which fosters collaboration across sectors and scales and encourages the participation of diverse stakeholders, including Indigenous and local communities. The need to promote the use of innovative technologies and strengthen monitoring systems is also emphasised as key directions for improving the understanding of the complex interlinkages between environmental and socio-economic factors in coastal areas.

Various systemic and deep-rooted challenges still remain that hinder transformative change towards sustainable and equitable futures, including the disconnection from nature and the prioritisation of short-term, material gains over long-term ecological and societal well-being.

However, throughout this multi-level analysis there are key messages and trends that arise again and again at various levels (international, European, national, regional, and local) and that are related to the ability of transformative change to successfully address biodiversity loss. These recurring key directions, messages, and trends highlight the essential elements of effective policies and practices for coastal management systems at various levels, aimed at successfully addressing biodiversity loss. These elements form the foundation for creating adaptive, integrated, inclusive, and informed management strategies that can protect coastal areas and ensure the long-term sustainability of both natural ecosystems and human communities.

LINKS WITH OTHER PROJECT ACTIVITIES

The PRO-COAST Project includes seven Work Packages (WP). Work Package 3 (Biodiversity Management), together with others, provides the main pillars for developing the research tools and methods that will be applied in the ten case studies. Deliverable 3.2 – Coastal ecosystem management data feeds into WP4 (Framework operationalisation), and also sustains WP5 (Case studies) and WP6 (Stakeholder engagement) in acting consistently with the state of the art of biodiversity knowledge at different levels. At the same time, it provides input for the innovative tools developed and disseminated in WP7 (Dissemination and communication).



WP structure

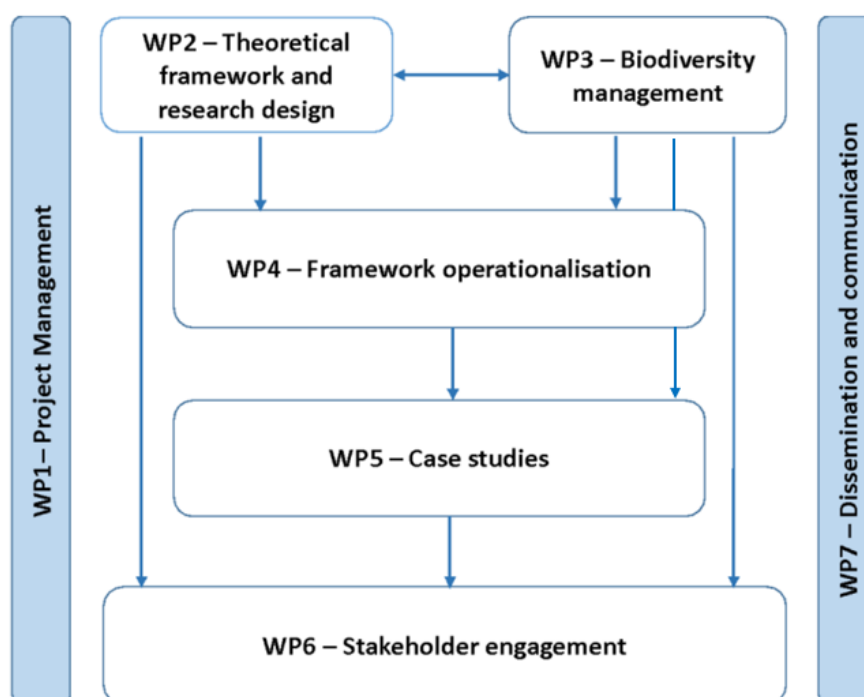


Figure 1: PRO-COAST Work Package structure

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We also acknowledge that in the course of our research and report writing, we employed artificial intelligence tools such as ChatGPT, Google NotebookLM, and Google Translate. These tools were utilised to streamline our internal organization and communication processes, enhance linguistic formal expression and clarity, and to assist in generating summaries of scholarly articles. Our use of these technologies adhered to strict ethical guidelines, ensuring transparency in their application. Additionally, all AI-generated content was thoroughly reviewed and carefully evaluated by our team to ensure the accuracy and reliability of our findings.

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1 INTRODUCTION

1.1 Scope and Structure of the report

This report serves as a key element of the PROactive Approach for Communities to Enable Societal Transformation (PRO-COAST) project, funded by the European Commission. The main scope of this deliverable is to **review current practices implemented across Europe to manage coastal ecosystems**. It aims to provide a comprehensive analysis of the **evolution of coastal management and governance**, the **driving factors that shaped the management framework** and the **key characteristics of successful management practises**, as well as the **common pitfalls of ineffective or failed management systems**. This knowledge is essential in order to identify leverage points for transformative change, with the aim to address conservation needs in balance with the socio-economic needs of human communities.

To achieve this, the report is structured around two main components and corresponding Sections:

a) The first component (Section 2: Key Policies for Coastal Ecosystem Management in EU) presents the development of coastal ecosystem management policies in the EU, tracing their evolution and examining how these are expressed through key legislative frameworks. It also highlights the main directions and thematic areas of these frameworks and explores how these have influenced the management design, implementation, and practices of coastal areas and ecosystems at various levels.

b) The second component (Section 3: Management Practices for Coastal Ecosystem Management in EU) presents a scoping review of the scholarly literature and results of previous relevant projects that implemented management practices for coastal areas, ecosystems, habitats, and species in Europe, providing a comprehensive overview of the complexities involved in effective coastal ecosystem management. It examines the management systems involved, which consisted of various interconnected components or practices, each playing a crucial role in the overall success of management systems and discusses the associated challenges.

Finally, Section 4: Conclusion & Key Messages synthesises the key messages and insights gained from these reviews in order to provide clear directions for sustainable coastal management practices.

An additional and associated outcome of this Deliverable is an open access dataset (an MS Excel table) which includes all the literature (scholar articles and projects) that were reviewed, covering management practices implemented for coastal areas, ecosystems, habitats, and species in Europe with standardised information extracted from each literature source (Annex).

1.2 Synopsis of relevant key messages from previous PRO-COAST Deliverables

Key messages, relevant to this deliverable, that arose from the extensive literature reviews that were analysed and presented in previous PRO-COAST Deliverables (mainly Deliverables 2.1 and 3.1) on the biodiversity value and loss in Europe's coastal ecosystems, the drivers and impacts of coastal biodiversity loss, and the complex governance of coastal ecosystems are summarised below:

1) Importance of coastal ecosystems

Coastal ecosystems are highly productive and diverse ecosystems and are vital for a wide range of goods and services (ecosystem services) essential for human existence, including food (fisheries), raw materials,



and opportunities for recreation and tourism. They also offer critical services such as shoreline protection, carbon sequestration, water purification, and habitats for diverse species, supporting both ecological health and human well-being. These ecosystems have an extremely positive impact on coastal human communities, which represent a very large part of the global human population.

2) Biodiversity loss in coastal ecosystems

In recent decades, human activities have exerted increasing pressures on coastal ecosystems, resulting in habitat degradation, habitat loss, and biodiversity reduction. Coastal biodiversity decline is extensively well documented through numerous scientific studies, environmental assessments, and reports from international organizations.

3) Drivers of biodiversity loss

The main drivers of coastal biodiversity loss include habitat destruction and degradation due to coastal development, land reclamation, tourism pressure and urbanization; pollution from agricultural runoff, industrial waste and untreated sewage, leading to eutrophication and poor water quality; climate change impacts such as rising sea levels, ocean warming and acidification; overfishing and destructive fishing practices that overexploit species and damage habitats; the introduction of invasive species that outcompete or harm native biodiversity; and coastal erosion and sedimentation caused by human activities, which smother habitats and reduce ecosystem health. All these drivers and factors interact and intensify the decline of biodiversity in coastal ecosystems, threatening their ecological balance and the services they provide.

4) Impacts of biodiversity loss on coastal ecosystems and ecosystem services

Biodiversity loss in coastal ecosystems leads to significant disruptions in their structure, function, and resilience, reducing the ability of ecosystems to provide essential services, such as shoreline protection, carbon sequestration, water filtration, and habitat for marine/ coastal species. The decline in species diversity weakens food webs and ecosystem stability, making these environments more vulnerable to environmental changes and disturbances, like storms and sea-level rise. Additionally, the loss of biodiversity undermines fisheries, tourism, and other economic activities that depend on healthy coastal ecosystems, negatively affecting both local communities, and global ecological health.

5) Complex nature of coastal ecosystems governance

The governance of coastal ecosystems is complex and multifaceted, involving the integration of ecological, social, and economic considerations across multiple scales and levels. Effective governance requires balancing the conservation of coastal ecosystems with the needs of local communities, whose livelihoods often depend on these resources. It involves coordinating diverse stakeholders, including government agencies, local communities, industries, and international bodies, to create and implement policies that address habitat protection, sustainable resource use, pollution control, and climate resilience. The challenges are compounded by the interconnected nature of coastal ecosystems, the overlapping jurisdictions, and the need for adaptive management to respond to shifting environmental and socio-economic needs and conditions. Achieving sustainable outcomes requires inclusive, collaborative, and participatory approaches that consider local knowledge, scientific expertise, and long-term socio-economic impacts. Conservation benefits for biodiversity are highest when protection and management efforts also deliver positive social outcomes for people.

6) Coastal Management

Several key policies and international frameworks have been developed and implemented, aiming at protecting coastal and marine ecosystems. Throughout the years, these policies gradually moved towards



a more sector-integrated, social inclusion, and ecosystem-based management approach. However, the complexity of coastal ecosystem governance, combined with the insufficient and/or ineffective enforcement of policies and regulations, as well as the complex interactions between drivers of change and the cumulative impacts of multiple environmental pressures, make the sustainable management of these ecosystems even more challenging.



2 KEY POLICIES FOR COASTAL ECOSYSTEM MANAGEMENT IN EU

2.1 Background and context

Coastal zones represent some of the most scenic, diverse and productive ecological and social systems. These zones are hot spots of biodiversity, rich in natural resources, and hubs of human activity, hosting a substantial portion of the global population (Barragan and Andreis, 2015). According to the United Nations Environment Programme (UNEP), around 37% of the world's population lives within 100 km of the coast; a population density representing twice the global average (UNEP, 2024) and ultra-coastal population (within 10 km of coast) encompasses 14.6% of the global population on 4% of the landmass (Cosby et al., 2024).

On the coast the human population affects the environment through multiple human activities, such as coastal development, tourism, fishing, aqua-culture, oil and gas exploitation, agriculture, and shipping, all of which place considerable pressure on the world's coastal and marine environment (Arefipour et al., 2022; Rangel-Buitrago, 2023). In addition to these pressures, climate change poses additional challenges for most coastal areas. Rising sea levels, extreme weather events, changing ocean currents, and water temperatures are intensifying the vulnerability of these areas. All these are leading to increased habitat and species loss and degradation, coastal erosion and flooding and at the same time undermine the livelihoods of coastal communities (Roffman et al., 2023).

According to UNEP, 34% of the world's coasts are at high risk of degradation from coastal development and another 17% are at medium risk. The most threatened regions are Europe with 86% and Asia with 69% of their coastal ecosystems at risk (UNEP, 2024).

The European Union (EU) has developed a comprehensive framework for coastal ecosystems management, responding gradually to the need for sustainable development, environmental protection, and social inclusion in coastal areas. This framework has been shaped by scientific research, environmental considerations coupled with political, social and financial trends, needs and pressures, over several decades. In this gradual process, the EU has moved towards a more sector-integrated, socially inclusive, and ecosystem-based management approach, aiming to address both the diverse challenges, that coastal ecosystems are facing, such as biodiversity loss, climate change, overexploitation, and habitat degradation, as well as the challenges and risks that coastal communities are facing. The policy landscape is reflected in key legislative documents, which have evolved in scope and ambition, offering concrete guidance and direction for EU Member States in managing their coastal resources. The first major EU policy efforts in this area were not specifically focused on coastal ecosystems, but rather on a broader environmental context, which includes the protection of the marine and coastal environment.

In the sections below, we describe the key legislative and policy frameworks that are directly or indirectly related or focussed on the management and protection of Europe's coastal zones. For each key legislative piece, a standardised brief presentation is included that follows this basic structure: Brief Description, Aim and Objectives, Implementation Road Map, Key changes introduced, and Evaluation of Implementation. Evidence is provided, where possible, to present how each legislation has shaped the management design, implementation, and practices for coastal areas at different levels. This presentation is based on reviewing the specific legislative frameworks, directives and agreements, as well as relevant scholarly literature and related projects. Greater emphasis is placed on the extensive literature evaluating the efforts

made thus far by the EU Member States to implement the European Integrated Coastal Zone Management (ICZM) Strategy, which is a key framework for the management and protection of Europe's coastal zones.

Finally, a separate sub-section (2.3) is dedicated to the 2024 a) Thematic Assessment of the Interlinkages among biodiversity, water, food, and health (Nexus assessment) and b) Thematic assessment of the underlying causes of biodiversity loss and the determinants of transformative change and options for achieving the 2050 Vision for Biodiversity of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Nexus Assessment addresses *“the complex and interconnected character of the crises and challenges of biodiversity loss, water availability, and quality, food insecurity, health risks, and climate change. It does so by providing a critical evaluation of evidence on interlinkages among five nexus elements: biodiversity, water, food, health, and climate change”* (IPBES Nexus Assessment, Summary for policymakers Advance Unedited Version, 2024). The results, main messages, and recommendations of the 2024 IPBES Nexus Assessment as they relate to coastal areas are key in improving the understanding of these interconnections and identifying opportunities for collaboration across sectors and scales, which in turn can contribute to synergistic and holistic management and governance. Additionally, overcoming challenges and barriers to achieve transformative change to address biodiversity loss and the projected collapse of key coastal ecosystem functions is a key objective of PRO-COAST.

2.2 Key Policies & Legal Frameworks

2.2.1 Common Fisheries Policy (CFP)

Brief Description

The Common Fisheries Policy (CFP) is the regulatory framework developed by the European Union (EU) to manage fish stocks and marine resources across EU waters. Its primary goal is to ensure that fishing and aquaculture activities are environmentally sustainable in the long term, are managed in a way consistent with achieving economic, social, and employment benefits, and contribute to the availability of food supplies. The CFP regulates fishing activities through various measures such as setting quotas, regulating fishing fleets, enforcing conservation methods, and ensuring a harmonious EU-wide approach (European Commission, 2024a).

The CFP has come a long way, since it was first formulated in the Treaty of Rome in 1957. Initially linked to the common agricultural policy, it gradually developed a separate identity. The first elements of a distinct fisheries policy were introduced in 1970, with the adoption of legislation that established a common organisation of the market for fishery products and a structural policy for fisheries. The core area of the CFP - conservation and management of fish stocks - was launched in 1983. Over the decades, the CFP has been reformed several times to address evolving challenges, including the depletion of fish stocks and the socio-economic conditions of coastal communities. Since its inception, the CFP has been reformed three times, in 1992, 2002 and 2013 (European Parliament, 2024a).

Aim and Objectives

The aim of the current framework of the CFP is to ensure that the activities of the fishing and aquaculture sectors are environmentally sustainable in the long term and are managed in a way that is consistent with the objectives of achieving economic, social, and employment benefits. The key objectives are (European Commission, 2024a):

- Sustainable Fishing & Aquaculture: Reduce overfishing and rebuild fish stocks to sustainable levels, with a target of achieving the Maximum Sustainable Yield (MSY) for all managed fish stocks and sustainable aquaculture through multiannual national plans.
- Economic Viability: Ensure the long-term economic viability of fisheries by promoting competitiveness and innovation in the sector and introducing marketing standards with respect to labelling, quality, and traceability.
- Environmental Conservation: Protect the marine environment and biodiversity by reducing the environmental impact of fishing practices.
- Fair Resource Allocation: Allocate fishing opportunities fairly among EU countries, considering historical fishing patterns and local needs.
- Data Collection: Improve fisheries data collection to inform scientifically based decisions.
- External Relations: Manage access for non-EU vessels to EU waters and align EU fishing practices with international conservation efforts. The European Commission can negotiate and conclude sustainable fisheries partnership agreements on behalf of the EU with certain non-EU partner countries.

Implementation Road Map

The CFP is implemented through a series of mechanisms and measures that focus on conservation, market organization, structural support, and external relations (European Parliament, 2024a):

- Conservation Measures: These include Total Allowable Catches (TACs) and quotas for fish stocks based on scientific advice to avoid overfishing, the landing obligation to eliminate discarding and waste, long-term management plans for fish stocks, technical measures, such as gear restrictions, areas closures, etc.
- Market Organization: The CFP supports a common market for fishery products, ensuring transparency, stable prices, and quality standards for consumers.
- Structural Support: Through the European Maritime and Fisheries Fund (EMFF), the CFP provides financial support to modernize the fishing industry and to help fishers adapt to sustainability requirements.
- External Relations: The CFP extends to agreements with non-EU countries and participation in international fisheries organizations to ensure sustainable global fishing practices.

Key changes introduced

The CFP introduced several significant changes, particularly within the 2013 reform, aiming to balance environmental conservation, sustainable fisheries, and economic benefits for coastal communities. One important change is the shift towards sustainable fishing practices through the adoption of the MSY principle, that aims to maintain fish stocks at levels that allow for the highest long-term yield, preventing overfishing, and helping to restore depleted fish populations. In addition, the CFP has introduced ecosystem-based management (EBM), which considers the broader marine environment, rather than focusing solely on fish stocks. By recognizing the interconnectedness of marine species and habitats, this approach promotes the protection of sensitive areas, such as spawning grounds and nursery habitats (e.g., seagrass beds and reefs), within marine protected areas (MPAs), including those under Natura 2000 (European Commission, 2019). Socially, the CFP has introduced more inclusive governance structures by increasing the participation of stakeholders, including fishers, coastal communities, and environmental organizations in the decision-making processes. Examples are the Regional Advisory Councils (RACs) and Advisory Councils (ACs) that have been established to involve stakeholders in policy discussions and management plans, promoting transparency, and creating local ownership of conservation efforts (Phillipson & Symes, 2013). Moreover, the CFP aimed to address the socio-economic sustainability of



coastal communities that rely on fishing. Through its EMFF, the CFP financially supports coastal communities in diversifying their economies by promoting sustainable aquaculture, eco-tourism, and other fisheries-related activities that reduce environmental impact and at the same time helps coastal communities to adapt to new environmental regulations while maintaining livelihoods (Symes & Phillipson, 2009). Overall, the CFP has influenced coastal and marine management design, implementation, and practices at various ecological levels (e.g., species, habitats, ecosystems, MPA), as well as social levels (e.g., local communities, fishers, and other targeted stakeholders, inter-governmental cooperation).

Evaluation of Implementation

The implementation of the CFP has brought many positive changes in the sustainable practice of fisheries, but still faces various challenges, as it strives to balance environmental sustainability with the economic interests of the fishing industry and coastal communities.

One of the major successes of the CFP is its role in the recovery of certain fish stocks in EU waters, particularly in the North-East Atlantic, where fishing at MSY levels has led to more sustainable fish populations (Cardinale & Scarcella, 2017). Additionally, stricter conservation measures, such as the landing obligation (discard ban) contributes to the reduction of waste and bycatch, improving the ecological impact of fisheries (Villasante et al., 2016). Furthermore, the regionalisation and its flexibility aim to ensure that both local needs and ecological characteristics are considered in decision-making (Carpenter and Kleinjans, 2017).

A significant advantage of the CPT is also the financial support for coastal communities through the EMFF. This contributes to the modernization of the fishing fleet and adaptation to the sustainability requirements of the CFP, leading in turn to improvement in the socio-economic resilience of these communities (European Commission, 2020). Finally, the CFP has improved the collection of fisheries data, which is vital for making evidence-based decisions on quota setting and stock management. In turn, better scientific advice has led to more sustainable practices and has reduced the overfishing problem (Marchal, 2016).

While the CFP has achieved notable successes, particularly in fish stock recovery, environmental conservation, and regionalized management, several challenges persist. Fishing enterprises accuse the landing obligation of increasing operational costs and it has been difficult to enforce due to gaps in monitoring (Condie et al., 2014). In addition, despite notable successes in overfishing, this remains an issue in certain regions, particularly in the Mediterranean, where the MSY target has not been achieved for many fish stocks. This is due to complex multispecies fisheries and weak enforcement in some areas (Froese and Proelss, 2013). Moreover, it has been argued that, although the CFP aims to support the economic viability of coastal communities, there are still some socio-economic disparities. Some small-scale fishers argue that the policy disproportionately benefits large fishing companies, leaving smaller operations struggling to meet CFP requirements (Phillipson and Symes, 2015). Regionalisation, even though it provides flexibility, has also led to inconsistencies in the implementation of fisheries management across EU Member States, which can undermine the broader sustainability goals of the CFP (Raakjær et al, 2014). Finally, another challenge is the existence of illegal, unreported, and unregulated (IUU) fishing, due to weak enforcement in some Member States and insufficient monitoring tools (Khalilian et al., 2010).

The CFP is an evolving framework that adopts the EU's ongoing commitment to the sustainable management of fisheries resources and the protection of marine ecosystems. Moving forward, the EU will need to continue refining the CFP to address existing challenges, include adapting policies to climate change, further integrating the ecosystem approach, and strengthening its governance to ensure the long-term sustainability of the European fisheries sector (Blanco et al., 2022; Frost & Andersen, 2006).



2.2.2 Natura 2000 Framework (Birds Directive & Habitats Directive)

Brief Description

The Natura 2000 framework is a keystone of the EU's nature conservation policy. The foundation of Natura 2000 dates to the EU's Birds Directive in 1979 (79/409/EEC, replaced by 2009/147/EC), the first EU law to focus specifically on the protection of wild birds and their habitats. This was followed by the Habitats Directive (92/43/EEC) in 1992, which broadened the scope to include a wide range of wildlife species and habitat types across Europe.

Together, these two directives form the legal backbone of the Natura 2000 network, identifying key areas for protection and setting conservation targets towards the protection of the most valuable and threatened biodiversity, by creating a network of Protected Areas (Special Areas of Conservation, SACs and Special Protection Areas, SPAs). These sites, while primarily focused on environmental protection, also allow sustainable development, through economic activities that are compatible with conservation objectives (European Commission, 2020).

The framework aims for a balance between the conservation and the social and economic needs of local communities. Reflecting this, the Natura 2000 network is not designed as a system of strict nature reserves, but as a system of areas where human activities, such as fishing, tourism, and agriculture, are managed sustainably to ensure that they do not harm biodiversity.

In the early years of the Natura 2000 network, there were challenges related to delays in designating sites as well as resistance from some sectors of the economy that feared restrictions on land use. Over time, however, the network expanded significantly. In 2022, there were 27,193 Natura 2000 sites, covering 18.6% of the European Union land area and 9% of its marine territory. The effective management of these sites remains the key to achieving the Natura 2000 network's conservation aims (European Environmental Agency, 2024).

Aim and Objectives

The main aim of the Natura 2000 framework is to ensure the long-term survival of Europe's most threatened species and habitats, which are listed in the Birds and Habitats Directives. These include species (and habitats) that are rare, endangered, vulnerable, or endemic to specific ecosystems. The Natura 2000 network is not focused solely on protecting isolated areas, but aims to maintain ecological connectivity across the landscape, ensuring that species can also flourish outside designated sites.

The key objectives of the Natura 2000 framework include (European Commission, 2016, European Commission, 2024b, Kettunen et al., 2014):

- Conservation of Biodiversity: Ensure the protection of habitats and species of European importance, promoting the restoration of degraded ecosystems.
- Sustainable Management: Promote sustainable economic activities, particularly in coastal and rural areas, ensuring that these activities are compatible with biodiversity conservation goals.
- Ecological Connectivity: Maintain a coherent network of protected areas that support ecological processes and species movement across the EU.

Implementation Road Map

The basis of the Natura 2000 network is its implementation through a site selection process that identifies protected areas, based on scientific criteria under the Birds and Habitats Directives. Once sites are designated, management plans are developed, which are tailored to the specific needs of each individual area. Key steps in the implementation of Natura 2000 framework include:

- **Site Designation:** Member States identify potential SACs and SPAs, based on ecological criteria. These sites are then evaluated at the EU level to ensure they meet the requirements of the Directives (McKenna et al., 2011).
- **Management Planning:** Each Natura 2000 site requires a specific management plan, often developed in collaboration with stakeholders such as local authorities, landowners, and environmental NGOs to ensure that conservation actions are integrated with socio-economic activities. These plans outline conservation objectives, management measures, and monitoring systems.
- **Monitoring and Enforcement:** The European Commission monitors the implementation of the Natura 2000 network through regular reporting by the Member States. Enforcement mechanisms exist to ensure compliance with the Directives.
- **Funding:** Financial support for the Natura 2000 network implementation is provided mainly through the EU's LIFE program, along with the European Regional Development Fund (ERDF) and the European Agricultural Fund for Rural Development (EAFRD).

Key changes introduced

The Natura 2000 framework has introduced several significant changes in the management of protected areas, concerning social and environmental parameters. These changes reflect a shift towards a more inclusive and sustainable management approach to biodiversity conservation.

One key change is the inclusion of stakeholders and a shift towards participatory governance in the decision-making processes for managing Natura 2000 sites. The framework emphasizes collaborative governance, engaging local communities, landowners, non-governmental organizations (NGOs), and economic sectors like agriculture, forestry, and fisheries. This approach aims to ensure that conservation considers local needs, cultural values, and socioeconomic needs, reducing conflicts and promoting sustainable development (Beunen & de Vries, 2011). In coastal and marine Natura 2000 sites, stakeholder involvement (fishers, local communities, business operators, etc) in the development and implementation of management plans, is essential in the management of these sites, balancing conservation goals with the livelihoods of coastal communities, which is key for long-term sustainability (Phillipson & Symes, 2013).

Moreover, the Natura 2000 framework promotes a more holistic approach to environmental protection, focusing on the protection of ecosystems and habitats alongside species conservation. This differs from earlier models that focused primarily on species. This is expressed in the emphasis on the connectivity between habitats, ensuring that species can migrate and adapt, especially in the face of climate change. In marine areas, for instance, the protection of critical habitats such as reefs and seagrass meadows can support broader ecosystem services that benefit both biodiversity and coastal communities (McKenna et al., 2011). Therefore, conservation and management of biodiversity are addressed through multiple ecological levels (species and habitats of European importance, network of protected areas).

Another key change is the emphasis on adaptive management, allowing adjustments based on ecological monitoring and stakeholder feedback. The Natura 2000 framework requires the development of site-specific management plans for protected areas, which include conservation objectives, activities and monitoring programs for species and habitats. Unlike previous top-down approaches, it emphasizes adaptive management, allowing adjustments based on ecological monitoring and stakeholder feedback. In coastal regions, for example, the management plans often incorporate sustainable tourism initiatives that support both environmental conservation and local economies (Kettunen et al., 2014).

Additionally, the Natura 2000 framework promotes a model where conservation is not seen as opposite to development, but as part of a sustainable socio-economic strategy. Rather than excluding all human activities, it integrates them in a way that can maintain the ecological integrity of protected areas. For

instance, agri-environmental schemes under the Common Agricultural Policy (CAP) encourage farmers to adopt biodiversity-friendly practices, providing financial incentives that align agriculture with conservation goals (European Commission, 2014). In the promotion of adaptive management and inclusion of human activities, Natura 2000 (and the equivalent Bern Convention Emerald Network outside the EU) strongly adopts the recommendations of CBD's Ecosystem Approach (1998) and Addis Ababa Principles and Guidelines for Sustainable Use (2004).

Finally, through financial instruments such as the LIFE program, the Natura 2000 promotes habitat restoration, such as at degraded coastal and wetland areas, which are critical for biodiversity (Kettunen et al., 2014).

Evaluation of Implementation

The Natura 2000 has played a significant role in protecting Europe's most vulnerable species and habitats, contributing to the stabilization or recovery of several endangered species and the restoration of vital ecosystems. Coastal wetlands, for example, have benefited from targeted conservation efforts (Cardoso et al., 2011). The expansion of the network to include marine areas has been a significant achievement towards the protection of ecologically important marine habitats and species (Rodríguez-Rodríguez et al., 2016). The Natura 2000 network, in many cases, has successfully integrated conservation with local socio-economic activities, allowing for sustainable development practices. This has helped reduce conflicts between conservation and local communities, ensuring smoother implementation (Beunen & de Vries, 2011). Another positive outcome is the integration of the Natura 2000 legislation into other EU sectoral policies, facilitating the creation of synergies. For instance, the Marine Strategy Framework Directive (2008), also supports the designation and management of MPAs within the Natura 2000 network, contributing to the EU's broader marine conservation efforts. This Directive sets goals for achieving good environmental status of EU marine waters, which complements the Natura 2000 network's objectives. Additionally, the Natura 2000 framework is aligned with the objectives of the Water Framework Directive (WFD, 2004), which aims to achieve good ecological status for all water bodies in the EU by addressing pollution, water usage, and ecosystem degradation. Since many Natura 2000 sites include wetlands, rivers, and coastal habitats, the WFD's goals complement those of the Natura 2000 framework by promoting the conservation of aquatic habitats. An example of this integration is in wetland restoration projects, where both the WFD and the Natura 2000 goals are aligned to improve water quality and restore habitats for endangered species.

Although the implementation of the Natura 2000 framework has contributed significantly to conservation efforts and to bridging the gap between biodiversity protection and socioeconomic interests, there are still various challenges in ensuring the effective protection of species and habitats. The Natura 2000 framework has faced criticism for being what some refer to as "paper parks", i.e., protected areas that exist on paper, but lack effective management, enforcement, or adequate resources for implementation. The enforcement of site protection measures remains inconsistent across the EU (McKenna et al., 2011). Many Natura 2000 sites are not efficiently monitored or managed, leading to limited on-the-ground impact for biodiversity conservation. Issues such as insufficient funding, weak stakeholder engagement, and lack of political remain significant challenges, particularly in the face of increasing anthropogenic pressures like agriculture, tourism, and urbanization (Sperandii et al., 2020, Kettunen et al., 2014). Also, without clear management plans or active restoration efforts, these sites often fail to deliver the expected conservation outcomes, particularly in areas under intensive human use, such as coastal zones. MacKinnon (2016) and Kati et al. (2015) also highlight that despite the formal establishment of these areas, the lack of adequate resources and governance structures has limited the ability of Natura 2000 to effectively mitigate biodiversity loss. The European Court of Auditors (2017) also criticized the EU's approach, noting that

progress in biodiversity conservation through the Natura 2000 has been slower than anticipated, emphasizing the need for better integration of conservation objectives with local development activities.

Finally, while the Natura 2000 aims for socio-economic integration, there are still tensions and conflicting interests and needs between conservation objectives and sectors like agriculture, fisheries, and tourism, particularly in coastal areas. Achieving a balance between economic development and environmental protection remains a challenge (Beunen et al., 2013)

2.2.3 Water Framework Directive (WFD)

Brief Description

The Water Framework Directive (WFD), adopted in 2000 (Directive 2000/60/EC), is a comprehensive EU legislation, aiming to achieve protection and sustainable management of all water resources across Europe. Its core aim is to achieve “good water status” for all of Europe’s inland, transitional, coastal, and ground waters by 2027. This includes improving water quality and quantity, preventing pollution, enhancing biodiversity, and promoting sustainable water use. The WFD adopts an integrated and holistic, river basin management approach, considering all water bodies in a connected, ecosystem-based manner, focusing on both ecological health and water quantity (European Commission, 2000).

Before the adoption of the WFD, water policy in the EU was fragmented, with multiple directives addressing specific aspects of water pollution, such as the Urban Wastewater Treatment Directive (1991) and the Nitrates Directive (1991). However, these were inadequate to fully address broader environmental concerns.

The WFD introduced an integrated approach that considers all water bodies, including rivers, lakes, coastal waters and groundwater. This holistic perspective includes aspects of cross-border cooperation, data sharing and comprehensive management (Kallis & Butler, 2001).

Aim and Objectives

WFD's primary aim is to protect and enhance the quality and quantity of Europe’s water resources, ensuring their sustainable use. Key objectives include:

- Achieving good ecological and chemical status for all surface waters and good quantitative and chemical status for groundwaters, by 2027.
- Reducing water pollution, particularly from agriculture, industry, and municipalities.
- Encouraging sustainable water use and minimizing water scarcity.
- Promoting public participation in water management decisions.
- Implementing standardised monitoring programs and methodologies, gathering data which feeds to the decision making.
- Implementing integrated river basin management, ensuring coordinated efforts for water quality management across political boundaries.

Implementation Road Map

WFD implementation follows a structured, step-by-step approach across six-year planning cycles:

- Initial Characterization (2004-2009): Member States required to characterise water bodies, assess their ecological and chemical status, identify pressures, and delineate river basin districts.
- River Basin Management Plans (RBMPs) (2009, 2015, 2021): These plans set out the measures for achieving WFD goals, including monitoring programs, pollution reduction, and other pressures

mitigation strategies and restoration projects.

- Programmes of Measures (PoMs): Specific actions and investments required to achieve good status, which are included in the RBMPs.
- Public Consultation: RBMP undergo public consultation, a basic requirement of the WFD, ensuring that stakeholders and the public have a role in planning and decision-making.
- Cross-Border Cooperation: Acknowledging that many water bodies cross national boundaries, the WFD asks for joint management efforts among countries sharing river basins.

Each Member State reviews and updates its RBMPs every 6 years based on new data and evolving challenges. The WFD requires reporting to the European Commission to assess progress and challenges (European Commission, 2000).

Key changes introduced

One of the most significant changes introduced by the WFD is the requirement for Member States to prepare RBMPs, which are reviewed and updated in 6-year cycles, to integrate water quality and quantity objectives with broader environmental goals, and to undergo public consultation. WFD sets its management structure both at a broader level, i.e., River Basin, but also at a smaller scale level, i.e., Water Bodies, each of which must reach its own targets (i.e., good ecological or chemical status for surface water bodies and good qualitative and quantitative status for groundwater). The WFD also requires the implementation of comprehensive and inter-calibrated monitoring systems. Member States are required to assess the status of water bodies regularly, employing a range of biological, chemical, and hydrological indicators. An innovative aspect of the WFD is biological monitoring (e.g., including invertebrates, diatoms, macrophytes) to evaluate water quality, which was first introduced at such a large scale by WFD (Borja et al., 2010). These monitoring programs provide critical data for adaptive management and are enabling real-time decision-making.

The participatory component of the WFD ensures that water management decisions reflect local and regional realities (European Commission, 2015). In coastal areas, stakeholders such as fisheries, tourism operators, and local governments can play a significant role in balancing the pressures of water use with the needs of aquatic ecosystems (Sperandii et al., 2020).

The WFD is closely linked to other EU legislation, such as the Natura 2000 and the Marine Strategy Framework Directive (MSFD) and incorporates in its requirements other relevant legislation pieces, such as the Bathing Water Directive (2006/7/EC), the Nitrates Directive (91/676/EEC), the Urban Waste Water Treatment Directive (91/271/EEC), the Directive on Priority Substances (2008/105/EC), the Floods Directive (2007/60/EC) and the Drinking Water Directive (98/83/EC). The WFD and the MSFD are working complementarily to enhance the quality and connectivity of coastal ecosystems, particularly in areas affected by overfishing, pollution, and habitat destruction (Sperandii et al., 2020). This collaborative approach will ensure synergy and enable the coherent management of water bodies across the EU.

Finally, the WFD's holistic approach has promoted the sustainable management of water, addressing the recurring need to balance people and ecosystems. In coastal areas, for example, this means adopting practices for wetland restoration and river rewilding to protect against flooding, enhance water quality, and support biodiversity. It also promotes resource efficiency, encouraging water reuse, and reducing the environmental footprint of water extraction processes (European Commission, 2015).

Evaluation of Implementation

The WFD represents a significant and comprehensive effort by the EU to protect water resources and promote sustainability. Its integrated approach has promoted cooperation across sectors, institutions, and



political borders, improving the management of water resources on a large scale. In many regions, water quality has significantly improved, particularly in reducing point-source pollution from industry and urban wastewater (Borja et al., 2010). At the same time, public involvement has increased the transparency of water management decisions and improved community support. Although it has achieved notable successes in improving water quality and creating integrated management approaches, further efforts are needed to overcome implementation challenges and achieve its aim. Several countries continue to struggle with full implementation, particularly in addressing diffuse pollution from agriculture and water scarcity issues in arid regions (Kallis & Butler, 2001). At the same time, enforcement remains a challenge in certain regions, particularly in less developed areas where governance capacity is weaker. Despite improvements in water quality, significant gaps remain in achieving biodiversity targets, particularly in heavily impacted water basins (Sperandii et al., 2020).

2.2.4 Integrated Coastal Zone Management (ICZM)

Brief Description

Promoting the sustainable use and preservation of coastal zones is the goal of the dynamic, iterative process known as Integrated Coastal Zone Management (ICZM). The ICZM method encourages adaptive management frameworks and acknowledges the interdependence of nature and human systems (Ducrotoy and Pullen, 1999; Jiang et al., 2023). With notable turning points such as the EU ICZM Demonstration Programme in 1999 and the subsequent releases of the European Commission's Strategy for Europe and Recommendation concerning the implementation of Integrated Coastal Zone Management, the idea gained considerable traction in Europe at the end of the 20th century (Ducrotoy and Pullen, 1999; Shipman and Stojanovic, 2007; Ballinger et al., 2010). The principles of ICZM contributed to targeting the increasing environmental deterioration of Europe's coastal areas, especially in the 1990s, through a number of resolutions and strategic documents that were included in the ICZM's framework (CEC 1994a,b; CEC 1995a,b). The urgent problems brought on by human activity and its damaging effects on the fragile coastal ecosystems were recognised in these communications. This preliminary approach on European ICZM Strategy consisted of three key elements (Ducrotoy and Pullen, 1999):

- **Demonstration projects:** Several projects across Europe were selected to demonstrate the application of ICZM principles in various contexts. These projects, funded under the LIFE Programme, covered a range of coastal issues and management approaches.
- **Thematic analyses:** A series of six thematic analyses were conducted, with support from the scientific community, to provide a deeper understanding of key ICZM concepts and challenges.
- **Discussions and dissemination:** The findings and conclusions from the thematic analyses and demonstration projects were widely distributed and discussed, fostering knowledge sharing and encouraging the implementation of ICZM concepts throughout Europe.

As an instrument of bringing positive change, the ICZM Strategy was developed in the late 1990s and early 2000s. It was formally established as part of the European Commission's Strategy (2000/547/EC), and particularly of the European Commission's Recommendation on ICZM (2002/413/EC), adopted on May 30, 2002. This recommendation set the groundwork for EU Member States to develop national strategies for integrated coastal zone management. From 2007, the European Cohesion Fund has played a significant role in providing direct support for the continued implementation of ICZM, primarily through



the Regions for Economic Change Initiative¹ and the Cooperation goal, both of which feature coastal management as one of their themes. Additionally, an axis of the European Fisheries Fund² is devoted to the sustainable and integrated development of regions that depend on fisheries. The goal of the 2006-launched EU-supported coordination activity ENCORA³ was to organize the disjointed approach to coastal zone research and education in Europe. The strategy was developed in response to growing challenges and pressures on Europe's coastal zones, including:

- Environmental degradation, such as pollution increase, habitat destruction, and biodiversity loss, were threatening the health of coastal ecosystems, while unsustainable practices in fishing, tourism, and industrial activities caused significant environmental damage.
- Population and economic pressures, since the coastal areas were becoming highly populated and economically active, led to overexploitation of resources, while the conflicts among different sectors (e.g., tourism, agriculture, and transportation) required a coordinated approach.
- Climate change and natural hazards, such as rising sea levels, coastal erosion, and extreme weather events highlighted the vulnerability of coastal zones to climate change, with the need for climate adaptation and resilience becoming a priority.
- Fragmented governance, since coastal management was often handled by multiple authorities with conflicting objectives, as well as a lack of integration among different policies (e.g., environmental, economic, and social policies) and across administrative levels (local, regional, and national).

The European ICZM Strategy lies within the framework of the EU Commitments to Sustainability, since it is aligned with the EU's broader commitment to sustainable development, as outlined in the 1992 Rio Earth Summit and subsequent initiatives such as the 1995 Mediterranean Action Plan. In addition, the European ICZM Strategy also supports the implementation of the EU's Marine Strategy Framework Directive (MSFD) and other environmental policies.

Aim and Objectives

The aim of the European ICZM Strategy is to ensure the sustainable development and management of coastal zones by balancing environmental, social, and economic interests and needs. It seeks to protect and enhance the natural and cultural values of coastal areas, while allowing economic development, improving the quality of life for local communities, and addressing challenges like climate change, coastal erosion, and biodiversity loss. The aim of the European ICZM Strategy is addressed by specific key objectives including (Commission of the European Communities, 2000; EEA, 2006; Ballinger et al., 2010; McKenna et al., 2008):

- Promoting sustainable development by ensuring that economic activities, such as tourism, fisheries, and industry, do not compromise the health of coastal ecosystems and by supporting sustainable use of natural resources, including water, land, and biodiversity.
- Preserving coastal ecosystems and biodiversity by protecting coastal habitats, species, and ecosystems from degradation and pollution and by managing human activities to maintain or restore ecological balance.
- Addressing climate change impacts, focusing on preparing coastal areas for the impact of climate change, such as rising sea levels, increased storm intensity, and coastal erosion, as well as by

¹ Regions for Economic Change, COM(2006) 675 and SEC(2006) 1432, 8.11.2006

² European Fisheries Fund, Council Regulation (EC) No 1198/2006, L223, 15.08.2006, p.1.

³ ENCORA <http://www.encora.eu/>



supporting adaptation and mitigation measures, in line with EU climate policies.

- Integrating policies and sectors by supporting coordination between sectors (e.g., fisheries, tourism, urban development, and transport) to avoid conflicts and maximize synergies and by aligning coastal management with regional, national, and EU-wide policies.
- Encouraging stakeholder participation (i.e., local communities, businesses, NGOs, and others) in decision-making processes and by promoting public awareness of and education on the importance of coastal management.
- Enhancing knowledge and data sharing through the support of the scientific research and the development of data-sharing platforms to inform evidence-based decisions, and by using tools like Geographic Information Systems (GIS) to monitor and assess coastal zone changes.
- Improving governance by establishing clear governance structures and legal frameworks for managing coastal zones and by ensuring cross-border cooperation for transnational coastal regions.

Implementation Road Map

The European Commission's Strategy for Europe in 2000 and the Recommendation concerning the Implementation of Integrated Coastal Zone Management in 2002 are the results of a complex process that began with the promotion of the European ICZM Strategy in the 1990s. The European ICZM Strategy's roadmap has evolved since its inception, guided by key documents, principles, and ongoing efforts to address implementation challenges. A timeline of significant advancements and an emphasis on the ongoing and adaptable nature of ICZM assists in clarifying this process. The Important Turning Points and Governing Documents are as follows:

- 1996-1999: The EU Demonstration Programme on ICZM serves as a catalyst for engaging various stakeholders in integrated coastal zone management, highlighting factors hindering effective governance and contributing to coastal problems (Schernewski and Löser, 2004, Facts et al., 2007).
- 1999: Recognizing the need for a more strategic and coordinated approach, the European Commission publishes "Towards a European Integrated Coastal Zone Management (ICZM) Strategy – General Principles and Policy Options." (CEC, 1999a,b,c).
- 2000: The European Commission adopts "Integrated Coastal Zone Management: A Strategy for Europe (COM/2000/547)." This document outlines the eight core principles of ICZM, emphasizing a holistic, long-term, and participatory approach to managing Europe's coasts (CEC, 2002; Stojanovic et al., 2004; CEC, 2007; Shipman and Stojanovic, 2007; Ballinger et al., 2010; Fritz, 2010).
- 2002: The European Parliament and Council issue the "Recommendation concerning the Implementation of Integrated Coastal Zone Management in Europe (2002/413/EC)." This non-binding recommendation urges Member States to develop national ICZM strategies and implement the ICZM's eight core principles (Ballinger et al., 1997; CEC, 2002; Cicin-Sain et al., 2002; European Commission, 2007; Shipman and Stojanovic, 2007; Ballinger et al., 2010; Le Tissier and Hills, 2010).

Furthermore, the continuous evolution and integration with the broader maritime policy, led the principle of the European ICZM Strategy to be linked with numerous European policies and guidelines:

- 2006: The European Commission releases the Green Paper on a European Maritime Policy, setting the stage for a more integrated approach to managing Europe's seas (LGA, 2002; Shipman and Stojanovic, 2007; EC, 2008; EC, 2012).
- 2007: The Integrated Maritime Policy (Blue Book) is adopted, aiming at creating a more coherent



and sustainable framework for managing maritime activities across various sectors (Burbridge and Humphrey, 2003; Pickaver et al., 2004).

- 2008: The Marine Strategy Framework Directive (MSFD) is adopted, setting ambitious targets for achieving good environmental status in Europe's seas (see CEC, 2008; Ballinger et al., 2010; Reis et al., 2014).
- 2013: The European Commission proposes a Directive establishing a Framework for Maritime Spatial Planning and Integrated Coastal Management, aiming to further integrate these two approaches (EC, 2013; Karnauskaitė et al., 2018).

As a means of moving towards a more sustainable future for European coastlines, the European ICZM Strategy roadmap consists of a dynamic process that necessitates constant adaptation, education, and cooperation, rather than a static blueprint. Europe may work towards more sustainable management of its valuable coastal zones by tackling the issues that have been highlighted, encouraging more integration with larger maritime and coastal policy initiatives, and adopting the fundamental ideas of ICZM.

Key changes introduced

This review of the European ICZM shows that it has introduced significant changes in the management of coastal areas, moving away from a fragmented and sectoral approaches, towards a more holistic, integrated, and sustainable framework. ICZM, embodied in key documents, outlines core principles that emphasize: (i) broad approach, (ii) integrated approach, (iii) long-term perspective, (iv) local specificity, (v) working with natural processes, (vi) adaptive management, and (vii) the crucial role of stakeholder engagement. The European ICZM Strategy has driven changes in coastal area management, as follows:

--> From sectoral to integrated management:

- Breaking down silos: The traditional sectoral approach was based on different agencies managing specific activities in isolation. Conversely, the European ICZM Strategy advocates for a paradigm shift, promoting integration across sectors, disciplines, and administrative boundaries to address the interconnectedness of coastal systems (Shipman and Stojanovic, 2007; Diedrich et al., 2010; Reis et al., 2014; Karnauskaitė et al., 2018).
- Aligning policies and actions: To guarantee clear and efficient coastal management, the ICZM Strategy promotes the use of a combination of instruments, including laws, spatial planning, financial incentives, and voluntary agreements (Ducrotoy and Pullen, 1999; Ballinger et al., 2010). This integration is essential for addressing difficult problems that cut across conventional lines (Shipman and Stojanovic, 2007; Karnauskaitė et al., 2018).
- Bridging the land-sea divide: The ICZM Strategy encourages a comprehensive approach that considers the land-sea interface, expanding management efforts to include both terrestrial and marine areas, acknowledging that coastal management should not be limited to the shoreline (Ballinger et al., 2010; Reis et al., 2014; Karnauskaitė et al., 2018). Considering new marine spatial planning systems and directives such as the Marine Strategy Framework Directive, this more comprehensive perspective is especially pertinent (Ballinger et al., 2010; Reis et al., 2014).

--> Embracing sustainability and natural processes

- Balancing development with protection: The European ICZM Strategy prioritizes sustainability in coastal management with the goal of striking a balance between social well-being, environmental protection and conservation, and economic development (Ducrotoy and Pullen, 1999; Shipman and Stojanovic, 2007; Ballinger et al., 2010). This idea is mirrored in initiatives to protect the integrity of coastal ecosystems, while advancing sustainable tourism, mariculture, and urban growth (Burns, 2004; McKenna et al., 2008).



- Shifting from control to adaptation: The ICZM Strategy promotes utilizing natural coastal dynamics rather than strict management of natural processes (Ducrotoy and Pullen, 1999; Ballinger et al., 2010; Karnauskaitė et al., 2018). This strategy seeks to mitigate the risks connected to coastal hazards, like erosion and sea level rise, while promoting coastal resilience and acknowledging the importance of natural systems (Hopkins et al., 2011; Newton, 2012).
- Promoting proactive measures: Specific management initiatives implemented throughout Europe demonstrate the move towards sustainability and adaptation. The creation of erosion management frameworks, controlled realignment initiatives, integrated shoreline management, and realignment of coastal protection programs are a few examples (ECE, 2002; Henocque, 2003; Gallagher, 2010; Gvilava et al., 2015; Karnauskaitė et al., 2018).

--> Empowering stakeholders and fostering collaboration

- From top-down to participatory approaches: The European ICZM Strategy encourages participatory approaches that enable all relevant actors to participate in decision-making, emphasizing the value of stakeholder involvement (Ducrotoy and Pullen, 1999; Shipman and Stojanovic, 2007; Ballinger et al., 2010; Reis et al., 2014). This includes not only governmental organisations, but also corporations, NGOs, scientists, and local communities (Karnauskaitė et al. 2018).
- Recognizing local knowledge and values: The ICZM Strategy places a strong emphasis on the necessity of local specificity, adjusting management strategies to suit particular local circumstances, while accounting for social, cultural, economic, and environmental factors (Birnie, 1992; Pernetta and Elder, 1993; Ducrotoy and Pullen, 1999). The focus on local involvement can assist in resolving possible disputes between centralised coastal managers and stakeholders and increase the efficacy of management measures (Reis et al., 2014).
- Fostering partnerships and networks: The ICZM Strategy supports the growth of networks and partnerships, which makes it easier for many stakeholders to collaborate and exchange expertise. In order to handle transboundary issues and make sure that management initiatives are influenced by a range of viewpoints, this cooperative approach is essential (Jemmett et al., 1999; Henocque, 2003; Ballinger, 2005; Shipman and Stojanovic, 2007).

Overall, the European ICZM Strategy can be seen as an important foundation for changing coastal area management.

Evaluation of Implementation

The evaluation of the European ICZM Strategy's implementation reveals a mixed picture of progress, with notable achievements in raising awareness and establishing policy frameworks, but persistent challenges remaining in translating principles into consistent action on the ground. The sustained success of ICZM in Europe depends on resolving implementation inequalities, enhancing data management, and successfully integrating climate change adaptation (EU Monitor, 2007).

The European ICZM Strategy mirrored in the relevant literature (e.g., Shipman and Stojanovic, 2007; EU Monitor, 2007; Ballinger et al., 2010; Reis et al., 2014; Karnauskaitė et al., 2018) shows significant contribution to the successes of:

- Policy Adoption and Awareness-Raising: The idea of integrated coastal management has been effectively spread throughout Europe by the European ICZM Strategy, which has resulted in a rise in awareness and the implementation of frameworks, policies, and strategies at different levels. The European Commission's top-down strategy has played a significant role in making ICZM a crucial component of coastal administration.



- **Development of National Strategies:** In accordance with the EU ICZM recommendation, numerous Member States developed national ICZM policies and carried out thorough assessments of their coastal zones. A more coordinated approach to coastal management was made possible by these tactics.
- **Enhanced Stakeholder Participation:** The ICZM Strategy approach encouraged the involvement of diverse stakeholders, including local communities, private sector, and non-governmental organisations, leading to more inclusive decision-making processes.
- **Improved Policy Integration:** Efforts were made to harmonize various sectoral policies affecting coastal areas, promoting a more cohesive management framework that considers multiple interests and reduces conflicts.
- **Creation of a progress indicator:** The European Commission's commitment to developing the ICZM Strategy progress indicator enables the ability to access the progress in progress of the ICZM. This indicator-based framework provides a standardised way to evaluate ICZM efforts, identify strengths and weaknesses, and track changes over time.

Despite these important advancements, challenges persist in effectively implementing the European ICZM Strategy principles and achieving sustainable coastal management. The challenges (e.g., EU Monitor, 2007; Reis et al., 2014; Karnauskaitė et al., 2018) are summarized below:

- **Varied Implementation Across Member States:** Differences in administrative structures, legal frameworks, and available resources led to inconsistent application of the ICZM Strategy principles across the EU. The complexity of responsibilities at the coast, with multiple agencies and overlapping legal jurisdictions, continues to pose challenges. Thus, some countries advanced significantly in implementing ICZM principles, while others lagged due to limited capacities.
- **Data Gaps and Monitoring Difficulties:** The effective implementation of the ICZM Strategy requires robust data on coastal environment and human activities. However, several Member States faced challenges in data collection, standardization, and sharing, hindering comprehensive assessments and informed decision-making.
- **Climate Change Impacts:** Coastal zones are particularly vulnerable to climate change effects, such as rising sea levels and increased frequency of extreme weather events. Integrating climate adaptation measures into the ICZM Strategy remains a complex task for many Member States.
- **Limited Integration and Holistic Approaches:** Despite the ICZM Strategy's emphasis on a broad, holistic viewpoint, many efforts fail to accomplish true integration across disciplines and sectors. Local ICZM initiatives frequently overlook socioeconomic and cultural factors in favour of concentrating primarily on environmental issues.
- **Stakeholder Engagement and Capacity Building:** Meaningful stakeholder engagement is crucial for effective European ICZM Strategy. However, securing consistent participation, addressing power imbalances, and building capacity among stakeholders remain significant hurdles.
- **Securing Long-Term Funding:** Sustainable financing mechanisms are necessary due to the European ICZM Strategy's long-term character. Over-reliance on finance for short-term projects frequently leads to instability and impedes the creation of cohesive and long-term plans.

2.2.5 Marine Strategy Framework Directive (MSFD)

Brief Description

The Marine Strategy Framework Directive (MSFD) (2008/56/EC) – adopted in 2008- is a keystone of the EU's marine environmental policy. Under this directive, EU Member States were required to achieve and



maintain Good Environmental Status (GES) of the marine environment by 2020. The directive adopted an ecosystem-based approach, integrating environmental, economic, and social considerations to ensure the sustainable use of marine resources (European Commission, 2008).

The MSFD was adopted as an overarching framework across all the different directives and regulations addressing marine issues, in response to increasing concerns about the declining health of European marine ecosystems. This directive also expressed the EU's commitment to the 2002 World Summit on Sustainable Development (WSSD) and the UN Convention on Biological Diversity (European Commission, 2008). It emphasized the need for comprehensive, integrated strategies to protect Europe's seas, addressing both environmental degradation and the sustainability of marine-related activities (European Commission, 2015).

Aim and Objectives

The primary aim of the MSFD was to achieve Good Environmental Status (GES) of the marine environment by 2020 and protect the resource on which marine-related economic and social activities depend. The directive outlined 11 descriptors of GES, covering aspects such as biodiversity, fish populations, eutrophication, sea floor integrity, and eutrophication. Member States were required to develop marine strategies that include (European Commission, 2008):

- Initial Assessment: Evaluating the current state of the marine environment.
- Determination of GES: Defining what constitutes GES for their marine waters.
- Establishment of Environmental Targets: Setting specific targets to achieve GES.
- Monitoring Programs: Implementing programs to monitor the state of the marine environment.
- Programmes of Measures: Developing measures to achieve or maintain GES.

Implementation Road Map

The implementation of the MSFD is structured in 6-year cycles. The first cycle (2012–2018) focused on the development of marine strategies, including initial assessments, the determination of GES and the establishment of environmental targets. The second cycle (2018–2024) aimed to implement and update the programmes of measures, with the goal of achieving GES by 2020. Subsequent cycles will review and update the strategies and measures to ensure continuous improvement based on more data collected, knowledge gained, and new challenges. Each cycle requires regular reporting to the European Commission, ensuring ongoing progress (European Commission, 2015).

Key changes introduced

The MSFD introduced a shift by moving away from sectoral management and fragmented legislation to a more holistic view of marine ecosystems, considering the interdependence of species, habitats, and human activities. By setting the goal of achieving GES and supporting the designation of Marine Protected Areas (MPA), the MSFD promotes an ecosystem-based approach to marine and coastal management, addressing key components and levels of biodiversity, such as species (e.g., fish populations), vulnerable habitats (e.g., coral reefs, seagrass beds, wetlands), ecosystems, and MPAs.

At the same time, emphasis is given to the involvement of stakeholders in the development and implementation of marine strategies, encouraging a more inclusive approach to marine conservation (European Commission, 2008).

Another crucial aspect of the MSFD is the emphasis it places on Marine Spatial Planning (MSP) as a key tool for achieving GES (Bertram & Rehdanz, 2013; Domínguez-Tejo et al., 2016) by coordinating various activities such as fishing, shipping, tourism, and conservation. By optimizing the spatial allocation of these activities, the MSP aims to minimize conflicts and maximize their long-term sustainability (Domínguez-Tejo



et al., 2016). The successful implementation of the MSP requires the involvement of multiple stakeholders—governments, industries, NGOs, and local communities—ensuring that the management decisions are based on comprehensive information, are transparent, and are equitable for all involved parties (Domínguez-Tejo et al., 2016; Leslie et al., 2015). Through the MSFD a shift is encouraged towards sustainable practices in marine-related activities by promoting the integration of environmental considerations into economic and social policies (Schaefer et al., 2016).

Moreover, the establishment of comprehensive monitoring programs facilitates the assessment of the state of the marine environment, focusing on data collection and analysis for effective management (ICES, 2016).

Finally, through the MSFD, strong emphasis is given to the protection and conservation of marine biodiversity, a key aspect of the GES. Biodiversity targets are central to ensuring the sustainability of marine ecosystems, which provide essential services such as food, carbon sequestration, and coastal protection. The directive identifies 11 descriptors of GES; one of the most critical descriptors focus on biodiversity (Descriptor 1). For example, the protection of sensitive coastal and marine ecosystems like seagrass meadows, mangroves, and coral reefs is a critical target due to their role in supporting biodiversity, enhancing water quality, and providing vital ecosystem services (Otero et al., 2018). At the same time, the MSFD requires Member States to take measures to protect endangered marine species and those that are vulnerable due to overexploitation, pollution, or habitat loss. One example is the focus on the protection of marine mammals such as the Mediterranean monk seal (*Monachus monachus*) and cetaceans, both of which face significant threats from human activities in Southern European seas (Otero et al., 2018).

Evaluation of Implementation

Despite the significant positive changes brought about by the MSFD, its implementation has also faced several challenges. Studies have highlighted critical inconsistencies, mainly in the early stages of implementation, with some Member States lagging in fulfilling their obligations (Schaefer et al., 2016). At the same time, a comparison of the degree of implementation of marine biodiversity indicators by European countries has shown varying levels of commitment and progress (Krohn, 2019).

The complexity of marine ecosystems and the lack of comprehensive data, with knowledge gaps on various aspects of ecosystem functioning, pose significant challenges in establishing clear and measurable targets, as well as in developing effective management measures (Bertram & Rehdanz, 2013; Domínguez-Tejo et al., 2016; Spiliopoulou et al., 2023). Furthermore, the MSFD's implementation necessitates close coordination among various EU Member States and the effective handling of cross-border environmental impacts. This underscores the need for robust cooperation and governance mechanisms at both the regional and international levels (Spiliopoulou et al., 2023).

Despite these challenges, the MSFD represents a key step towards a more sustainable, integrated, and science-driven approach for the protection and restoration of the seas and oceans (Bertram & Rehdanz, 2013; Domínguez-Tejo et al., 2016).

2.2.6 Blue Growth Strategy

Brief Description

The EU's Blue Growth Strategy, introduced in 2012, is an integrated approach to connect the economic potential of Europe's oceans, seas, and coasts with environmental sustainability and social inclusivity. It

promotes sustainable growth in the marine and maritime sectors, recognising the ocean as a driver of the European economy with great potential for innovation and job creation. The strategy focuses on five key areas, or "blue economy" sectors: aquaculture, coastal and maritime tourism, marine biotechnology, ocean energy, and seabed mining (European Commission, 2012). However, the strategy also underscores the importance of protecting marine ecosystems and aligning economic activities with environmental goals.

Aim and Objectives

The primary aim of the Blue Growth Strategy is to support the long-term growth of the blue economy, while addressing environmental and social challenges associated with maritime activities. The strategy's key objectives centre around:

- **Economic Growth:** Promote growth and employment in marine and maritime sectors by unlocking the potential of underdeveloped sectors, such as marine biotechnology and ocean energy.
- **Environmental Sustainability:** Ensure that economic growth does not come at the expense of marine ecosystems and biodiversity. The strategy emphasizes sustainable practices and the reduction of negative environmental impacts, particularly in sectors such as aquaculture and tourism (Schupp et al., 2019).
- **Innovation and Technology:** Foster innovation in marine and maritime industries through research and technological advancements, thereby enhancing Europe's competitiveness in the global blue economy (European Commission, 2012).
- **Social Inclusivity:** Ensure that the benefits of blue growth are shared equitably, particularly among coastal communities that rely heavily on marine resources for their livelihoods.

Implementation Road Map

The implementation of the Blue Growth Strategy follows a structured approach, guided by key actions across the blue economy sectors:

- **Policy Integration:** The strategy is implemented through the EU Integrated Maritime Policy, which ensures the coordination of policies across different sectors and member states. Maritime Spatial Planning (MSP) and Marine Strategy Framework Directive (MSFD) are key tools for integrating environmental, social, and economic goals (Soma et al., 2020).
- **Sector-Specific Actions:** The European Commission supports sustainable aquaculture through research funding, regulatory improvements, and promotion of best practices. At the same time, the strategy promotes investment in marine biotech research to develop new products from marine organisms, with applications in healthcare, food, and energy (European Commission, 2012). Additionally, coastal tourism is supported through initiatives that promote eco-tourism, cultural heritage preservation, and sustainable infrastructure development.
- **Investment in Research and Innovation:** The Horizon 2020 research framework and the European Maritime and Fisheries Fund (EMFF) provide financial support for blue growth-related innovation, particularly in sectors like ocean energy and marine biotechnology.
- **International Cooperation:** The EU fosters global partnerships to promote sustainable ocean governance and align with international commitments, such as the United Nations Sustainable Development Goal 14 (SDG 14) to conserve and sustainably use oceans, seas, and marine resources.

Key changes introduced

The Blue Growth Strategy aimed to introduced significant changes in the management of marine resources, particularly in how economic, social, and environmental aspects are addressed. For example, the strategy promotes sustainability by aligning blue growth with marine conservation goals. This is

achieved through Marine Spatial Planning (MSP) and the Marine Strategy Framework Directive (MSFD), which aim to ensure that economic activities are planned and regulated to minimise environmental impacts (Soma et al., 2020). The MSP, in particular, has improved the coordination between sectors and stakeholders, helping to reduce conflicts and protect biodiversity. Additionally, a key focus of the strategy is the inclusion of coastal communities and small-scale fishers in the blue economy. The strategy emphasizes the need to support traditional livelihoods, while promoting new employment opportunities in emerging sectors (Schupp et al., 2019). Coastal tourism initiatives, for instance, are designed to benefit local economies, while promoting sustainability. The strategy underscores the importance of preserving marine biodiversity and maintaining the ecosystem services provided by healthy oceans, such as carbon sequestration, fish stocks, and coastal protection (van Hoof et al., 2015). Marine Protected Areas (MPAs) and ecosystem-based management approaches have been promoted to ensure that economic activities do not lead to irreversible ecosystem degradation (van Hoof et al., 2015). Finally, ocean energy is a critical sector under the Blue Growth Strategy, with a focus on developing renewable energy sources, such as offshore wind and wave energy, to combat climate change. This aligns the blue economy with broader EU climate objectives, such as achieving climate neutrality by 2050 (European Commission, 2019).

Evaluation of Implementation

The EU's Blue Growth Strategy has yielded several positive outcomes, particularly in promoting economic growth and innovation within marine sectors such as offshore energy, aquaculture, and marine biotechnology. One of the notable achievements of the strategy is the expansion of the blue economy, which has led to the creation of jobs and economic opportunities, particularly in emerging sectors like offshore wind energy. The strategy has also fostered innovation through research and development, with initiatives such as Horizon 2020 funding new technologies in marine industries (European Commission, 2019). Additionally, the implementation of Marine Spatial Planning (MSP) has improved the coordination of marine activities, helping to reduce conflicts between sectors like fishing, tourism, and energy production (Soma et al., 2020).

However, the strategy has faced criticism for not fully addressing the environmental impacts of some blue economy activities. While the strategy promotes sustainability, sectors such as aquaculture and seabed mining continue to pose risks to marine biodiversity, particularly in coastal areas where environmental degradation from pollution and habitat destruction is still prevalent (Schupp et al., 2019). Furthermore, although Marine Protected Areas (MPAs) have been established to safeguard ecosystems, many remain inadequately managed and underfunded, limiting their effectiveness in halting biodiversity loss (van Hoof et al., 2015). The tension between economic growth and environmental protection remains a challenge, with concerns that the focus on economic benefits could undermine long-term ecological sustainability.

Socially, the strategy has made progress in emphasizing the inclusion of coastal communities and stakeholders in marine governance. However, marginalized groups, such as small-scale fishers and indigenous coastal populations, often continue to face barriers in accessing decision-making processes and benefiting from blue economy opportunities (Schupp et al., 2019).

2.2.7 Maritime Spatial Planning Directive (MSP)

Brief Description

The Maritime Spatial Planning Directive (MSP Directive), officially known as Directive 2014/89/EU, was adopted by the European Union (EU) in 2014 to establish a common framework for maritime spatial planning across the EU Member States (European Commission, 2014). It is a legal instrument aiming to

coordinate the use of marine space to avoid conflicts between human activities while promoting the sustainable use of marine resources. It encompasses a broad range of sectors, such as energy, shipping, aquaculture, fishing, and environmental conservation (Jay, 2012; Zaucha, 2014).

In the late 2000s, the EU recognized the need for integrated maritime management to balance economic activities and environmental sustainability. This led to the development of the EU Integrated Maritime Policy (IMP) in 2007, which sought a coordinated approach to managing maritime affairs (Schultz-Zehden et al., 2008).

Aim and Objectives

The MSP Directive builds on and contributes to earlier legislative frameworks, such as the Habitats Directive and the MSFD, it aims to harmonize approaches to managing Europe's seas, and ensures a more holistic management of marine ecosystems to maintain the health of marine and coastal environment (Qiu & Jones, 2013; Ehler & Douvere, 2009).

The key objectives are:

- Promote sustainable growth of maritime economies: The MSP Directive encourages the sustainable growth of maritime sectors, including shipping, aquaculture, and renewable energy, in line with the EU's Blue Growth Strategy (Koundouri et al., 2017; Katsanevakis et al., 2011).
- Promote the sustainable development of marine areas: The MSP Directive ensures that the planning of human activities in marine areas is aligned with environmental objectives, such as those set out in the MSFD for achieving GES (European Commission, 2014).
- Ensure cooperation across borders: The Directive fosters cross-border cooperation, especially in sea basins shared by multiple EU member states, such as the Baltic Sea and North Sea (Jones et al., 2016).
- Promote the sustainable use of marine resources: By coordinating different activities, the MSP helps to optimize resource use, while avoiding conflicts between sectors, thereby aiming to ensure the sustainability of both economic and ecological resources (Calado et al., 2019).

Implementation Road Map

The implementation of the MSP includes

- Transposition into national law: Member States had to transpose the MSP Directive into their national laws by September 2016 (European Commission, 2014).
- Development of maritime spatial plans: Member States were required to develop national maritime spatial plans by March 2021, integrating environmental, economic, and social objectives (Zaucha & Gee, 2019).
- Cross-border cooperation: Collaboration between countries sharing sea basins was required to ensure coherent plans, particularly for large-scale projects like offshore wind farms and shipping routes (Ehler & Zaucha, 2020).
- Monitoring and adaptation: Member States are responsible for monitoring and periodically reviewing their maritime spatial plans, ensuring they remain aligned with new data, scientific research, and evolving environmental and socio-economic conditions (Ansong et al., 2017).

Key changes introduced

The MSP Directive has introduced several changes that impact the management of marine spaces with an emphasis on social and environmental parameters. One of the significant shifts it introduced is the emphasis on participatory governance. Member States are required to consult stakeholders—including industry representatives, local communities, environmental organizations, and scientific experts—during



the planning process (Jones et al., 2013). This inclusion helps to ensure that the plans reflect a balance between socio-economic needs and environmental concerns (Katsanevakis et al., 2011).

Moreover, the MSP Directive integrates an ecosystem-based management (EBM) approach, which considers the cumulative impacts of human activities on marine ecosystems. EBM is essential for ensuring that economic activities, such as fishing and energy production, do not compromise marine biodiversity (Foley et al., 2010; Stelzenmüller et al., 2013). Also, EBM contributes to achieving biodiversity goals by ensuring that the MSP incorporates the protection of marine habitats and species, as outlined in the EU Biodiversity Strategy and the Natura 2000 network (Ansong et al., 2017). Designating Marine Protected Areas (MPA) is a crucial aspect of these biodiversity targets. The MSP framework aligns with other EU Directives, such as the MSFD's goals of achieving Good Environmental Status (2008/56/EC), the Habitats and Birds Directive and the CFP, ensuring a coherent framework for environmental protection and resource management (Qiu & Jones, 2013). This integration allows for better coordination between conservation efforts and economic activities, leading to more effective management of marine and coastal biodiversity (Domínguez-Tejo et al., 2016).

Additionally, the MSP Directive requires the collection of data on environmental, social, and economic parameters to inform and provide feedback to spatial planning. The European Marine Observation and Data Network (EMODnet) plays an important role in collecting and providing access to relevant marine data (Pınarbaşı et al., 2019).

The MSP Directive represents a transformative shift toward sustainable development in maritime governance, moving beyond traditional sectoral approaches to promote integrated management of the marine environment, combining economic, social, and environmental objectives (Zaucha, 2014; Gilliland & Laffoley, 2008). At the same time, it encourages innovation and adaptive management in response to challenges, such as climate change and evolving economic pressures.

Evaluation of Implementation

Maritime spatial planning has emerged as a valuable tool to mitigate the impacts that the range of economic activities in coastal and marine environment can have on marine and coastal biodiversity, integrating in its implementation the ecosystem-based management approach.

There is evidence that the MSP has contributed to better management of marine ecosystems by reducing the spatial conflicts between biodiversity protection and economic activities (Domínguez-Tejo et al., 2016). This has led to more effective management of MPAs and reduced pressures on vulnerable habitats. Additionally, it has improved participatory governance, as well as cross-border cooperation, especially in regions like the Baltic and North Sea, where joint planning initiatives have led to more coherent management of shared resources (Schultz-Zehden et al., 2008). These efforts have reduced conflicts between sectors, such as offshore wind development and fishing, and supported the development of sustainable energy projects, such as offshore wind farms (Ansong et al., 2017).

However, there are disparities in the level of stakeholder engagement across EU Member States. In several countries, limited access to data and insufficient resources have hindered meaningful participation, particularly for smaller stakeholders such as artisanal fishers and local environmental groups (Koundouri et al., 2017). Pınarbaşı et al. (2019) indicated that, in some cases, stakeholder consultation was conducted as a formality, without fully incorporating local knowledge and a wide variety of concerns into the final maritime spatial plans. This has led to criticism that the participatory governance model has not been fully realized across all regions, especially in cases where economic interests dominate the planning process (Zaucha, 2014).



Despite significant progress in cross sectoral integration, stakeholder inclusion, ecosystem-based management approach, etc., there are challenges in the implementation of the MSP Directive. Differences in national priorities, inconsistent data availability, and variations in stakeholder engagement processes have hindered full harmonization across EU Member States (Jay et al., 2012). Future efforts will need to focus on improving data-sharing mechanisms, ensuring that all sectors are adequately represented in the planning process, incorporating the insights from new technologies, and research towards the complex interactions between human activities and marine ecosystems (Foley et al., 2010).

2.2.8 Biodiversity Strategy for 2030

Brief Description

The EU Biodiversity Strategy for 2030 was adopted in May 2020. It is part of the European Union's Green Deal towards a broader vision of climate neutrality and sustainability. It aims to address biodiversity loss and ecosystem degradation by implementing actions to protect nature and restore ecosystems, recognizing the interdependence of healthy ecosystems, economic resilience, and human well-being (European Commission, 2020).

It builds on the previous EU Biodiversity Strategy for 2020 and aligns with global frameworks such as the United Nations Convention on Biological Diversity (CBD) (IUCN, 2020). The previous EU Biodiversity Strategy for 2020 sought to halt biodiversity loss, but, despite some progress, the State of Nature Report 2020 revealed that biodiversity continued to decline (European Commission, 2020; Maes et al., 2020). At the same time the IPBES Global Assessment (2019) highlighted the extinction risk to over 1 million species (IPBES, 2019). In response, the Biodiversity Strategy for 2030 was developed, placing greater emphasis on transformative change, ecosystem restoration, and integrating biodiversity into other policy areas, such as agriculture, fisheries, and urban planning (European Commission, 2020).

Aim and Objectives

The primary aim of the Biodiversity Strategy for 2030 is to protect nature, restore ecosystems, and increase biodiversity by setting ambitious targets for 2030. One of the key commitments is to protect 30% of the EU's land and sea, and restore degraded ecosystems by promoting sustainable agriculture, forestry, fisheries, and nature-based solutions (European Commission, 2020; European Environment Agency, 2021). It has several key objectives (European Commission, 2020; Maes et al., 2021):

- **Protect and restore ecosystems:** The Strategy calls for legally protecting at least 30% of the EU's land and sea areas, with 10% under strict protection, focusing on biodiversity-rich ecosystems, such as wetlands, forests, grasslands, and marine areas
- **Restore degraded ecosystems:** By 2030, the Strategy aims to restore significant areas of degraded ecosystems, with specific actions such as planting 3 billion trees and reducing pesticide use by 50%.
- **Create a network of protected areas:** Establishing a Trans-European Nature Network that will improve ecological connectivity across Europe and ensure better resilience of ecosystems.
- **Integrate biodiversity into economic sectors:** The Strategy aims to mainstream biodiversity into agriculture, forestry, fisheries, and other sectors, and to encourage sustainable practices that conserve biodiversity while providing economic benefits.
- **Tackle the drivers of biodiversity loss:** The Strategy identifies unsustainable land and sea use, overexploitation of resources, climate change, pollution, and invasive species as key drivers of biodiversity loss. It proposes actions to mitigate these pressures, including promoting sustainable agricultural practices, reducing pesticide use, restoring degraded ecosystems, and increasing

investment in research and innovation (Spiliopoulou et al., 2023).

- Enhance governance and stakeholder participation: Effective biodiversity governance, including strong stakeholder participation and enhanced cooperation among Member States, is a main objective.
- Mobilize funding and investment: The Strategy recognizes the need for substantial investment to implement its objectives, with plans to mobilize at least €20 billion per year for biodiversity from public and private sources.

Implementation Road Map

The Implementation Road Map of the EU Biodiversity Strategy for 2030 involves coordinated actions between EU institutions, Member States, local governments, and civil society. The European Commission provides guidance, while Member States are responsible for developing national plans and achieving the strategy's targets. Key milestones include:

- Establishment of Protected Areas: By 2022, Member States were supposed to designate new protected areas to meet the 30% coverage goal. By 2024, effective management plans for these areas should have been in place (European Environment Agency, 2021). This goal was based on the recognition that protected areas are key to safeguarding biodiversity, preserving ecosystem processes, and mitigating the effects of climate change (Spiliopoulou et al., 2023).
- Nature Restoration Law: In August 2024, the EU Nature Restoration Law was adopted. This piece of legislation is the first to set legally binding restoration targets for the long-term recovery of nature in Europe. Its overarching objective is to restore 20% of EU's degraded ecosystems by 2030 and all by 2050, also adding time-bound targets for specific ecosystems, habitats, and species. Funding mechanisms, such as the EU Recovery Plan and LIFE Programme, will be directed to support biodiversity initiatives
- Integration with Other Policies: The Strategy is closely aligned with other legislations, such as the Farm to Fork Strategy, EU Climate Law, the Marine Strategy Framework Directive, the Marine Spatial Planning Directive, Birds and Habitats Directives, Common Agricultural Policy, Water Framework Directive, etc., ensuring coherence across sectors that impact biodiversity (Sarkki et al., 2021; Hesselink et al., 2021).
- Monitoring and Enforcement: To ensure compliance, the European Commission has established a comprehensive monitoring framework using indicators such as biodiversity health indexes, satellite monitoring, and species population assessments (European Environment Agency, 2021; Maes et al., 2020).
- Mid-term evaluation and adaptive measures: A mid-term evaluation will assess progress, identifying gaps and areas where adaptive management is needed. This phase will focus on strengthening protected areas, monitoring, and enhancing biodiversity governance mechanisms (Pe'er et al., 2020).

Key Changes introduced

The Biodiversity Strategy for 2030 emphasizes inclusive governance, ensuring the active participation of a wide range of stakeholders, including local communities, indigenous groups, farmers, fishers, civil society organizations, and the private sector. This participatory approach seeks to address social inequalities in access to resources and decision-making processes, fostering collaboration among diverse groups and recognizing that the biodiversity management cannot succeed without the buy-in and involvement of those who are directly impacted by conservation policies (Young et al., 2018). It also introduces a bottom-up approach that requires stronger public participation in decision-making processes. The inclusion of smallholder farmers, local fishers, and marginalized communities in biodiversity



discussions and actions is crucial to making the policy more equitable (Maes et al., 2021). For example, coastal communities are increasingly involved in the design and management of MPAs, ensuring that conservation measures respect local livelihoods and cultural practices (Coll et al., 2021).

The environmental dimension of the Biodiversity Strategy for 2030 represents a radical shift toward a more holistic and ecosystem-based approach to biodiversity management. The strategy integrates biodiversity protection with other environmental priorities, such as climate change mitigation, land use management, and pollution reduction. It introduces, for the first time, legally binding nature restoration targets to restore degraded ecosystems. It also highlights the role of healthy ecosystems in addressing climate change, recognizing that nature-based solutions can contribute significantly to climate mitigation and adaptation. It sets ambitious targets for the reduction of harmful practices, such as reduction of pesticide use by 50% and fertilizer use by at least 20% by 2030.

Achieving the ambitious targets of the Strategy requires substantial financial investment. The Strategy estimates that at least €20 billion per year will be required for biodiversity action across Europe. This funding will come from a mixture of EU, national, and private investments. To meet this ambition, it introduces new mechanisms to already existing ones. These will finance biodiversity conservation, ecosystem restoration and integration of biodiversity into the various economic sectors, such as green finance initiatives, biodiversity-friendly investment portfolios, and sustainable business practices, ecosystem services valuation, integration with the Common Agricultural Policy, etc.

Overall, the s Biodiversity Strategy introduces a new approach to biodiversity management, which includes rethinking economic incentives, reorienting investment priorities, and fostering a shift from short-term profit maximization to long-term sustainability (Pe'er et al., 2020).

Evaluation of Implementation

The Biodiversity Strategy for 2030 is still in its early stages of implementation. The mid-term evaluation in 2025 will provide a clearer picture of progress, and adaptive measures will be needed to address gaps. Ongoing investments in research, restoration, and monitoring are critical to ensuring that Europe can meet its 2030 biodiversity targets and contribute to global biodiversity conservation efforts (IUCN, 2020).

2.2.9 Other treaties, conventions, agreements related to Coastal Ecosystems Management & Protection

European coastal areas are also governed by a series of international conventions, treaties, and regional agreements that focus on the sustainable management, protection, and conservation of coastal and marine environments and communities. They also highlight the importance of transboundary cooperation, given the shared nature of many coastal and marine ecosystems. Some of the key conventions are the following:

- Convention for the Protection of the Mediterranean Sea Against Pollution - Barcelona Convention (1976)

The Barcelona Convention aimed to reduce pollution in the Mediterranean Sea and promote regional cooperation in the protection of marine and coastal environments, providing a legal framework for Mediterranean countries to collaborate on coastal management issues. It has been expanded to include biodiversity conservation, integrated coastal zone management (ICZM), and sustainable development goals for Mediterranean coastal regions (Barcelona Convention, 1976).

- Convention for the Protection of the Marine Environment of the North-East Atlantic - OSPAR

Convention (1992)

The OSPAR Convention aimed to protect the marine & coastal environment of the North-East Atlantic. It covers the North Sea, the North-East Atlantic, and Arctic waters, providing essential guidelines for coastal management in these regions. The Biodiversity Strategy within the OSPAR Convention focuses on protecting marine species, habitats, and ecosystems along the North-East Atlantic coastline (OSPAR Convention, 1992).

- Convention on the Protection of the Marine Environment of the Baltic Sea Area - Helsinki Convention (1992)

The Helsinki Convention aimed to protect the Baltic Sea from all sources of pollution, including coastal and marine activities, and focussed on the cooperation between Baltic Sea countries for sustainable coastal management. The convention is particularly important for addressing eutrophication and pollution in the Baltic Sea, which is heavily affected by nutrient runoff from coastal agriculture and urbanization. The Baltic Sea Action Plan (BSAP), developed under the Helsinki Convention, aims to restore the ecological balance of the Baltic Sea by 2030 (HELCOM, 1992).

- Convention on Wetlands of International Importance - Ramsar Convention (1971)

The Ramsar Convention is an international treaty focused on the conservation and sustainable use of wetlands, including coastal wetlands and estuaries. Countries that are Parties to the Convention commit to the wise use of all wetlands, designate important wetlands for the Ramsar List of Wetlands of International Importance, and promote conservation actions. Coastal wetlands, including salt marshes, mangroves, and estuaries, are included in Ramsar-designated sites, with EU Member States playing an active role in the Convention's conservation efforts (Ramsar Convention, 1971).

- Convention on Access to Information, Public Participation in Decision-Making, and Access to Justice in Environmental Matters - Aarhus Convention (1998)

The Aarhus Convention granted public rights regarding access to information, public participation, and access to justice in environmental matters, including coastal management and marine protection. It aims to ensure that citizens and environmental organisations have the right to obtain information on environmental matters, participate in decision-making processes, and challenge violations of environmental laws. It is a critical tool for ensuring transparency and public involvement conservation initiatives across Europe (Aarhus Convention, 1998).

- Convention on the Conservation of European Wildlife and Natural Habitats - Bern Convention (1979)

The Bern Convention, under Council of Europe aegis, aimed to conserve European wildlife, habitats, and ecosystems with particular attention to endangered species and their habitats, regulate the exploitation of species, and sustainably manage natural habitats. All European states, including Russia, and some African states are members of a convention on which the EU Birds and Habitats Directives are based. Coastal habitats and species that are under threat, such as sea turtles and migratory birds, are protected under the Bern Convention (Bern Convention, 1979).

- Convention on the Conservation of Migratory Species of Wild Animals (CMS) - Bonn Convention (1979)

The Bonn Convention aimed to conserve migratory species of wildlife across their entire range by promoting international cooperation between countries that share these species. It provides a legal framework for the protection of migratory species, aiming to ensure their conservation and sustainable

management through agreements and action plans. The convention addresses threats such as habitat loss, pollution, and climate change while promoting global partnerships for species protection. It has been expanded to include not only species-specific measures, but also habitat conservation and broader biodiversity goals for migratory species and their ecosystems (CMS, 1979).

- Convention on Biological Diversity (CBD) (1992)

The CBD is an international treaty aimed at conserving biological diversity, ensuring the sustainable use of its components, and promoting the fair sharing of benefits arising from genetic resources. It emphasizes the conservation of coastal and marine biodiversity, particularly through the establishment of MPAs (CBD, 1992).

2.3 IPBES 2024 Assessment

The IPBES 2024 Nexus Assessment addressed “the complex and interconnected character of the crises and challenges of biodiversity loss, water availability and quality, food insecurity, health risks and climate change. It did so by providing a critical evaluation of evidence on interlinkages among five nexus elements: biodiversity, water, food, health, and climate change” (IPBES Nexus Assessment, Summary for policymakers - Advance Unedited Version, 2024). Additionally, the underlying causes of biodiversity loss and the determinants of transformative change and options for achieving the 2050 Vision for Biodiversity are described (IPBES, Thematic Assessment Report on the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity, Summary for Policymakers, 2024).

The IPBES Nexus Assessment is critically relevant to the scope of this report, as well as to the aim and objectives of the PRO-COAST project, since the understanding of these interconnections and the identification of opportunities for collaboration across sectors and scales, can contribute to synergistic and holistic management and governance, applicable to coastal areas. Additionally, overcoming challenges and barriers to achieving transformative change to address biodiversity loss and the projected collapse of key coastal ecosystem functions is a key objective of PRO-COAST.

The paragraphs below summarise the key information on the results, main messages, and recommendations of the Assessment, and the determinants and options of transformative change, and relate them to the scope of this deliverable, i.e., efficient management strategies and practices for coastal areas. All the information used is drawn from the 2024 Summary for policymakers⁴.

⁴ a) IPBES (2024) **Summary for policymakers of the thematic assessment of the interlinkages among biodiversity, water, food and health (Nexus Assessment)**. Advance unedited version, 16 December 2024. IPBES (2024).

b) **Summary for Policymakers of the Thematic Assessment Report on the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services**. O'Brien, K., Garibaldi, L., Agrawal, A., Bennett, E., Biggs, O., Calderón Contreras, R., Carr, E., Frantzeskaki, N., Gosnell, H., Gurung, J., Lambertucci, S., Leventon, J., Liao, C., Reyes García, V., Shannon, L., Villasante, S., Wickson, F., Zinngrebe, Y., and Perianin, L. (eds.). IPBES secretariat, Bonn, Germany
PRO-COAST _D3.2_v1.0



2.3.1 IPBES Nexus Assessment

The IPBES Nexus Assessment provides an evaluation of science-based evidence on the interlinkages between five critical elements: biodiversity, water, food, health, and climate change, focusing on their past, present, and future interactions. Even though climate change is not explicitly mentioned in the title of the assessment, its significance in relation to the other nexus elements is emphasised. The nexus approach highlights the need to address the interconnectedness of challenges rather than treating each issue individually or in isolation. Isolated decision-making often results in misaligned policies, unplanned trade-offs, and unintended consequences. By adopting the nexus approach, the assessment improves the understanding of the synergies and trade-offs across multiple spatial and temporal scales. The assessment identifies opportunities for collaboration and integrated governance, which align with global goals such as Sustainable Development Goals, the Kunming-Montreal Global Biodiversity Framework, and the Paris Agreement.

The summary for policymakers includes: a) past and current nexus interactions, b) future nexus interactions, c) response options that address nexus interactions and d) governance of the nexus for achieving just and sustainable futures. It also provides key messages, which describe the high-level findings from the assessment for decision-makers. All these are summarised below.

A. Past and current nexus interactions

- Biodiversity is fundamental for human existence and ecosystem functions, ensuring clean water, securing food supplies, supporting human health, and stabilizing climate. However, for the last 30–50 years, biodiversity has been declining significantly in all regions of the world (by 2–6% per decade), with widespread consequences for all these interconnected systems. Coastal and marine ecosystems, including fisheries and coral reefs, are at high risk because of overharvesting, pollution, and habitat destruction. Coral reefs, in particular, are facing extinction in the near future.
- The loss of biodiversity undermines the ability of ecosystems, such as forests and oceans, to sequester carbon, worsening greenhouse gas concentrations and accelerating climate change. This decline also reduces water availability, increases pollution, and raises the risk of disease outbreaks.
- Indirect drivers like economic growth, demographic changes, and technological advancements have increased pressures on biodiversity, such as habitat destruction, unsustainable resource use, pollution, and climate change, affecting both terrestrial and marine ecosystems. The fragmented governance of biodiversity, water, food, health, and climate change, with different institutions and actors, worsens the impact of these pressures. Also, direct and indirect drivers interact with each other and cause cascading impacts across the nexus.
- Governance, policy, and economic priorities often focus on short-term benefits and financial gains, with \$7 trillion being invested annually in activities that damage biodiversity and other nexus elements. These result in unsustainable and inequitable economic growth, prioritising only a limited set of nature's contributions to people (e.g., water and food) while not accounting for diverse values of nature, leading to unequal human well-being outcomes. Developing countries, including small island developing states, Indigenous People, and local communities, as well as those in vulnerable situations in higher-income countries are disproportionately affected.

B. Future nexus interactions

- Current trends in resource extraction, overconsumption, and unsustainable practices will result in continuing significant negative outcomes for biodiversity, water, food security, human health, and climate change. Delaying action on biodiversity and climate goals will also lead to significantly

higher costs. It is estimated that the costs of addressing biodiversity loss will double if delayed by ten years, with an additional minimum of \$500 billion per year needed to address climate change.

- Achievement of positive outcomes for all nexus elements is challenging, but possible through coordinated and equitable strategies, which are characterised by sustainable management of natural resources, inclusive economic growth with just distribution of benefits across different societal groups, and sustainable consumption patterns.
- Scenarios focused on synergies among nexus elements will have more beneficial outcomes for global policy goals, than siloed policy approaches that prioritise a single nexus element.

C. Response options that address nexus interactions

Response options are actions or policies that contribute to advanced governance and sustainable management of one or more elements of the nexus. The response options highlighted in the IPBES report are not an exhaustive list but represent a range of evidence-based options involving different actors and sectors, spatial and temporal scales, and feasibility levels that can be adapted to different national and local circumstances. They represent a menu of options that can be applied in different contexts.

71 response options were identified that were grouped into 10 categories (Figure 2.3-1):

- 1) Conserve or halt conversion of ecosystems of high ecological integrity
- 2) Restore natural and semi-natural ecosystems
- 3) Manage ecosystems in human-exploited lands and waters
- 4) Consume sustainably
- 5) Reduce pollution and waste
- 6) Integrate planning and governance
- 7) Manage risk
- 8) Ensure rights and equity
- 9) Align financing
- 10) Others

Many response options offer benefits across multiple nexus elements. For example, integrated landscape and seascape management, ecosystem restoration, and sustainable healthy diets can improve biodiversity, water quality, human health, and climate resilience. Restoration of coastal and marine ecosystems, such as mangroves and seagrass meadows, also has multiple benefits across the nexus. Marine Protected Areas (MPA) have led, in some areas, to increases in biodiversity, greater abundance of fish for human consumption, and improved incomes for local communities and revenues from tourism. Additionally, bundling and sequencing response options can amplify their effectiveness. For example, combining sustainable agricultural practices, ecosystem restoration, and water management can potentially deliver higher overall benefits.

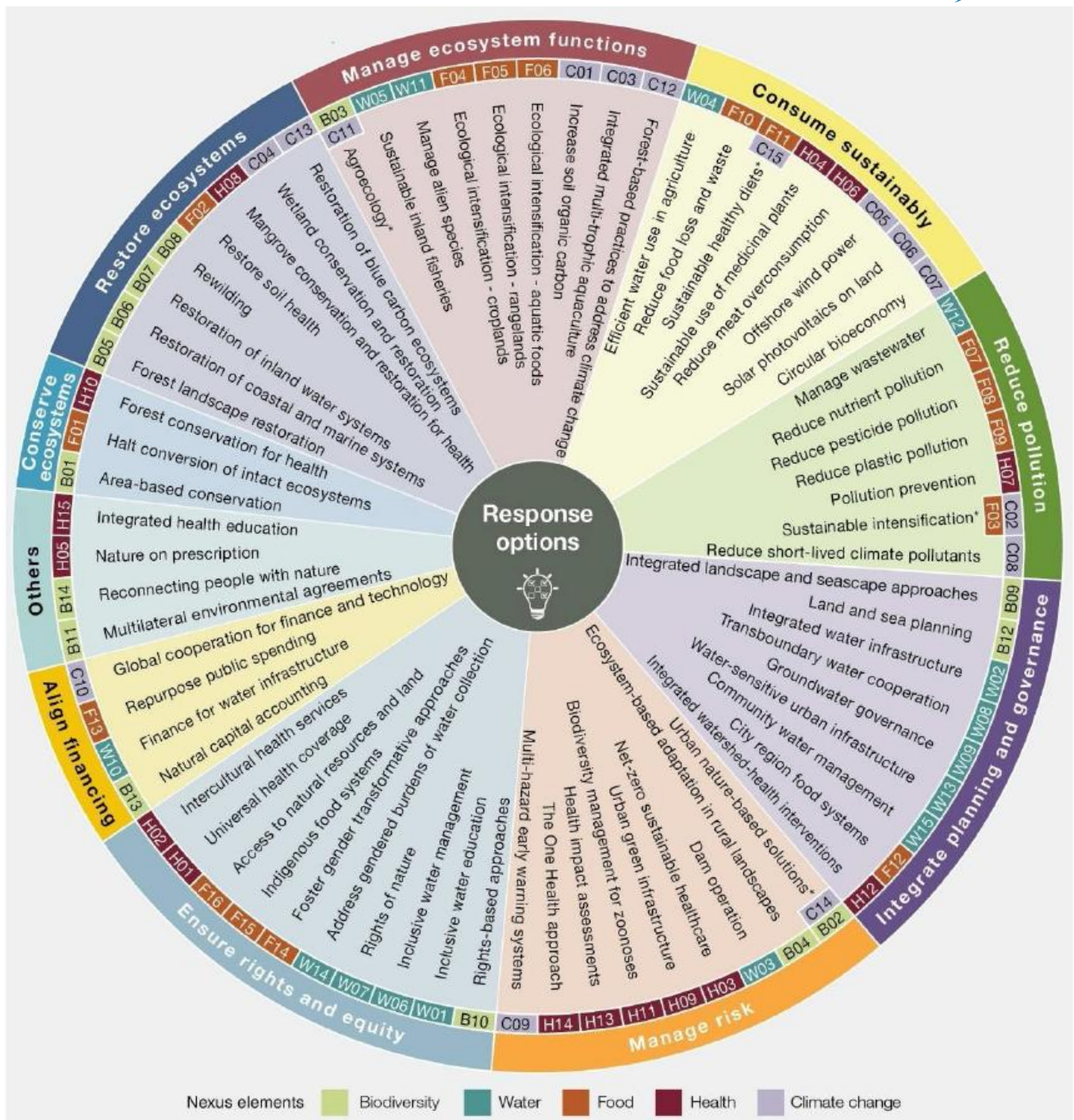


Figure 2.3-1: IPBES Nexus Assessment 71 response options - displayed as wedges and grouped into 10 broad categories of actions ⁵

The implementation of response options that benefit multiple nexus elements simultaneously contributes significantly to the global policy goals, like the Sustainable Development Goals, the Kunming-Montreal Global Biodiversity Framework, and the Paris Agreement.

⁵ IPBES (2024) Summary for policymakers of the thematic assessment of the interlinkages among biodiversity, water, food and health (Nexus Assessment). Advance unedited version, 16 December 2024.
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Governance plays a critical role in the success of response options. Integrated planning, right-based approaches, and inclusive participation of diverse actors, especially Indigenous local communities, are essential for achieving nexus-wide outcomes.

D. Governing the nexus for achieving just and sustainable futures.

Improved governance approaches across biodiversity, water, food, health, and climate change are important for addressing the interconnected and compounding challenges of the nexus. These approaches need to focus on integration, inclusion, equity, accountability, and adaptability to create policies and actions that work across sectors and scales. Existing governance structures, often siloed and sector-specific, have resulted in misaligned and inconsistent policies that fail to address the direct and indirect drivers of the change. Challenges in governing the nexus include:

- Fragmented and sectoral decision making that overlooks the socio-ecological complexities
- Multiple and diverse values
- Insufficient, inaccessible, and unpredictable finance
- Inadequate and inappropriate scaling of actions

“These challenges can be addressed through improved and reoriented “nexus governance approaches”, defined as the development and use of coordinating structures and processes that enhance the engagement of multiple actors through horizontal (e.g., across various nexus elements and associated sectors) and vertical (e.g., cross-scale connectivity or multilevel governance) channels to address nexus challenges, identify policy and socio-political options and manage their implementation”. These approaches:

- (i) Use integrative, holistic, and transdisciplinary frameworks for problem-solving
- (ii) Promote inclusivity and ensure diverse actors are engaged
- (iii) Address equity, justice, and accountability in decision-making
- (iv) Strengthen mechanisms for collaboration across scales and sectors
- (v) Employ adaptive, reflexive, and experimental approaches to learn and scale up

Response options are likely to be most effective when co-designed with a variety of actors and institutions. This approach acknowledges trade-offs, strengthens enabling conditions, and fosters synergy. Nexus governance helps align actors across sectors, fosters shared understanding, reduces tensions, and promotes cost-effective collective action. Collaborative design, implementation, and monitoring of response options, can enhance transparency, cooperation, and acceptability, while fostering co-learning among diverse stakeholders. When response options are not co-created with relevant stakeholders, they often lack legitimacy, leading to resistance, low adoption rates, and ineffective implementation. Strengthening the capacities of under-resourced actors, through capacity building programs, along with improved institutional coordination and collaboration, participatory stakeholder processes, and increased allocation of financial and technical resources, is important.

Financial and economic policy reforms are important to redirect resources in order to restore biodiversity and to support fair transitions across nexus elements. Current systems drive biodiversity decline and nature-related risks, which is estimated in trillions of dollars, exacerbating climate risks, and underscoring the urgency for the need for action. Despite the increase of biodiversity funding, a significant gap remains, with \$0.3–1 trillion annually required for biodiversity and an additional \$4 trillion for nexus-related Sustainable Development Goals. Three key categories of response options to align economic and financial systems with biodiversity were identified:

- Improving information availability and use: This includes adopting metrics beyond Gross Domestic Product (GDP), integrating nexus-related data into public spending appraisals, and enhancing transparency and reporting in the private sector.
- Increasing access to financial resources: Mechanisms like green bonds, microfinance, payments for ecosystem services, and tax policies can increase the availability of funds.
- Reducing negative incentives: Addressing harmful subsidies and improving investment safeguards and standards are vital to minimizing activities that harm biodiversity.

Disparities in funding allocation can limit resource access for low-income countries and Indigenous Peoples, highlighting the need for inclusive and equitable financial mechanisms. Addressing challenges such as debt burdens, investment risks, and transition costs is important to secure sustainable funding and to promote innovative business models that can support nature conservation and sustainability.

Reforming governance and economic systems requires identifying challenges, engaging with diverse actors, and developing adaptive and scalable solutions. A road map for nexus governance (Figure 2.3-2) provides a structured framework to encourage collaborative efforts in order to address nexus challenges through methods that improve knowledge, cooperation, and decision-making. Key steps include:

- 1) Characterising the underlying drivers of nexus challenges and their impacts
- 2) Convening governance actors across scales to foster collaboration
- 3) Understanding the interactions among nexus elements
- 4) Co-creating visions that align values and strengthen legitimacy for response options
- 5) Identifying response options, assessing trade-offs, and synergies
- 6) Assessing enabling conditions and overcoming barriers related to equity, institutional capacity, and policy design
- 7) Negotiating implementation and strengthening transformative outcomes of response options through scaling and increased capacities
- 8) Embedding adaptive governance through monitoring, reflection, evaluation, and learning.

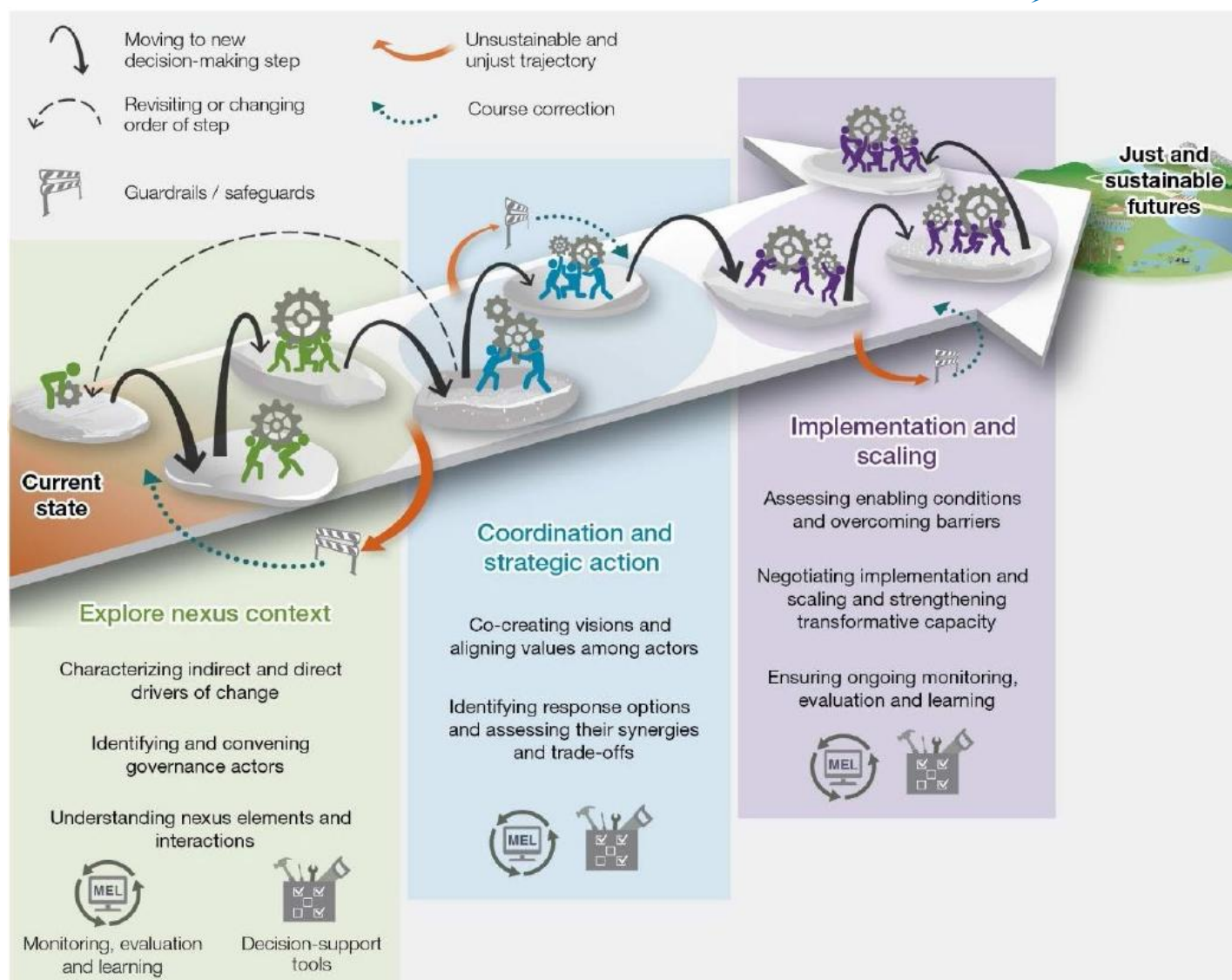


Figure 2.3-2: Road map for applying nexus approaches⁶

2.3.2 IPBES Assessment on Transformative Change

Transformative change for a just and sustainable world is urgent, necessary, and challenging but possible, to halt and reverse biodiversity loss and safeguard life on Earth. Transformative change is defined as “fundamental, system-wide shifts in views, structures and practices. Deliberate transformative change for a just and sustainable world shifts views, structures and practices in ways that address the underlying causes of biodiversity loss and nature's decline”.

⁶ IPBES (2024) Summary for policymakers of the thematic assessment of the interlinkages among biodiversity, water, food and health (Nexus Assessment). Advance unedited version, 16 December 2024.
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The goal is achieving the 2050 Vision for Biodiversity, where *"biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people"*.

The identified underlying causes of biodiversity loss relate to:

- Disconnection from and domination over nature and people - This includes the view that humans are separate from and superior to nature and see nature primarily as resources.
- Concentration of power and wealth – This acknowledges that a relatively small number of wealthy individuals disproportionately drive biodiversity loss locally or through their levels of consumption and associated patterns of resource extraction and this also creates unequal access to decision-making processes.
- Prioritization of short-term, individual, and material gains - Economic and social systems often prioritise immediate goals over long-term well-being of the community and ecology.

The overarching systemic challenges that impede transformative change, include:

- Persistent relations of domination over nature and people, especially those that emerged and were propagated in colonial eras.
- Economic and political inequalities that undermine efforts for conservation.
- Inadequate policies and unfit institutions that do not account for the scale of biodiversity loss.
- Unsustainable consumption and production patterns, including individual habits.
- Limited access to clean technologies and uncoordinated knowledge and innovation systems.

Transformative change is possible, and it is characterized by the quality and direction of change. Both small- and large-scale changes contribute, provided they address the underlying causes of biodiversity loss, embody the principles of transformative change, and are directed towards visions for a just and sustainable world. This type of change requires that we shift away from the currently dominant views, structures and practices that perpetuate the underlying causes of biodiversity loss. Clearly, from the report's concluding diagram (above), both monitoring/evaluation/learning (i.e., adaptive management) and decision support tools are essential underpinnings for these processes.

Delaying action to halt and reverse biodiversity loss globally by ten years is estimated to be twice as expensive as taking immediate action. A large proportion of the global GDP is dependent on nature, with over half (approx. \$58 trillion) generated by economic activities moderately to highly dependent on nature. Externalities associated with sectors contributing to biodiversity loss are estimated at \$10.7 trillion. Annual support needed to sustainably manage biodiversity is estimated between \$722 and \$967 billion per year, while financial flows for biodiversity conservation are only about \$135-156 billion.

Five key strategies and associated actions have been identified for Transformative Change with complementary and synergistic effects:

1. Conserving and regenerating places of value to nature and people.
2. Driving systemic change in the key sectors responsible for biodiversity loss and nature's decline (agriculture, fisheries, forestry, infrastructure, mining, fossil fuels).
3. Transforming economic systems to prioritise nature and social equity over private interests.
4. Transforming governance systems to be integrated, inclusive, accountable, and adaptive.
5. Shifting societal views and values to recognize and prioritize fundamental interconnections between humans and nature.

Key directions to enable Transformative Change are:

- **Shared Visions:** Shared positive visions that recognize socio-ecological interdependencies, the agency of non-human life forms, and an ethics of care, are essential for inspiring transformative change. Five core themes emerged from an assessment of 881 visions with transformative aspirations for desirable futures for humans and nature: 1) regenerative and circular economies, 2) community rights and empowerment, 3) biodiversity and ecosystem health, 4) spiritual reconnection (between humans and nature) and behavioural change and 5) innovative business and technology.
- **Whole-of-Society Approach:** Achieving transformative change requires a whole-of-society and whole-of-government approach that engages all actors and sectors in visioning and contributing collaboratively. Coalitions of diverse actors that bring together complementary resources and capacities, including visioning, are more effective than individual action.
- **Governmental Role:** Governments are key enablers of transformative change when they foster policy coherence, enforce stronger regulations to benefit nature and nature's contributions to people in policies and plans (regulations, taxes, fees, tradable permits) across different sectors, deploy innovative economic (including financial) and fiscal tools, eliminate, phase out or reform environmentally harmful subsidies, and promote international cooperation.
- **Role of civil society organizations:** Civil society organizations, by fighting against biodiversity loss and nature's decline, point to the need for transformative change. Civil society organizations have piloted new, scalable models for sustainable use of biodiversity, mobilized citizens for social actions against environmentally harmful processes, held governments and private sector accountable for harmful practices, and fuelled public debates on biodiversity and nature. Social mobilizations to pursue change, however, have often triggered responses that have rights violations. Protecting civil society organisations will support transformative change.
- **Well-designed policies and economic incentives:** Well-designed policies and private sector initiatives and tools, aimed at transformative change for a just and sustainable world, provide economic incentives that influence socioeconomic development and consumption practices.

3 MANAGEMENT PRACTICES FOR COASTAL ECOSYSTEMS IN EU

3.1 Background and context

Section 3 of this report presents a scoping literature review, based on scholarly articles and relevant EU projects, that explores current practices for managing coastal ecosystems across the EU. The primary aim of this review is to identify the key features of successful management practices, as well as the common pitfalls associated with failed or ineffective systems. An open-access dataset (in MS Excel format) containing all the scholarly articles and projects analysed in this review is included in the Annex of this report.

3.2 Methods

The methodology for conducting the literature review entailed a structured approach to comprehensively understand the key features of successful management practices in Europe, as well as common caveats associated with inefficient systems. To better achieve a broad and inclusive understanding, the literature review included both scholarly articles and relevant EU-funded projects.

For the literature review, the following procedure and steps were applied:

1. Scholar literature search

For the academic articles, a search was done across three prominent academic databases: initially the **Web of Science and Scopus**, followed by **Google Scholar**, by using a search string comprised of multiple components. These databases were selected for their extensive repository of scientific and social sciences literature, offering a wide array of peer-reviewed articles.

The search strategy employed a combination of keywords and Boolean operators to accurately capture studies related to the topic of the literature review. Additionally, only English language scientific articles and peer reviewed publications and reviews were selected. The literature search was applied to the period from 2004 to 2024. The search was conducted in March and April 2024.

The keywords were structured as follows:

Table 3.2-1: Key words search-string used in the literature review.

Aspect	Key words
Coastal Environment	{Coastal zone} OR {coastal area*} OR {coastal ecosystem*} OR {beach*} OR {lagoon*} OR {shore*}
Coastal Features	{stocks} OR {community} OR {communities} OR {population} OR {species} OR {indices} OR {index} OR {indexes} OR {non-indigenous} OR {biodiversity} OR {habitat*} OR {coastal dunes} OR {sandy shore*} or {coastal shingle} OR {sea cliff*}
Management Practices	{management} OR {practice*} OR {governance} OR {integrated coastal zone management} OR {social ecological} OR {sustainable coastal development*} OR {Coastal Zone Policies} OR {MSFD}
Europe	{Albania} OR {Belgium} OR {Bulgaria} OR {Croatia} OR {Cyprus} OR {Denmark} OR {Estonia} OR {Finland} OR {France} OR {Germany} OR

Aspect	Key words
	{Greece} OR {Iceland} OR {Ireland} OR {Italy} OR {Latvia} OR {Lithuania} OR {Malta} OR {Montenegro} OR {Netherlands} OR {Norway} OR {Poland} OR {Portugal} OR {Romania} OR {Slovenia} OR {Spain} OR {Sweden} OR {Ukraine} OR {United Kingdom} OR {Europe}
Timeframe	2004 - 2024

Following the original Scopus and Web of Science search, the results were compared and duplicate documents were removed. This resulted in 1256 publications. The search was then extended to Google Scholar, limiting the results to the first 150 hits, and removing duplicate documents that were in the 1256 publications, resulting in the inclusion of 10 more publications.

After the evaluation of these publications, it was also deemed necessary to place greater emphasis on the implementation of Nature-based Solutions (NbS) in coastal areas, to provide to the PRO-COAST project team specific examples of NbS application and key lessons learned. This will also serve as valuable input for project Task 3.4, which includes a dedicated component on this topic. Thus, an additional search was done, as described above, by using a search string comprised of multiple components. The search was conducted in January 2025. Only English language scientific articles and peer reviewed publications and reviews were selected. The literature search was applied to the period of 2004 to 2024. This resulted in 183 publications. The keywords search-string used was as follows:

Table 3.2-2: Key words search-string used in the literature review for Nature Based Solutions.

Aspect	Key words
Coastal Environment	{{coastal} OR {Coastal zone} OR {coastal area*} OR {coastal ecosystem*} OR {beach*} OR {lagoon*} OR {shore*} OR {estuarine}}
Management Practices	{{nature-based} OR {nature based solutions}}
Europe	{Albania} OR {Belgium} OR {Bulgaria} OR {Croatia} OR {Cyprus} OR {Denmark} OR {Estonia} OR {Finland} OR {France} OR {Germany} OR {Greece} OR {Iceland} OR {Ireland} OR {Italy} OR {Latvia} OR {Lithuania} OR {Malta} OR {Montenegro} OR {Netherlands} OR {Norway} OR {Poland} OR {Portugal} OR {Romania} OR {Slovenia} OR {Spain} OR {Sweden} OR {Ukraine} OR {United Kingdom} OR {Europe} OR {Mediterranean}
Timeframe	2004 - 2024

2. Screening

The following step was used to further screen the publications, using the title and abstract of each paper to determine the relevance of each article to the scope of this review. Three researchers were involved in the screening of literature and frequent meetings/ discussions took place to ensure similar approaches. This resulted in the selection of 248 publications.

A full-text review of these 248 selected studies was conducted to evaluate their direct relevance to the literature review objective, particularly focusing on management practices implemented for coastal areas, ecosystems, habitats, or species in Europe. For an article to be included in the review, it needed to meet the following criteria:

- To present management practices implemented in the framework of its research/implementation activities for coastal areas, ecosystems, habitats, or species in Europe

OR



- To evaluate/ review management practices implemented in the framework of other research/ implementation activities for coastal areas, ecosystems, habitats, or species in Europe.

In total, a final sample of 128 articles was identified for content coding and analysis; 106 based on the initial search and an additional 22 articles discussing Nature-based Solutions.

3. Content coding and analysis

For the analysis of the literature, a coding scheme within a MS Excel I table was used to code data from each publication (Annex). This included general information (i.e., title, authors, year of publication, country, spatial scale, methodology, ecological level, pressures addressed). Additionally, the management practices identified were divided into three categories, as follows:

- Management challenges: In many publications, management challenges are discussed and how these affected the success of any conservation, protection, restoration and/or management efforts.
- Management best practices implemented: This category includes the management best practices applied in the publication.
- Proposed management practices: This category includes management practices that were not implemented, but the researchers/ authors consider that their implementation is crucial for successful conservation, protection, restoration, and/or management efforts.

In the process of reading and analysing this literature, management practices were divided into six standardised categories with common themes (Table 3.2.3).

Table 3.2-3: Coding of management practices in coastal ecosystems as standardised categories.

Category	Sub-Category	Definition
a) Better Knowledge & Understanding	Monitoring (on-going)	Ongoing and systematic monitoring programs that are implemented to gather consistent data on environmental, and/or social, and/or financial aspects.
	Data collection (fill in gaps)	Ad-hoc monitoring campaigns to gather data in cases where there are information gaps.
	Data analyses, assessments, evaluations	Analyses, assessments, and evaluation of datasets through various methods, such as statistical analyses, modelling techniques, Geographic Information Systems, trend analyses, remote sensing and image processing, indicators/ indices, Artificial Intelligence (AI), etc.
	Better understanding/ definitions	Refinement of the definitions of concepts' through reviews and discussions in order to have a better and common understanding.
b) Governance	Institutional coordination & collaboration	Coordinated efforts among governmental organisations, non-governmental organisations, research institutes, and the private sector to work together for cohesive and integrated management policies and practices.
	Participatory processes & stakeholder consultation	Involvement of local communities, related stakeholders, and various interest groups in decision-making processes to ensure that coastal management practices address diverse perspectives and needs.
	Political will	Commitment and determination of political leaders and governments to support, implement, and enforce coastal management policies and regulations.
	Diversity of expertise	Integration of knowledge from various disciplines (e.g., ecology, land planning, economics, engineering, social sciences, etc.) to ensure comprehensive and effective coastal area management.
	Increased allocation of resources	Enhanced allocation of financial, technical, and human resources dedicated to implementing and sustaining coastal management practices.
	Dedicated management at local/ regional scale	Establishment of specialised and dedicated management authorities/structures at the local or regional level to oversee and

Category	Sub-Category	Definition
		implement the management strategies and plans, and to oversee and address specific coastal area needs and challenges.
	On-going, on-the-ground, effective management	Implementation of on-going, on-the-ground, practical, and adaptive management to apply management plans and measures (incl. maintenance) responding to evolving environmental, social, and financial conditions.
	Capacity building	Strengthening the skills, knowledge and abilities of individuals and institutions/ organisations that are responsible for the design and implementation of management strategies and governance.
c) Conservation & Restoration Actions	<i>Conservation and restoration measures were not further categorised to standard groups/ categories, because they included many different kinds of actions and measures according to their scope and target.</i>	
d) Education/ Public Awareness/ Citizen Science	Education	Environmental educational programs and actions to groups of society not involved directly with the management of coastal areas in order to provide better knowledge and understanding about coastal ecosystems (e.g., environmental programs addressed to schools, environmental information centres, etc.).
	Public awareness	Campaigns and actions to promote better understanding, inform and engage the general public on the value of coastal ecosystems, species, and habitats, as well as on management issues and challenges and to encourage sustainable practices and behaviours.
	Citizen science	Involvement of non-professional volunteers in scientific research and data collection to support coastal monitoring, conservation, and management efforts.
e) Other measures/ solutions	Nature - based solutions	Actions to protect, sustainably manage, and restore natural or modified ecosystems, addressing societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits (IUCN, 2016).
	Suitable & sufficient size and boundaries of MPAs	Designation of suitable & sufficient sized Marine Protected Areas in order for proper protection, conservation, and management of ecosystems, habitats, and species.
	Mitigation measures on pressures	Measures that are designed and implemented, focusing on specific pressures.
f) Policy	Policies integration & coordination	Integration and alignment of various sectoral policies to ensure a unified approach to coastal areas management.
	Legal protection - protection status	Formal designation of protection status by legal frameworks and regulations that safeguard coastal areas by restricting activities that could harm ecosystems or biodiversity.
	Set-back policies	Regulations that establish minimum distance between development and the shoreline to reduce environmental impacts, prevent erosion, and protect coastal habitats.
	Ecosystem services approach within policies	Incorporation of ecosystem services approach into development and implementation of policies for coastal areas management.

In terms of relevant EU-funded projects, the below procedure and steps were followed:

1. EU-funded projects search & 2. Screening

For relevant EU-funded projects, a search was done in two databases: a) Cordis (Community Research and Development Information Service) for EU-funded research and innovation projects, mainly Horizon-funded projects⁷ and b) LIFE public database⁸ for LIFE projects.

⁷ <https://cordis.europa.eu/>

⁸ <https://webgate.ec.europa.eu/life/publicWebsite/search/advanced>



In the Cordis database, the following key words were used for the search of relevant projects: «Coastal» «Management» «Biodiversity» from 2004 to 2024 (reflecting the end-date of project). This resulted in 144 projects.

Further screening of projects then took place, based on the information available in the database (title, objectives, short description, results). The inclusion criteria focused on selecting those that implemented management practices as part of their research or practical work and where this related to coastal areas, ecosystems, habitats, or species within Europe. This resulted to 33 relevant projects (Annex).

In the LIFE database, the key word that was used was «Coastal», from 2004 to 2024 (end date of project) and the target EU legislative references were: ICZM, Barcelona Convention for Protection of Marine and Coastal Environment of the Mediterranean, Natura 2000 Directives. This resulted in 145 projects. These were further screened based on the information available (title, objectives, short description, results), resulting in a selection of 75 relevant projects (Annex).

3. Content coding and analysis

For the analysis of the information from projects, a similar coding scheme, as described above for the scholar literature, was followed and a MS Excel table was used to code data from each project (Annex).

3.3 Results

3.3.1 General Analysis of literature

The paragraphs below provide a general overview of the literature for the selected scientific articles. It is noted that this general analysis of scholar articles does not include those from the additional search for Nature-based Solutions (NbS), which is addressed separately in section 3.3.2.

The scientific articles that were used for content coding and analysis, span the period from 2006 to 2024, with more publications from 2014 onwards (Figure 3.3-1).

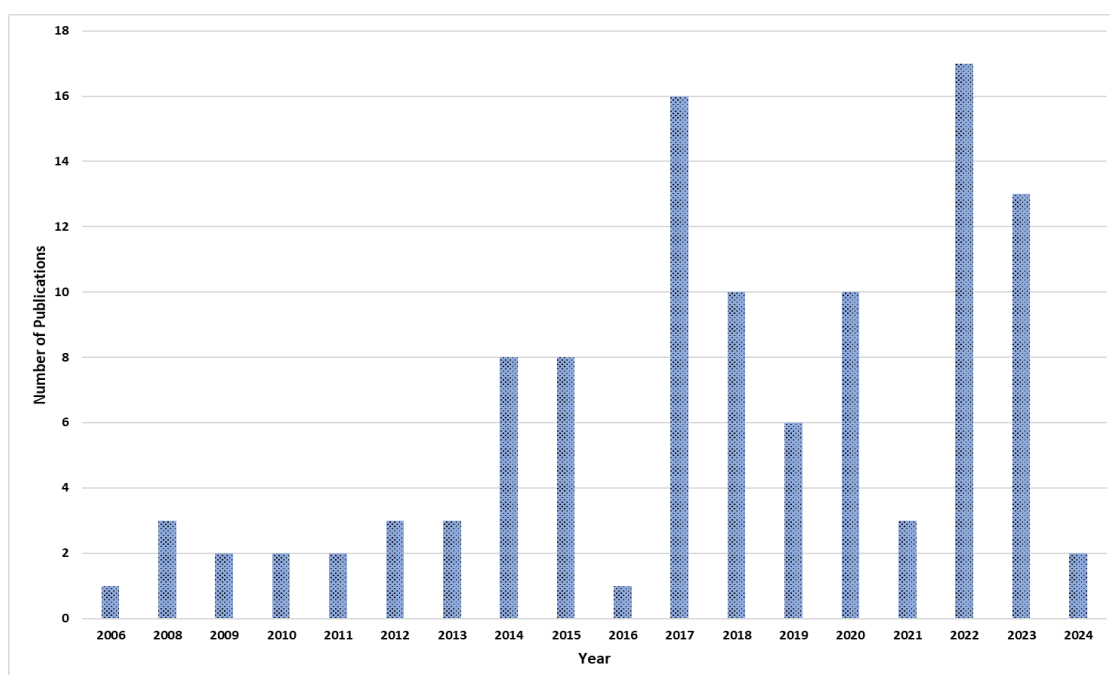


Figure 3.3-1: Scientific articles that were used for content coding and analysis during 2006-2024 (number of occurrences).

From a total of 106 articles considered, 12 were reviews of coastal zone management, while 94 articles focused on specific aspects and/or coastal areas. Considering their geographic spread, there were more publications from Mediterranean countries, such as Italy (17%), Portugal (16%), Spain (13%) and France (10%) (Figure 3.3-2). In addition, several publications discussed coastal zone management at the European level.

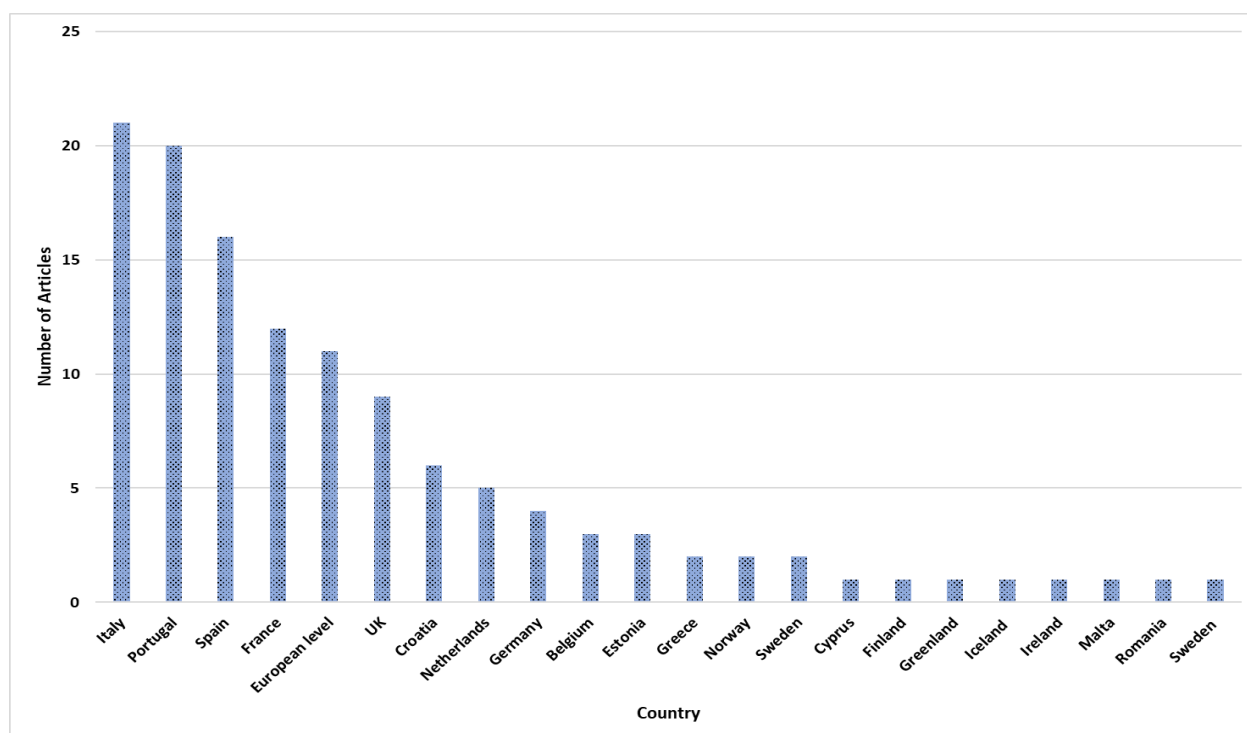


Figure 3.3-2: Geographical distribution of scientific articles reviewed on coastal management (number of occurrences).

The spatial scale of the publications shows that 42% focused on specific local areas, 24% addressed the topic at a regional level, 11% referred to national level and 23% explored the subject at a European level (i.e., involving two or more European countries) (Figure 3.3-3).

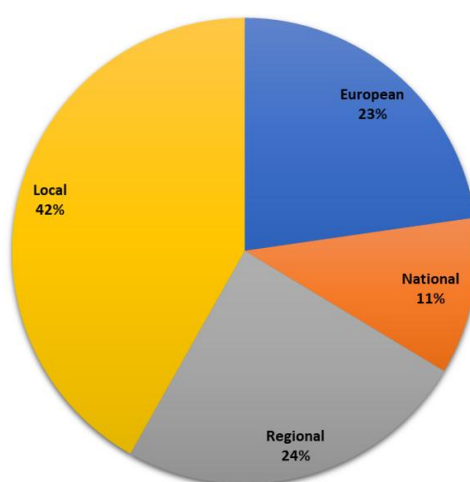


Figure 3.3-3: Spatial scale distribution of scientific articles (percentage of articles) reviewed on coastal management.

Regarding the ecological levels targeted by the management practices reported in the publications, 54% focused on coastal area management, 19% addressed practices at the species level, 15% at the habitat level, and 13% at the ecosystem level.

In relation to the analysis methodologies used in the scientific articles, 59% of the publications employed a combination of methods (e.g., fieldwork, interviews, workshops, desk-based analyses, and/or literature reviews) to address specific research questions. Another 21% relied solely on desk-based analyses (such as statistical analyses, modelling, GIS, remote sensing, or the use of indicators/indices), 19% were literature reviews and discussions of existing research and 1% of the studies used solely interviews or workshop-based approaches.

In terms of the pressures and threats that the management practices in the reviewed articles aimed to address, these were categorized according to the standardized list used by the European Environment Information and Observation Network (EIONET)⁹ for reporting under various directives, such as Natura 2000, the Water Framework Directive (WFD), and the Marine Strategy Framework Directive (MSFD). Each paper could include more than one category of pressures and threats (e.g. “Pollution” and “Climate Change”), as well as more than one pressure/ threat sub-category, which belong in the same category (e.g. “Marine and Freshwater Aquaculture” and “Fishing and harvesting aquatic resources”, which both belong to the category “Biological resource use other than agriculture & forestry”). Figure 3.3-4 represents the percentage (%) of occurrence of pressures and threats affecting the coastal areas in the reviewed papers.

Many of the pressures and threats fall in the category of “Human intrusions and disturbances” (22%), which includes recreational, sports, and leisure activities and structures, followed by “Urbanisation, residential and commercial development” (12%), “Pollution” (11%), “Natural biotic and abiotic processes” (10%), such as erosion, “Natural System modifications” (10%), such as sea defence or coast protection works, dredging etc., “Biological resource use other than agriculture & forestry” (10%), which includes fishing, aquaculture, hunting, illegal removal of plants/ fauna, and “Climate Change” (9%) (Figure 3.3-4).

⁹ https://cdr.eionet.europa.eu/help/birds_art12
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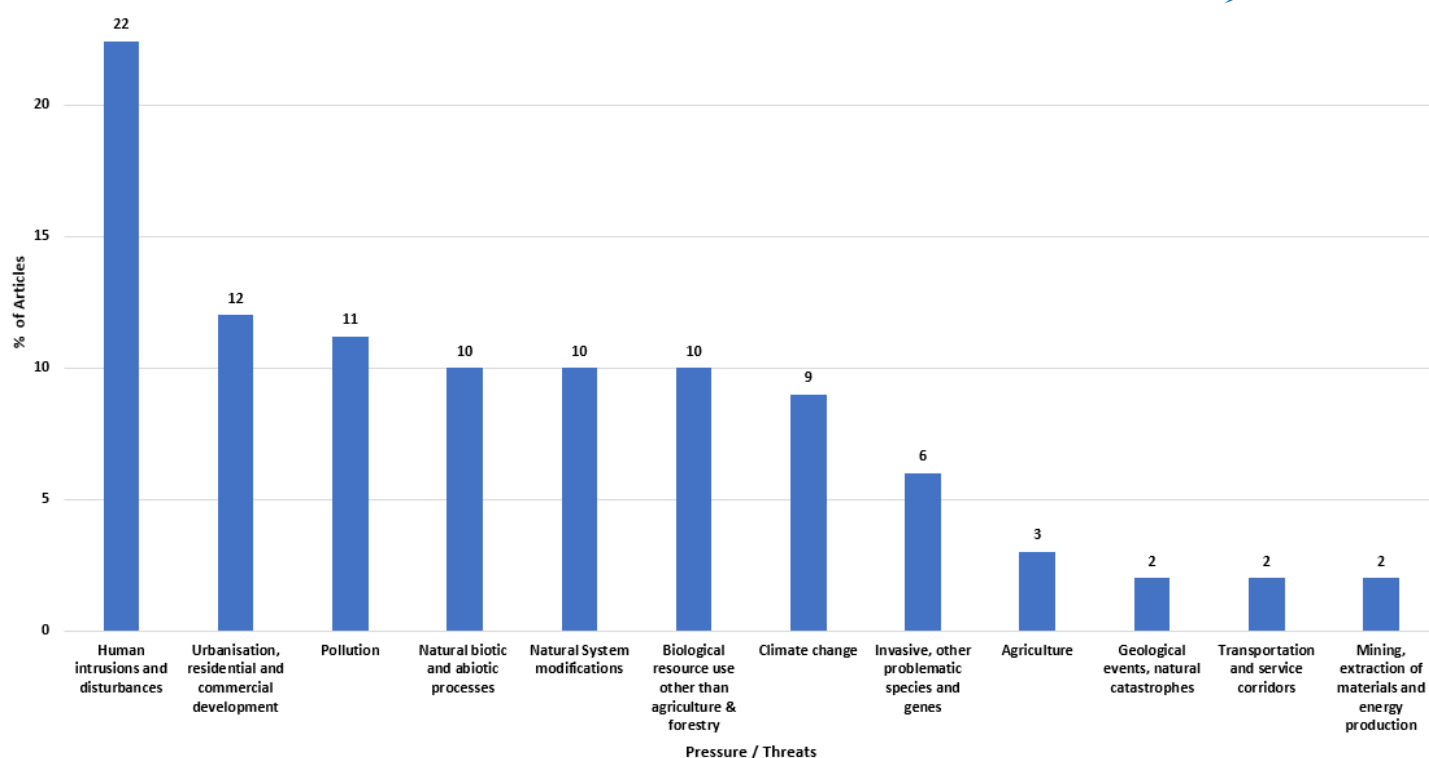


Figure 3.3-4: Identification of pressures and threats affecting the coastal areas - percentage of occurrence in reviewed papers

Finally, Table 3.3-1 collates the keywords / phrases in the reviewed articles that appeared in more than two papers and that were related to specific ecological and management aspects of coastal systems. Key words connect to: a) management aspects (highlighted in blue), such as: management, dune restoration, conservation, integrated coastal zone management, management measures, ecosystem-based management, governance, marine spatial planning, MPA management, bottom-up approach, integrated management, monitoring, protection, social-ecological systems, nature-based solutions, policy integration, public participation, coastal management, or b) ecological levels of management (highlighted in green), such as: marine protected areas, *Posidonia oceanica*, biodiversity, Mediterranean sea, marine reserves, or c) human activities and/or pressures (highlighted in grey), such as: coastal erosion, tourism, climate change, fisheries, aquaculture. From this presentation, we see that “management”, “marine protected areas”, “coastal erosion” and “biodiversity” were predominant themes.

Table 3.3-1: Occurrence frequency of keywords and phrases detected in reviewed articles.

Keywords / Phrases	Frequency	Keywords / Phrases	Frequency
management	10	Mediterranean	2
marine protected areas	8	<i>Posidonia oceanica</i>	2
coastal erosion	5	dune restoration	2
biodiversity	5	tourism	2
conservation	4	integrated coastal zone management	2
ecosystem services	4	small-scale fisheries	2
Croatia	4	non-indigenous species	2
Mediterranean Sea	4	management measures	2
ecosystem-based management	4	water framework directive	2
marine reserves	4	EU policy	2
governance	3	marine spatial planning	2
climate change	3	MPA management	2
fisheries	3	bottom-up approach	2
marine protected area	3	integrated management	2
monitoring	3	ecological impact	2

Keywords / Phrases	Frequency	Keywords / Phrases	Frequency
protection	3	multifunctionality	2
social-ecological systems	2	nature-based solution	2
policy integration	2	public participation	2
coastal management	2	aquaculture	2

3.3.2 Management Practices

As described in section 3.2. “Methods”, the management practices were divided in three categories, according to the “implementation status” in each article or project: a) Management challenges, b) Management best practices implemented and c) Proposed management practices. “Management challenges” and “proposed management practices” concern practices that were not implemented in the specific source of literature, but rather their absence or inefficient implementation created challenges that affect the success of any conservation, protection, restoration and/or management efforts (challenges), or proposed management practices that the researchers/ authors consider are crucial for the successful conservation, protection, restoration, and/or management efforts. “Management best practices implemented” are those practices that were applied in the publications reviewed and are considered successful.

Additionally, management practices were divided in standardised categories and sub-categories with common themes (refer to Table 3.2-3 for detailed explanation of each category and related sub-categories), as follows:

- a. Better knowledge & understanding
- b. Governance
- c. Conservation & restoration actions
- d. Education/Public awareness/Citizen science
- e. Other measures/ solutions
- f. Policy

The following paragraphs provide a **quantitative overview of the above categorisation of management practices**, presented separately for scientific articles and EU-funded LIFE and Horizon projects. It is important to emphasize that this quantitative analysis offers only preliminary and indicative insights regarding a) the frequency that management best practices were implemented, b) the frequency of the proposed management practices, which contribute -according to the researchers- to efficient management of coastal ecosystems and c) the frequency of identified challenges related to ineffective or failed systems. This analysis has some inherent biases and constraints, which are discussed in detail in Section 3.4 - Considerations.

1. Scientific Articles

In terms of **Management Challenges**, the scholarly literature shows that most challenges fall under the category "Better Knowledge & Understanding" (55%), followed by the categories "Governance" (16%), and "Conservation and Restoration Actions" (13%) (Figure 3.3-5). The implication is that a lack of, or the ineffective implementation of, practices within these categories poses significant obstacles to the success of conservation, protection, restoration, and management efforts.



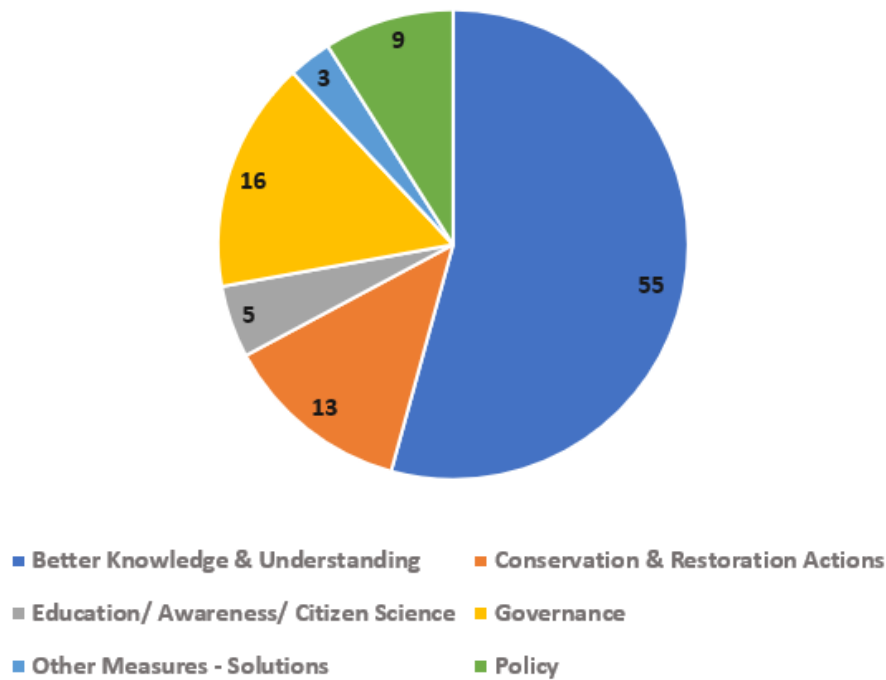


Figure 3.3-5: Prevalence (percent %) in scientific articles of Management Challenges.

Figure 3.3-6 shows the sub-categories frequency for each management category that are identified as Management Challenges.

Exploring deeper into the category "Better Knowledge & Understanding", most of the identified challenges fall under the sub-category "Data Analyses, Assessments, Evaluations" (66 *occurrences*). This implies that many authors see a critical need to improve or better integrate the results of data assessment and evaluation methods in the coastal ecosystems management design and implementation, in order to better understand the factors influencing coastal ecosystems. Additionally, many challenges are related to the sub-category "Better Understanding/Definitions" (36 *occurrences*), highlighting the need for refining concepts and definitions through reviews and discussion to establish a clearer and better shared understanding of concepts related to coastal ecosystems. Finally, challenges are associated with ad-hoc monitoring campaigns aimed at filling data gaps (10 *occurrences*), while some relate to absence or better implementation of ongoing, systematic monitoring programs (4 *occurrences*).

Within the "Governance" category, challenges were primarily identified where there was a lack of or ineffective "Dedicated Management at the Local/Regional Scale" (8 *occurrences*), "Institutional Coordination & Collaboration" (6 *occurrences*), "Participatory Processes & Stakeholder Consultation" (6 *occurrences*) and "On-going, on-the-ground, effective Management" (5 *occurrences*). Other challenges included issues with "Capacity Building" (3 *occurrences*), "Allocation of resources" (3 *occurrences*), and "Political will" (3 *occurrences*).

Within the "Policy Category", most management challenges relate to lack or inefficient "Policy Integration & Coordination" (8 *occurrences*), followed by lack or inefficient integration of "Ecosystem services approach" within policies (4 *occurrences*) and need formal designation of protection status by legal frameworks and regulations (2 *occurrences*).

Challenges in the category "Other Measures – Solutions" are only related to the designation of suitable and sufficient sized Marine Protected Areas.

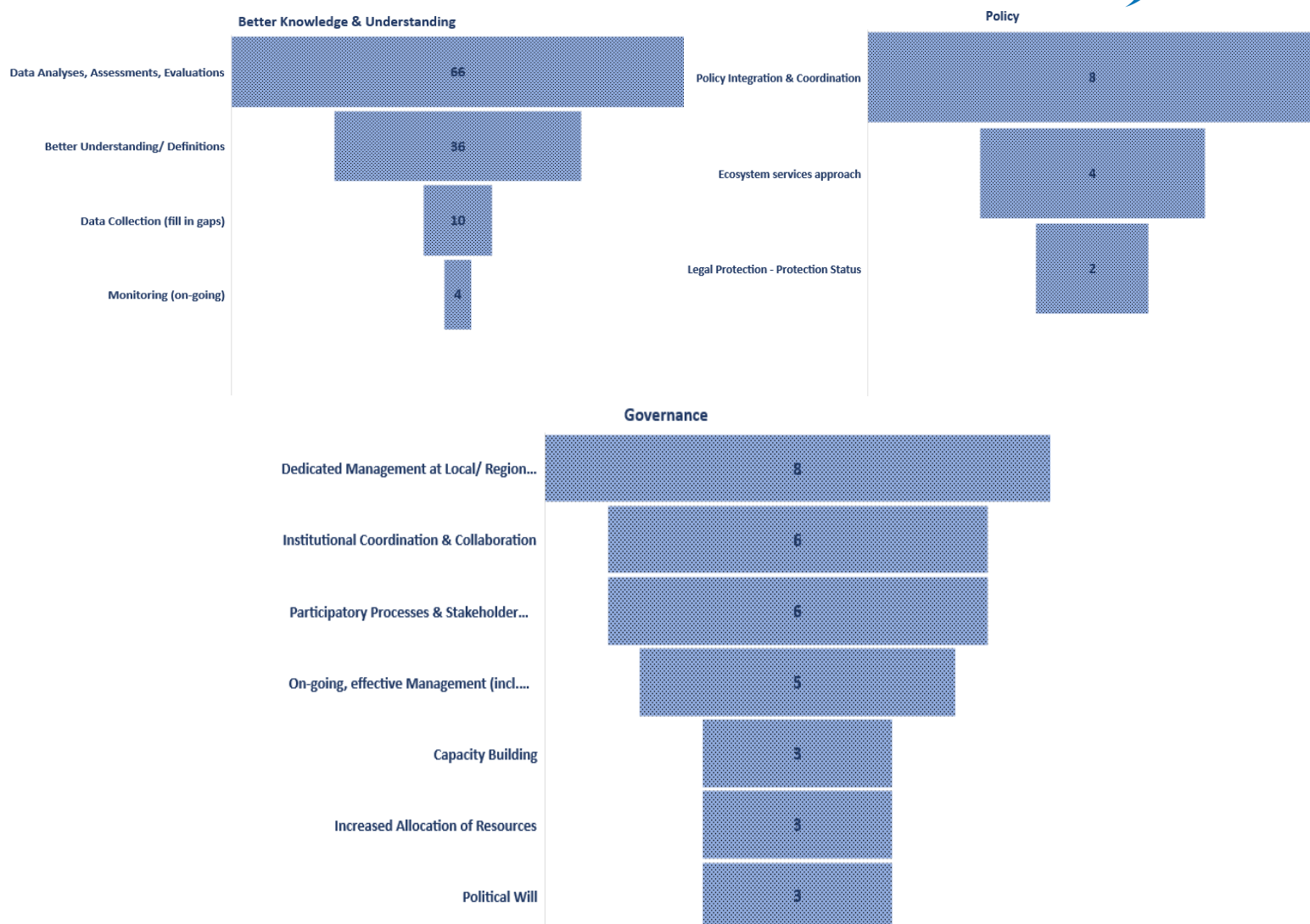


Figure 3.3-6: Prevalence in scientific articles of Sub-Categories of Management Challenges.

In relation to **Management Best Practices Implemented**, i.e., management practices that were implemented in the scholarly articles with successful results for the management of coastal ecosystems, our review shows that these are related to and graded as follows: “Better Knowledge & Understanding” (47%), “Conservation & Restoration Actions” (14%), “Governance” (11%) followed by “Education/ Awareness/ Citizen Science” (9%), “Other Measures-Solutions” (9%) and “Policy” (9%) (Figure 3.3-7).

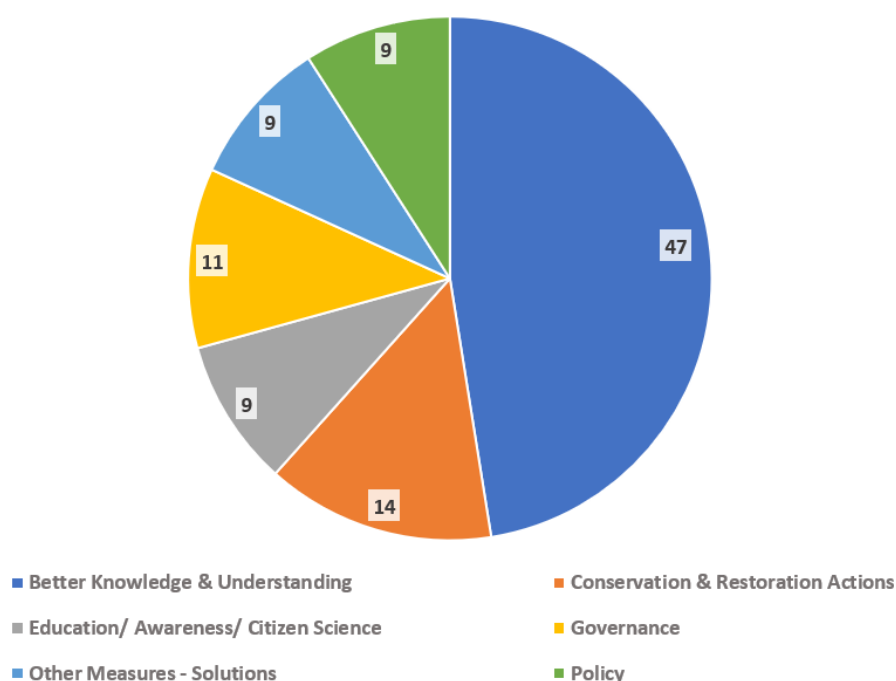


Figure 3.3-7: Prevalence (percent %) in scientific articles of Management Best Practices Implemented.

Figure 3.3-8 shows the sub-categories frequency for each management category that are identified as implemented management best practices with successful outcomes.

Management Best Practices Implemented recognised as successfully contributing to coastal ecosystems management in the category “Better Knowledge & Understanding” are mainly related to “Data Analyses, Assessments, Evaluations” (67 occurrences), followed by “Better Understanding/Definitions” (55 occurrences), “Data collection”, i.e., ad-hoc monitoring campaigns aimed at filling data gaps (29 occurrences), and ongoing, systematic monitoring programs (16 occurrences) – see Figure 3.3-8.

In the “Governance” category, Management Best Practices Implemented relate to practices that contributed successfully in promoting “Institutional Coordination & Collaboration” (11 occurrences), “Participatory Processes & Stakeholder Consultation” (11 occurrences), followed by “On-going, on-the-ground, effective Management” (5 occurrences), “Capacity Building” (3 occurrences), “Dedicated Management at the Local/Regional Scale” (2 occurrences), “Diversity of expertise” (1 occurrence), and “Allocation of resources” (1 occurrence).

Management Best Practices Implemented within the category “Other Measures-Solutions” include mainly measures that focus on “Mitigation on pressures” (12 occurrences) that are case specific, “Designation of suitable and sufficient sized MPAs” (2 occurrences) and “Nature-based Solutions (2 occurrences).

Finally, Management Best Practices Implemented within the category “Policy” are related to “Legal Protection – Protection Status” (6 occurrences), i.e. formal designation of protected areas, “Policies Integration and Collaboration” (5 occurrences), followed by integrating “Ecosystem-based approaches” into policy (3 occurrences), and “Set back policies” (2 occurrences).

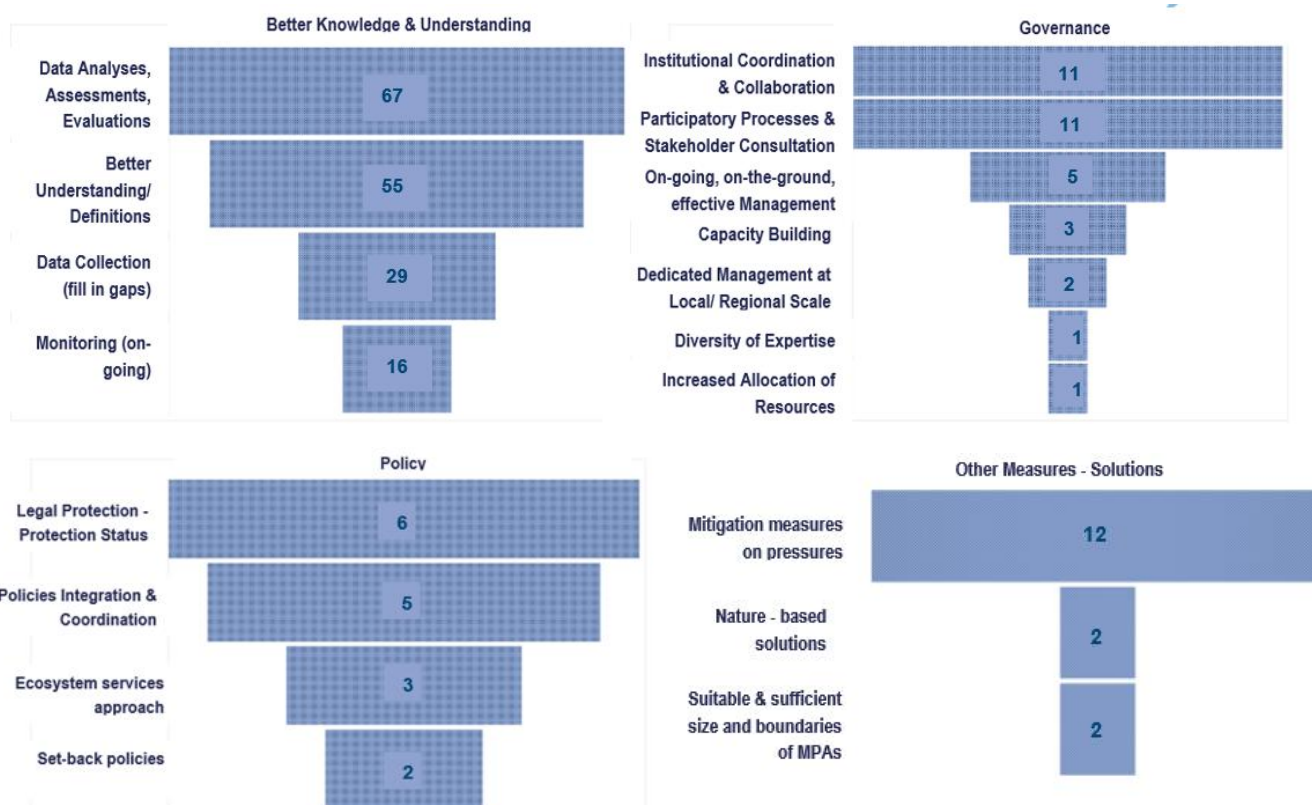


Figure 3.3-8: Prevalence in scientific articles of Sub-Categories of Implemented Management Best Practices.

In terms of **Proposed Management Practices**, i.e., management practices that are not implemented within the scholar articles, but the researchers/authors consider that their efficient implementation is crucial for the successful conservation, protection, restoration, and/or management efforts of coastal ecosystems, the literature analysis (Figure 3.3-9) shows that a great emphasis is given to practices that are related to efficient “Governance” (28%), followed by “Better Knowledge & Understanding” (20%). Then, proposed practices related to “Policy” (16%) and “Other Measures-Solutions” (16%), followed by “Conservation & Restoration Actions” (11%), and “Education/ Awareness/ Citizen Science” (9%).

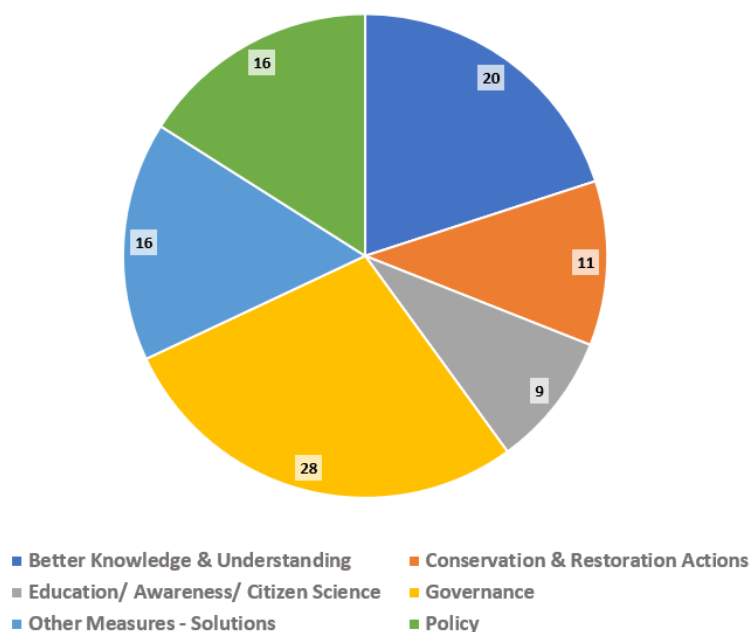


Figure 3.3-9: Prevalence (percent %) in scientific articles of Proposed Management Practices.

Within the above categories, the number of occurrences of each sub-category is presented in Figure 3.3-10.

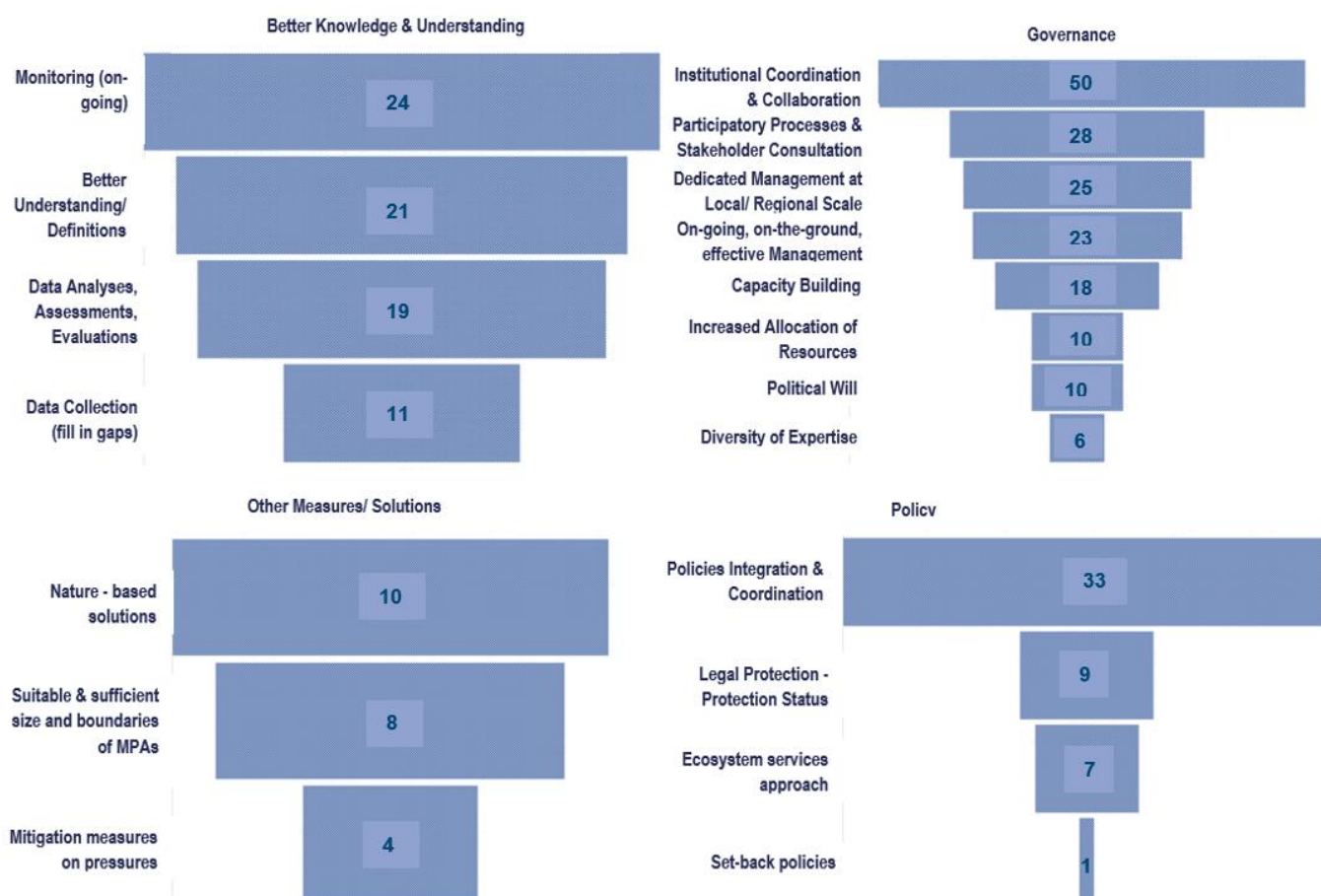


Figure 3.3-10: Prevalence in scientific articles of Sub-Categories of Proposed Management Practices.

Delving deeper into the category "Governance", it becomes evident that the majority of identified proposed management practices fall within the sub-category of "Institutional Coordination & Collaboration" (50 occurrences). This highlights the widespread recognition among authors that coordinated efforts among various stakeholders are essential for implementing cohesive and integrated management policies and practices. Additionally, other recommended management strategies that support successful biodiversity protection in this category include: "Participatory Processes & Stakeholder Consultation" (28 occurrences), "Dedicated Management at the Local/Regional Scale" (25 occurrences), "Ongoing, On-the-Ground, Effective Management" (23 occurrences), "Capacity Building" (18 occurrences), "Increased Allocation of Resources" (10 occurrences), "Political Will" (10 occurrences), and "Diversity of Expertise" (6 occurrences).

Within the category "Better Knowledge & Understanding", proposed management practices relate to "Ongoing, systematic monitoring programs" (24 occurrences), followed by "Better Understanding/Definitions" (21 occurrences), "Data Analyses, Assessments, Evaluations" (19 occurrences) and "Data collection", i.e., ad-hoc monitoring campaigns aimed at filling data gaps (11 occurrences).

Proposed management practices within the category "Policy" are related mainly to "Policies Integration and Collaboration" (33 occurrences), followed by formal designation of protected areas (9 occurrences), integrating "Ecosystem-based approaches" into policy (7 occurrences), and "Set back policies" (1 occurrence).

Finally, in "Other measures – solutions" category, proposed management practices relate to implementation of "Nature-based solutions" (10 occurrences), followed by "Designation of suitable and sufficient sized MPAs" (8 occurrences) and measures related to "Mitigation on pressures" (4 occurrences).

2. EU-funded projects

Similar analysis was performed for the EU-funded projects only for **Management Best Practices Implemented** due to the information available for these projects.

In **Horizon projects**, management practices implemented with successful results for the management of coastal ecosystems are related to and graded as follows (Figure 3.3-11): "Better Knowledge & Understanding" (41%), "Governance" (31%), followed by "Other Measures-Solutions" (17%), "Education/Awareness/ Citizen Science" (5%), "Policy" (4%) and "Conservation & Restoration Actions" (1%).

Within the category "Better Knowledge & Understanding", most management practices that were implemented fall under the sub-category "Data Collection (fill in gaps)" (27 occurrences) and then under "Data Analyses, Assessments, Evaluations" (7 occurrences), and "Better Understanding/Definitions" (4 occurrences).

Similarly, in the "Governance" category, most management practices implemented were primarily for promoting "Institutional Coordination & Collaboration" (16 occurrences), fostering "Participatory Processes & Stakeholder Consultation" (13 occurrences), improving "Capacity Building" (6 occurrences), and "Diversity of Expertise" (3 occurrences).

The category "Other measures and solutions" includes "Mitigation measures on pressures" (12 occurrences) and Nature Based Solutions (1 occurrence).

Within the category "Policy", practices focussed on "Policy Integration and Coordination" (3 occurrences).

Similarly, for **LIFE projects**, management practices implemented with successful results for the management of coastal ecosystems are related to and graded as follows (Figure 3.3-11): "Better



Knowledge & Understanding" (23%), "Conservation & Restoration Actions" (22%), "Education/ Awareness/ Citizen Science" (20%), "Other Measures-Solutions" (15%), Policy" (11%) and "Governance" (8%).

Within the category "Better Knowledge & Understanding", most implemented management practices fall under the sub-category "Monitoring (on-going)" (44 occurrences), "Data Collection (fill in gaps)" (37 occurrences), "Better Understanding/Definitions" (14 occurrences), and "Data Analyses, Assessments, Evaluations" (14 occurrences).

In the "Governance" category, most implemented management practices were primarily for "Participatory Processes & Stakeholder Consultation" (13 occurrences), Dedicated Management at Local/ Regional Scale (8 occurrences), On-going, effective Management (incl. Maintenance) (5 occurrences), followed by "Institutional Coordination & Collaboration" (3 occurrences), "Increased Allocation of Resources" (1 occurrence), and "Diversity of Expertise" (1 occurrence).

The category "Other measures and solutions" includes "Nature Based Solutions" (28 occurrences) and "Mitigation measures on pressures" (16 occurrences).

Finally, the category "Policy" includes "Policy Integration & Coordination" (21 occurrences), "Legal Protection - Protection Status" (14 occurrences) and "Set-back policies" (1 occurrence).

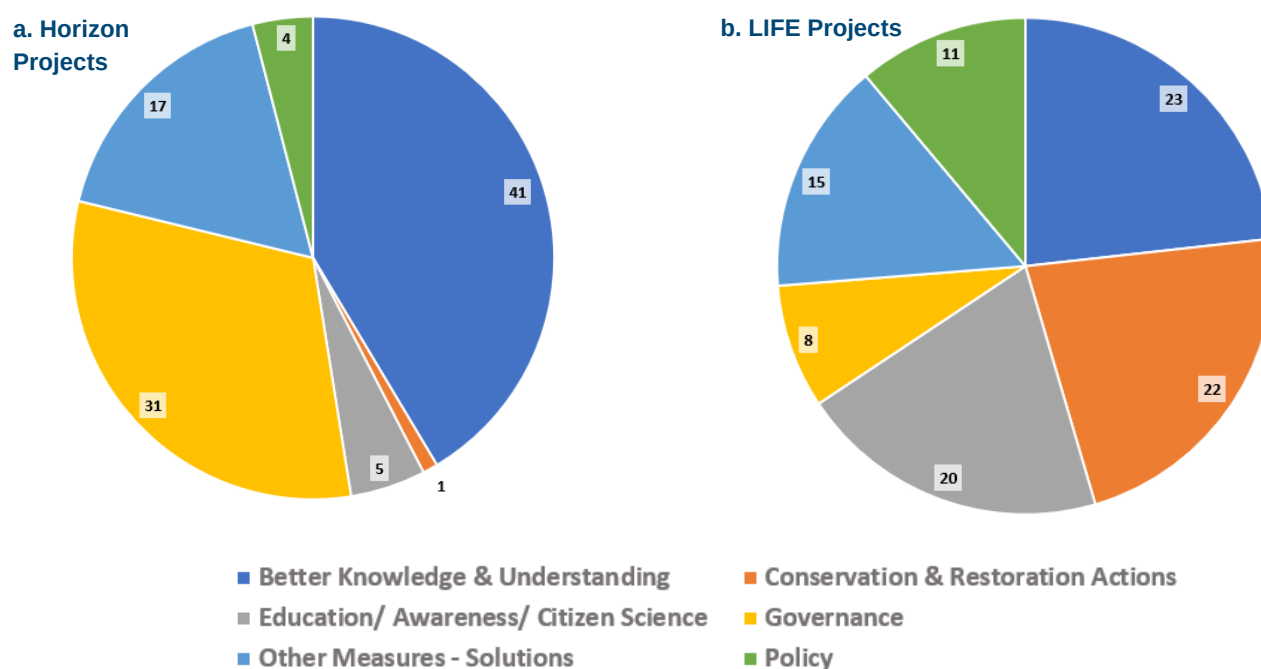


Figure 3.3-11: Prevalence (percent %) in EU-funded projects of Management Best Practices Implemented

The quantitative analysis of management practices in coastal areas, as categorized in this review and outlined separately for scientific articles and EU-funded LIFE and Horizon projects in the previous sections, provides some initial and indicative insights relating to the prevalence of implemented best management practices.

When interpreting these initial insights, it is important to recognise that findings are drawn from different contexts. On one hand, we have the general scholarly literature, as well as Horizon projects, which tend

to be more research-focused and exploratory in nature. On the other hand, LIFE projects are more action-oriented, aiming to implement tangible management practices on the ground.

Additionally, some management practices, such as conservation and restoration actions, data analyses, monitoring campaigns, and educational or awareness initiatives, are relatively more straightforward to implement within a project or academic study. These practices have clearly defined objectives, measurable outcomes within a set timeframe, and can be documented and reported with relative ease.

In contrast, other management aspects—like fostering political will, enhancing institutional coordination and collaboration, securing increased resource allocation, and achieving policy integration—are inherently more complex. These require engaging a wide array of stakeholders and decision-makers and often involve long-term commitments that extend beyond the typical lifespan of a project or study. Their success is more challenging to quantify and depends on broader systemic changes and sustained efforts over time.

Thus, while the initial insights provide a useful snapshot, they must be considered in light of these different contexts and the varying degrees of difficulty associated with implementing and measuring the outcomes of diverse management practices.

Based on the analysis above, management practices falling under the "Better Knowledge & Understanding" category have been most frequently and successfully implemented with successful results, especially within scholarly literature and Horizon projects, and to a lesser but also significant degree in the LIFE projects. In LIFE projects, "Nature Based Solutions" are considered as a management practice with successful outcomes. Furthermore, "Conservation & Restoration Actions" are a key implemented management approach in LIFE projects, as well as in scholarly literature, where they occur with less frequency. In the "Governance" category, initiatives focussing on participatory processes and stakeholder consultations, as well as efforts to enhance institutional coordination and collaboration, have also been recorded as successful.

The following sections provide a detailed description and analysis of management practices for coastal ecosystems, based on the literature review. This analysis highlights the significance of these practices, outlines potential challenges, and distills key insights for future management strategies.

3.3.2.1 Better Knowledge & Understanding

Monitoring (on-going)

The literature we reviewed emphasised the importance of ongoing and systematic monitoring programs to gather consistent data on environmental social and financial aspects for effective coastal area management. These programs are essential for tracking changes, assessing the effectiveness of management actions, and supporting adaptive management approaches (Maestro et al., 2022; Painting et al., 2020).

There is a recognised need for more integrated monitoring that addresses multiple environmental and social aspects simultaneously. This involves coupling biological data with physical and chemical parameters, as well as socioeconomic data, to better understand ecosystem functions and the interlinkages with human perspectives (Painting et al., 2020). Thus, the design and implementation of monitoring programs need to measure and analyse various parameters at different levels, including physical parameters (e.g., temperature, salinity, sea level), chemical parameters (e.g., nutrients, pollutants), biological parameters (e.g., phytoplankton, zooplankton, fish, benthos, macroalgae, birds,

mammals), other variables (e.g., marine litter), socio-economic data (e.g., visitor numbers, fishing effort, local perceptions) and ecosystem services data (Floris et al., 2020; Maestro et al., 2022; Painting et al., 2020).

Nowadays, the emergence of new and innovative tools and technologies are being used to monitor and analyse data in coastal areas. These include remote sensing for tracking large-scale environmental changes, Unmanned Aerial Vehicles (UAVs) for providing high-resolution data to monitor habitats, DNA-based techniques for detecting species presence and monitoring biodiversity, acoustic monitoring (passive and active), camera trapping for studying wildlife in remote or inaccessible areas, and Artificial Intelligence and Machine Learning tools that enhance data analysis and improve decision-making processes (Painting et al., 2020; Pinna et al., 2024).

Additionally, an essential component of monitoring is data sharing, which enables more comprehensive and integrated analyses of monitoring data. Data gathered through monitoring programs should be submitted to local, national, and international databases, in order to enhance data flow and ensure that information remains up to date (Painting et al., 2020).

Challenges that are associated with current practices include (Painting et al., 2020):

- Insufficient spatial coverage: Some areas, particularly those in the deep-sea and sub-regions of the Mediterranean Sea, have limited spatial monitoring.
- Insufficient temporal resolution: Some monitoring occurs over timescales that are too short to assess long-term impacts. For example, some programs conduct annual monitoring, potentially missing seasonal variations and short-term impacts. Additionally, acquiring long-term datasets is important, particularly for addressing cross-cutting issues, like climate change.
- Inadequate monitoring of biological parameters: There is often less coverage of biological parameters compared to physical and chemical ones.
- Lack of integration: There is a lack of integration in monitoring programs, as well as between indicators and descriptors.
- Lack of standardisation: Heterogeneity in monitoring methods limits the integration of coastal observations across different locations.
- Limited funding: A lack of sustained funding poses a risk to the sustainability of monitoring programs

Data Collection (fill in gaps)

Ad-hoc monitoring campaigns are implemented in order to gather data in specific situations, often to address information gaps or to supplement existing monitoring efforts (Corrales et al., 2020; Painting et al., 2020; Lehtiniemi et al., 2020). They can be used to supplement existing monitoring programs, particularly when resources are limited. Citizen science initiatives, for example, are often ad-hoc, utilising public participation to collect observations that can be used to supplement monitoring efforts (Lehtiniemi et al., 2020).

Ad-hoc monitoring might be needed following extreme events, such as a severe storm, which can significantly alter the environment and require additional data collection to assess the impacts and inform management decisions (Ferreira et al., 2017). The analysis of data from ad-hoc campaigns needs to consider associated limitations, such as the lack of long-term trends data, limited scope, and the possibility of bias in the case of citizen science data (Ferreira et al., 2017; Lehtiniemi et al., 2020).



Ad-hoc monitoring campaigns can play a crucial role in addressing specific knowledge gaps or supplementing existing monitoring efforts, but these efforts should be complemented by long-term, systematic monitoring programs to provide a more complete understanding of coastal ecosystems and to ensure that management decisions are based on consistent and comprehensive data.

Data Analyses, Assessments, Evaluations

A significant amount of the literature we reviewed emphasised the essential role of data analysis, assessments, and evaluations for effective coastal area management, discussing and implementing various analytical methods to derive meaningful insights from collected data. These methods are crucial for understanding complex coastal dynamics, assessing the effectiveness of management interventions, and informing future strategies and decisions.

The following are categories of data analysis, assessment, and evaluation techniques derived from the literature:

1) Statistical Analyses: Statistical analyses are crucial for interpreting patterns in coastal ecosystems. Methods such as descriptive statistics, correlation analyses, and multivariate techniques help in identifying trends and relationships in large datasets (Ernoul et al., 2021; Rodríguez-Rodríguez et al., 2019; Afonso et al., 2018; Ferreira et al., 2017).

2) Modelling Techniques: Ecosystem models and ecological forecasts are recognized as essential for decision-making, despite limitations due to uncertainties, and complex ecosystem characteristics (Corrales et al., 2020). Modelling techniques, such as Bayesian networks and ecosystem models, offer predictive power by simulating different management scenarios. Indicative examples are:

- Numerical models, such as the Long-Term Configuration (LTC) model are used to simulate shoreline evolution and predict the impacts of coastal management measures, like artificial nourishments, where sand or other sediment is used to supplement coastal areas (Pais-Barbosa et al., 2023).
- Quantile regression models to predict spatial distributions of benthic communities (Cozzoli et al., 2017).
- Bayesian Belief Networks (BBNs) are used to integrate empirical data with expert knowledge to predict the effects of human activities on coastal ecosystems (Rettig et al., 2023).
- Simplified shoreline evolution models are used to classify areas lost, maintained, or gained due to nourishment interventions (Pais-Barbosa et al., 2023).

3) Geographic Information Systems (GIS): GIS are used extensively for mapping, spatial analysis, and data integration. Their uses and applications are multiple in conservation and management in general, as well as in coastal management. GIS enable the integration of data layers spatially, related to species, habitats, pressures, etc. in order to visualize ecological impacts and plan conservation efforts. For example, GIS can be used to digitize and map the geographic locations and/or extent of species and habitats and identified coastal stressors, to integrate stressor maps with biodiversity and environmental sensitivity indices to create vulnerability maps, to analyse the spatial distribution of human activities to understand potential conflicts, to create comprehensive sensitivity, risk, and hazard layers for coastal management (Harik et al., 2017; Said et al., 2017; Ribeiro et al., 2022; de Andrés et al., 2017; Pruckner et al. 2022) and for predictive modelling.

4) Remote Sensing and Image Processing: Remote sensing and image processing techniques, such as satellite imagery and Unmanned Aerial Vehicles (UAVs), offer high-resolution monitoring of coastal habitats. These technologies are particularly useful in monitoring remote or difficult-to-access areas, enabling the detection of large-scale environmental changes over time. High-resolution satellite and aerial

images can be used to assess coastal typology and sensitivity, coastal vulnerability, condition of ecosystems-amongst other habitat characteristics. (Harik et al., 2017; Ferreira, 2023).

5) Trend Analyses: Trend analyses of long-term datasets allow for the identification of gradual changes in coastal ecosystems, such as sea level rise, sediment deposition, habitat degradation, and the assessment of the effectiveness of management practices (Pais-Barbosa et al., 2023; Inácio et al., 2018). Trend analysis is particularly important in managing ecosystems affected by climate change, as demonstrated by studies on heatwave-induced seagrass loss (Pruckner et al., 2022).

6) Indicators and Indices: Multi-criteria indices and indicators are developed to assess the condition of ecosystems and their components and its functioning, to evaluate the impact of human activities, the success of management actions, and to inform management decisions (Corrales et al., 2020). Indicative examples of indices are (Harik et al., 2017; Pruckner et al., 2022; Corrales et al., 2020): Coastal Vulnerability Index (CVI), a commonly used index for areas with limited data, Environmental Sensitivity Index (ESI) to quantify coastal sensitivity to pollution, Biodiversity Richness Index (BRI) to quantify coastal anthropogenic vulnerabilities, and Seagrass residency index (SRI) to score the dependency of Mediterranean fish species in seagrass compared to other habitats, etc.

7) Artificial Intelligence (AI) and Machine Learning (ML): AI and ML are emerging tools that are greatly enhancing the capabilities of coastal data analysis. AI can process large datasets and identify patterns that may be too complex for traditional methods, often in a shorter amount of time. AI-based models are becoming increasingly popular in the automation of data collection, as well as in predictive modelling for ecosystem management. These models can process vast amounts of data from various sources, such as remote sensing, satellite imagery, and field surveys, and integrate this information into models that predict future trends, allowing for better-informed decisions and targeted conservation measures (Ernoul et al., 2021; Shivaprakash et al., 2022).

All the methods described above, and their combination, provide critical insights for understanding ecosystem dynamics, human impacts, and the effectiveness of management strategies. They not only significantly contribute to decision-making, but also support adaptive management practices.

Better Understanding/ Definitions

Throughout the literature review, we identified a recurrent theme, which was related to the need for the common understanding of concepts and shared and agreed perceptions, particularly in the context of complex systems and environmental management.

For instance, Morelli et al. (2024) address the resilience approach to the governance of complex systems, using as a case study the Po delta area in Italy. They argue that in order to effectively integrate resilience into the realm of coastal governance, gaining a better understanding of the concept is necessary. Engaging various actors in the assessment of a system's resilience is vital as it helps incorporate stakeholders' perspectives on the definition of coastal resilience and on governance options and also fosters social learning.

Zanin et al. (2023) discuss various approaches to coastal risk management based on insights from Italy and argue that risk management involves cultural aspects, including perception. The acknowledgement of risk perception by stakeholders and local communities, as one of the social pillars of risk analysis, is often lacking.

Similarly, Martinez et al. (2020), in their study of two coastal communities in Northern Germany and Western Portugal, highlight the critical role that culture, along with socio-economic and political factors,



plays in addressing risks and developing effective disaster risk reduction strategies. Based on interviews and participatory observations, the authors emphasize the importance of involving communities in these processes to build trust in scientific information and improve decision-making by coastal authorities. They argue that community engagement is essential for the successful formulation and implementation of risk reduction solutions.

3.3.2.2 Governance

Coastal regions are typically governed by multiple institutions across various administrative levels, with overlapping jurisdictions, responsibilities, and interests. Today's governance "landscape" involves a wide array of stakeholders and actors responsible for decision-making at multiple levels, from international to local, aiming to coordinate actions and policies across different administrative and spatial scales. With the emergence of maritime spatial planning policies in the late 20th century, the management of land-sea interactions along the coast has gained greater importance, calling for multi-level governance and new forms of policy and governance integration. The integration and coordination of various sectoral policies for coastal areas are seen as vital to the success of management strategies, despite the numerous challenges in achieving them. Governance is no longer solely the responsibility of governments; it now involves a broad range of public and private actors with differing, often conflicting, interests, values, and perspectives. Governance is characterized by a continuous co-evolution between the governance system (institutions and actors) and the system being governed (coastal areas), shaped by their interactions in terms of power, cooperation, and knowledge.

For successful, adaptive, and inclusive governance of coastal areas, institutional coordination, collaboration, participatory processes and stakeholder inclusion, diversity of expertise, adequate resource allocation, ongoing capacity-building for all stakeholders, dedicated local and regional management structures, and strong political will, are all essential. Given the persistent global environmental challenges, especially in coastal regions, it is increasingly recognized that without substantial changes in coastal governance, these regions are at high risk of further decline, unable to adapt to the evolving climate and societal changes (Gonçalves & Pinho, 2024).

Institutional Coordination & Collaboration

The governance of coastal zones by various policies, institutions, actors, and changing needs creates challenges, related to fragmentation and poor coordination of coastal management strategies and plans, resulting in conflicting dynamics, diverse perspectives, jurisdictional disparities, and different configurations (Motta Zanin et al., 2023; Gonçalves and Pinho, 2024). Poor communication and lack of coordination between institutions responsible for management aspects of coastal areas can be a significant obstacle in design and implementation of coherent plans and strategies (Morelli et al. 2024) and can create many weaknesses such as short-term political objectives, insufficient resources, conflicts, and inadequate communication (Morelli et al. 2024).

Coordination of actions and policies across all different administrative and spatial levels is essential (Gonçalves and Pinho, 2024; Cavallo et al., 2018). This includes both vertical (national to regional-local) and horizontal (inter-sectorial and interdisciplinary) integration (Motta Zanin et al., 2023). Efficient coordination between sectorial policies, such as tourism and fisheries, as well as between public and private sectors is essential (Kyvelou & Ierapetritis, 2020). Inter-institutional cooperation is needed to encourage national, regional, and local initiatives, adopt measures to reinforce cooperation and coordinate

inter-sectoral activities promoted by administrative institutions and local authorities in coastal zones (Floris et al., 2020). Additionally, institutional coordination and collaboration considers the range of knowledge from different disciplines, such as hydrology, ecology, biology, economics, sociology that is essential in coastal area management (Bryhn et al., 2017).

Participatory Processes & Stakeholder Consultation

Effective coastal governance involves numerous stakeholders and actors, from international to local levels, including government, the private sector, and civil society (Gonçalves and Pinho, 2024). It requires incorporating multiple values, interests, and agendas (Morelli et al., 2024). The involvement and inclusion of local communities, related stakeholders, and various interest groups at all stages of coastal planning and management processes is nowadays imperative and crucial for greater transparency, social acceptability, and support (Maestro et al., 2022). Also, equally important is the empowering of local communities and stakeholders, so their involvement in decision-making processes can be efficient and fruitful (Morelli et al. 2024). The inclusion of local communities and stakeholders in decision-making processes is not just a procedural step, but a fundamental component of effective coastal governance, recognised as highly important by both scientific community and policy makers, and is strongly advocated by international and European frameworks (Pais-Barbosa et al., 2023; Morelli et al. 2024), since it contributes to:

- Improved decision-making: Including stakeholders in discussions and allowing them to influence decisions leads to improved decision-making (Bryhn et al., 2017). Stakeholder engagement ensures that diverse perspectives and additional insights are considered, which leads to knowledge strengthening and more comprehensive and effective strategies for coastal management and resilience (Morelli et al., 2024; Bryhn et al., 2017).
- Increased acceptance and trust: When stakeholders are involved in all phases of a process, it is more likely that they will accept resulting measures (Bryhn et al., 2017). By engaging stakeholders in the decision-making process, their perspectives are considered, and their concerns are addressed, leading to increased trust and greater acceptance of coastal management policies and preventing conflicts (Pais-Barbosa et al., 2023).
- Social learning and knowledge exchange: Stakeholder engagement promotes social learning by reducing the gap between different perspectives and changing actors' relationships, understanding, values, and norms (Lago et al., 2019; Motta Zanin, 2023).
- Understanding local context and conditions: Stakeholder participation, and especially local communities, is essential to understand the local context and the specific needs, characteristics, and priorities in different coastal areas (Gonçalves and Pinho, 2024; Malinauskaite et al., 2022). The incorporation of local knowledge and values is crucial for any effective coastal governance (Morelli et al. 2024).
- Empowerment: Efficient and transparent stakeholder involvement and consultation can empower them and contribute to the development of a more resilient community (Morelli et al. 2024). Empowering local communities ensures that regulations and measures better reflect the specific needs of the local coastal area (Gonçalves and Pinho, 2024).
- Addressing conflicts: Stakeholder involvement is key to addressing conflicts between user-groups and in mediating disputes and conflicts (Piñeiro-Antelo et al., 2020). Dialogue facilitation and mediation of disputes are important components in addressing conflicts (Gonçalves and Pinho, 2024), through having a discussion mediator, who is not part of the government, and can help bridge different perspectives, ensure legitimacy, and help consensus building (Greenhill et al.,

2021).

- Improved implementation: Successful participatory governance promotes local willingness to implement conservation programs (Maestro et al., 2022) and fosters collaboration and consensus-building (Motta Zanin, 2023).

Political Will

Political will is a critical component of effective coastal governance. A recurring theme across multiple scholarly articles we reviewed is the lack of strong political will to support and implement effective coastal governance. Its absence is viewed as a major impediment to addressing the complex challenges facing coastal regions. Insufficient political will leads to inadequate resource allocation, limited policy development, and implementation with a short-term vision (Gonçalves and Pinho, 2024; Schmidt et al., 2014). This further results in a sectoral approach and the continuation of overexploitation of coastal resources and landscape degradation (Morelli et al., 2024).

Guidetti et al. (2018) discussed that a general lack of political will in some Member States has contributed to the ineffectiveness of marine Natura 2000 sites. Even when legal frameworks and conservation tools exist, they may not be properly implemented or enforced without sufficient political support. For instance, in Portugal, despite the development of the National Strategy for Integrated Coastal Zone Management, the absence of reliable political will and institutional coordination and collaboration led to its non-implementation. Additionally, there have been long-standing calls for a Framework Law for the Coast, but the political will to implement such a law has been inconsistent. This highlights the crucial role of political support in translating policy goals into action (Gonçalves and Pinho, 2024). Also, governments tend to have short-term visions and prioritise economic development over conservation, especially when there are conflicts between the two (Sebastiá-Frasquet et al., 2014).

Gonçalves and Pinho (2024) suggest that ways to foster political will include: a) increasing awareness among policymakers and the public about the value and vulnerability of coastal areas, b) effective public participation and stakeholder engagement to ensure that coastal communities are more aware of the importance of coastal areas and thus are more likely to pressure the government to take action, and c) learning from environmental catastrophes, where significant changes may only take place if a new environmental catastrophe occurs, underscoring the need for proactive measures driven by political will rather than reactive measures driven by crisis.

Diversity of Expertise

Coastal zones are complex areas with overlapping uses and diverse and evolving ecological, social, and economic needs that require diverse perspectives to manage them effectively (Morelli et al., 2024). Coastal management requires an integrated approach, which necessitates the involvement of multidisciplinary teams to reconcile the protection of ecosystems and their services with the economic development of local populations and social needs (Maestro et al., 2022). Encouraging knowledge exchange and collaboration of scientific experts from regional and interregional agencies, administrations, universities, and research institutes are essential for providing technical and scientific knowledge for efficient coastal management (Motta Zanin, 2023). In this knowledge exchange and collaboration, a crucial component is local and traditional knowledge by local communities and local stakeholders, which possess valuable insights into the coastal environment and can contribute to more sustainable practices (Ernoul et al., 2021).



Diversity of expertise in coastal management ensures a more comprehensive understanding of the complex interactions between human activities and coastal ecosystems, contributes to more informed decision-making, enhances the effectiveness of management strategies, improves legitimacy of the decisions, facilitates conflict resolution, leads to more sustainable outcomes, promotes adaptive management, and strengthens the social-ecological system's resilience to climate change and other environmental hazards (Gonçalves and Pinho, 2024; Maestro et al., 2022; Martínez-López et al., 2019; Harik et al., 2017).

Increased Allocation of Resources

Many authors highlight that the long-term planning and implementation of coastal ecosystem management strategies rely significantly on the adequate allocation of financial, technical, and human resources (Morelli et al., 2024; Gonçalves and Pinho, 2024; Maestro et al., 2022; Ferreira et al., 2019). Continuous financial investment is essential to ensure the presence of specialised, diverse, and well-trained staff and to support the consistent development and execution of management plans, along with associated activities, such as monitoring programs, conservation actions, education and awareness efforts. Technical resources, including advanced technologies and scientific expertise, are necessary to monitor and effectively address emerging challenges. Finally, skilled professionals across various fields are vital for the successful implementation of management plans, conservation actions, monitoring, enforcement of regulations, fostering community, and stakeholder engagement in conservation initiatives and sustainable practices (Ferreira et al., 2019; Maestro et al., 2022).

Adequate financial resources are essential for basic management and surveillance, including staff salaries, equipment, and fuel. However, funding should also support innovative initiatives, including research, development, educational programs, and monitoring efforts. Successful funding models, such as those implemented in Croatian MPAs, emphasize (a) diversified funding sources - combining public and private funds, projects, donations, sponsorships, and self-generated income and (b) autonomous, sustainable financing strategies, like concession programs for tourism (Maestro et al., 2022).

Human resources for managing coastal areas require multidisciplinary teams that allows them to approach management with an ecosystem approach, which is necessary to reconcile the protection of ecosystems and their services with the economic development of local populations (Cárcamo et al., 2014; Tallis et al., 2009). Appropriate on-going training and capacity building is fundamental to successfully addressing management evolving challenges. For example, conflict resolution and working towards a sustainable relationship between environment and society is a multifaceted process that encompasses many different forms of capacity building (Van der Molen, 2018, Maestro et al., 2022).

Technical resources, including technology, research, and expertise, are also an integral part of designing and implementing effective coastal management solutions. Modern technologies such as remote sensing, GIS, DNA, and satellite monitoring offer innovative ways to track environmental changes in coastal zones, enabling timely interventions. These technical tools enable the collection of important data on aspects like shoreline erosion, water quality and biodiversity, which are fundamental to making informed conservation decisions. Moreover, technical expertise is necessary to design and execute coastal conservation projects, such as the restoration of wetlands and the design of nature-based solutions. Without access to emerging technologies and scientific knowledge, coastal management practices may fail to address the complex challenges facing these environments (Tallis et al., 2010).



Dedicated Management at Local/ Regional Scale

The challenges faced by coastal areas - ranging from habitat degradation, non-sustainable practices, coastal erosion and impacts of climate change - require a coordinated and tailored approach. Specialized and dedicated coastal management authorities or structures at the local or regional level are vital for addressing the specific local needs and challenges, ensuring that sustainable management strategies are not only planned, but also effectively executed (Maestro et al., 2022). A lack of dedicated local or regional coastal actors to address multi-level governance in coastal regions creates challenges (Gonçalves and Pinho, 2024).

Coastal regions vary significantly in terms of their ecological features, economic activities, and social dynamics. As a result, management strategies that work in one region may not necessarily be effective in another. Specialised local or regional management structures are better at allowing for enhanced coordination among local stakeholders and communities, including governmental agencies, local communities, private sectors, and environmental organizations (Sebastiá-Frasquet et al., 2014). These agencies and organizations can form relationships with local actors and communities, enabling them to work together to achieve common conservation and management goals (Berkes, 2004). Local management authorities, which operate with in-depth knowledge of the specific conditions of the area they oversee, are better positioned to create, and implement context-specific strategies (Sebastiá-Frasquet et al., 2014; Maestro et al., 2022).

Furthermore, localized management allows for adaptive governance, where strategies can be adjusted based on real-time environmental monitoring and community feedback and allows the flexibility to respond rapidly to emerging issues (Greenhill et al., 2021). Decision-making at this level is more responsive and contextually informed, compared to top-down management systems (Armitage et al., 2009). Local authorities can implement context-specific solutions, such as restricting activities in sensitive habitats during certain times of the year, managing sustainable fishing quotas, or balancing tourism with conservation efforts. For instance, Croatia's MPA management framework focuses on sustainable tourism through concessions, which allows for economic benefits while minimizing the environmental footprint (Maestro et al., 2022). Tailoring strategies to local needs also enhances the ability of management authorities to garner public support and compliance, as these strategies will align with the livelihoods and interests of local communities.

Moreover, local management structures can facilitate knowledge transfer between scientists, policymakers, and local communities, thereby improving the effectiveness of conservation and management efforts. For instance, co-management approaches, where local communities participate in decision-making, have been shown to be successful in integrating scientific and traditional ecological knowledge (Berkes, 2009). This combination of expertise enhances the ability to manage coastal areas sustainably, while also empowering local communities.

Dedicated management authorities are also crucial for ensuring accountability in the execution of coastal management plans. By establishing clear governance structures with well-defined roles and responsibilities, these authorities can monitor the progress of management actions, enforce regulations, and ensure transparency in decision-making processes. This level of accountability is particularly important for addressing challenges such as illegal activities, pollution control, and habitat destruction (Van der Molen, 2018).

On-going, on-the-ground, effective Management

In some cases, protected areas are designated as such, but are not given adequate resources. The result is that biodiversity conservation is not ensured, leading to ineffective management. This is referred to as “paper parks”, i.e., areas that have been designated as protected, perhaps they have management plans, but in practice they receive no management at all (Maestro et al., 2022). One of the reasons is that there are no on-going, on-the-ground, effective management structures. Additionally, there are examples, where conservation and restoration actions are implemented through project funding, but following on from that there are no human or financial resources to continue the work or implement on-going maintenance and management of implemented actions beyond the relevant project, resulting in inefficient practices (Ermgassen et al., 2023).

Management fundamentally involves executing the plans and programs developed during the planning stage. Alongside the implementation of various measures, continuous monitoring is also crucial. Many authorities adopt adaptive management as a core approach to conservation efforts. This cyclical process involves systematically testing assumptions, generating insights through evaluating outcomes, and continuously refining and improving management practices (Van der Molen, 2018). By doing so, it helps identify the most effective strategies to achieve desired results and enhances the understanding of how objectives should adapt to changing conditions (Maestro et al., 2022). Regular systems of monitoring and evaluation are necessary, with particular attention to the analysis of socio-economic aspects of coastal areas and local community perceptions. This process cannot be followed efficiently if there are no management structures, dedicated to the on-going, on-the-ground, and effective management of coastal areas.

Capacity Building

Capacity building, which involves strengthening the skills, knowledge, and abilities of individuals and institutions responsible for designing and implementing coastal management strategies and governance, is of utmost importance for effective and sustainable coastal management.

Capacity building is necessary for the development of modern coastal adaptation strategies that encompass social, environmental, and economic factors (Pais-Barbosa et al., 2023). Without adequate capacity, management plans cannot be fully implemented, monitoring is insufficient, and the potential for long-term conservation is compromised (Maestro et al., 2022).

Capacity building is a multifaceted process that includes various forms, such as conflict resolution and working towards a sustainable relationship between the environment and society. It also involves enhancing the quality and durability of decisions, creating ownership, and resolving trade-offs (Maestro et al., 2022; Lago et al., 2019).

Those managing coastal areas, whether staff or volunteers, must be trained in planning, conservation, and management aspects, based on current and emerging priorities and specific needs, though many coastal areas lack established training programs (Maestro et al., 2022). Interdisciplinary and transdisciplinary knowledge is fundamental, as is effective stakeholder involvement, and capacity building should include training in specific skills, such as conflict resolution techniques, negotiation and decision-making, and resource economics, among many others, in order to promote sustainable environmental and socio-economic conditions (Gonçalves and Pinho, 2024; Maestro et al., 2022; Morelli et al., 2024).

Capacity building is not only for individuals, but also for institutions and organisations. This includes creating networks of managers linked to different coastal areas to promote the exchange of experience

and knowledge. It also involves developing an inter-institutional program to train staff in integrated coastal and marine management (Maestro et al., 2022).

Capacity building can also help in navigating governance complexities. It supports the integration of resilience into coastal governance, enabling better management of complex situations (Morelli et al., 2024). Additionally, it can enhance the ability to negotiate and share resources among various actors (Morelli et al., 2024). It is a key process that helps to build the capacity of actors to mobilize knowledge and resources for action and promotes social learning, improving their ability to adapt to changing conditions in coastal areas (Lago et al., 2019).

3.3.2.3 Policy

Policies Integration & Coordination

The integration and alignment of various sectoral policies are crucial for effective coastal areas management, which is inherently complex due to the multifaceted interactions between environmental, social, and economic factors, as well as the complexity of interactions that exist between species, habitats, and ecosystem processes (Bryhn et al., 2016). Coastal areas serve as hubs for many human activities, such as tourism, fishing, shipping, and urban development, and they are also vulnerable to environmental degradation, climate change, erosion, and natural disasters.

When policies from different sectors are not aligned, conflicting objectives arise (Cantaluppi et al., 2023; Gonçalves and Pinho, 2024). There is a call for greater coherence between environmental and sectoral policies to prevent biodiversity loss and maximize ecosystem services (Cantaluppi et al., 2023). Policies are often developed or implemented individually with reference to different scales and objectives, resulting in a patchwork of incoherent ambitions (Rouillard et al., 2018). Moreover, by coordinating policies, decision-makers can better address cross-cutting issues like biodiversity conservation, disaster risk reduction, and pollution control, while also considering the livelihoods of coastal communities (Barbosa et al., 2023)

The EU has developed a comprehensive framework for coastal ecosystems management, responding gradually to the need for sustainable development, environmental protection, and social inclusion in coastal areas, moving gradually towards a more sector-integrated, social inclusion and ecosystem-based management approach. ICZM, MSP and MSFD are examples of such unified approaches that help harmonize these policies to avoid conflicts, serve as tools for coordinating and integrating different uses, and ensure, at policy level, that actions in one sector support the broader objectives of sustainability, resilience, and social equity (Douvere and Ehler, 2009; Gonçalves and Pinho, 2024; Pye et al., 2020; Cavallo et al., 2018). This integration promotes synergies and enhances the efficient use of resources. However, although the EU provides this policy framework and direction, it is on Member States to implement these policies, and in many cases the desired level of integration is not achieved (Cavallo et al., 2018; Gonçalves and Pinho, 2024).

There are several challenges and barriers acknowledged in achieving true policy integration, such as lack of coordination of actions and policies across different administrative and spatial levels, the presence of conflicting interests among different actors and sectors, the tendency to divide governance into separate components, such as coastal, spatial, marine, environmental, and landscape planning; these are a sign of a lack of a more systemic approach and the absence of a strong political will for integrated approaches (Gonçalves and Pinho, 2024).



Legal Protection - Protection Status

The formal designation of protected areas through legal frameworks and regulations can play a pivotal role in safeguarding coastal biodiversity. By restricting harmful human activities and promoting conservation efforts, legal designation serves as a fundamental tool for the protection of ecosystems (Rodríguez-Rodríguez et al., 2016). Marine Protected Areas (MPAs), for example, are legally designated regions that focus on the long-term conservation of biodiversity, ecosystem services, and cultural values. These areas are specifically created to restrict or prohibit activities that negatively impact the environment, thus offering a structured approach to conservation (Rodríguez-Rodríguez et al., 2016). In many MPAs, as well as in Natura 2000 protected areas, a zoning is applied, designed to have varied levels of restrictions on human activities, reflecting the need to balance protection with some sustainable uses (Afonso et al., 2018).

Even though, it is emphasised that legal designation is a key step towards achieving effective conservation outcomes, it is however not sufficient on its own, and should be combined with other management strategies and considerations (Afonso et al., 2018; Floris et al., 2020; Maestro et al., 2022; Rodríguez-Rodríguez et al., 2016). Decades of studies have shown that the designation of protected areas can preserve biodiversity and ecosystem functions, when these are well managed (García-Rubies and Zabala, 1990; Marbà et al., 2002; Sala et al., 2012; Edgar et al., 2014; Zupan et al., 2018; Frascchetti et al., 2022 in Gianni et al. 2022). While legal designation of protected areas through legal frameworks is undeniably significant for safeguarding coastal biodiversity, achieving successful conservation outcomes requires more than just legal protection. Many protected areas are underperforming due to several factors, including weak enforcement mechanisms, poor design in terms of boundaries and zoning, ineffective stakeholder involvement, insufficient education of local communities, stakeholders, and visitors, as well as the failure to implement management plans and monitoring programs (Afonso et al., 2018, Gianni et al. 2022).

Set-back policies

Set-back policies refer to regulations that establish a minimum distance between development and the shoreline to minimise environmental impacts from anthropogenic activities, prevent erosion, protect coastal habitats, as well as minimise environmental and climate change risks to coastal communities (Mirauda et al., 2022; Motta Zanin et al., 2023; Gonçalves & Pinho, 2024; Van der Biest et al., 2017; Bullimore, 2014).

Set-back policies can be informed by long-term estimates of erosion or sea-level rise, meaning that the distance between development and the shoreline can be adjusted based on scientific projections of future coastal changes (Mirauda et al., 2022). Despite their advantages, implementing set-back policies can face challenges, such as land use conflicts and opposition from residents and landowners (Bullimore, 2014).

These policies are used in various aspects of coastal protection, such as:

- Protection of coastal habitats and species: Set-back policies help to protect coastal ecosystems by reducing the impacts of human-made structures, such as those that inhibit the natural movement of habitats or runoff that leads to increased water pollution (Mirauda et al., 2022; Gonçalves and Pinho, 2024). Additionally, set-back policies can contribute to the preservation of habitats, where certain plants and animals can thrive by prohibiting new development within a certain distance from the coast (Mirauda et al., 2022). For example, they can contribute to natural sand dune migration (Van der Biest et al., 2017). Additionally, set-back policies can help mitigate the effects of coastal squeeze, where coastal habitats are trapped between the sea and human development, allowing for landward migration



(Bullimore, 2014).

- Facilitation of natural shoreline movement: Set-back policies enable the natural movement of the shoreline in response to erosion or sea-level rise, instead of being constrained by development and impediments from the built environment (Mirauda et al., 2022).
- Protection of coastal communities by managed retreat: Set-back policies can be part of a broader management strategy of managed retreat, which involves allowing the shoreline to move naturally inland, in response to erosion or sea-level rise, rather than trying to hold it in place with hard structures (Bullimore, 2014; Mirauda et al., 2022). Decision support tools that integrate climate change risks, land use changes, and population growth forecasts can also help reduce risks by preventing development in high-risk areas or relocating people and property away from risk zones (Mirauda et al., 2022; Van der Biest et al., 2017). Set-back policies also ensure continued public access to the coastal zone (Gonçalves & Pinho, 2024). However, local communities may sometimes perceive managed retreat as disproportionate to their perceived risk (Motta Zanin et al., 2023).
- Prevent erosion: Set-back policies serve as a "soft" or "green" coastal protection measure, which is more adaptable to rising sea levels and less likely to cause additional erosion, compared to hard structures like seawalls (Mirauda et al., 2022; Motta Zanin et al., 2023).

Ecosystem services approach within policies

The sustainable management of coastal ecosystems is a multifaceted process that requires an integrated approach, considering the interactions between natural systems and human factors (Floris et al., 2020; de Andrés et al., 2018). This integrated method, referred to as ecosystem-based management, is increasingly being used as a framework for delivering sustainable development in both the terrestrial and the coastal and marine environment (Floris et al., 2020; de Andrés et al., 2018; Douvere and Ehler, 2009).

Ecosystem-based management emphasizes the need to manage ecosystems holistically, recognizing the functional relationships between species, habitats, and ecosystem processes, as well as the impact of human activities on these systems (Floris et al., 2020; Douvere and Ehler, 2009).

A key element of ecosystem-based management is the understanding and assessment of the ecosystem services provided by coastal ecosystems (Inácio et al., 2018; Floris et al., 2020). These services can be divided into four main categories: provisioning services (e.g., food), regulating services (e.g., climate regulation), cultural services (e.g., recreational opportunities), and supporting services (e.g., coastal protection, Inácio et al., 2018; Floris et al., 2020). Management and planning should aim to maintain and enhance these services (Martínez-López et al., 2019).

Valuing ecosystem services, whether through monetary or non-monetary methods, can provide valuable insights for decision-making (Inácio et al., 2018). This process highlights the significance of coastal ecosystem services to society and emphasizes the benefits that local communities receive from these systems. The outcomes of such valuations have implications for future governance actions related to coastal areas and can help justify sustainable investments in coastal management. This is essential for maintaining the flow of coastal ecosystem services for both present and future generations (Inácio et al., 2018; Ferreira et al., 2017).

An ecosystem services approach promotes the use of adaptive management practices, the need to carry out management actions at multiple scales, inter-sectoral cooperation, improved policy integration, stakeholder engagement, with monitoring to assess the impact of coastal management on ecosystem services (Douvere and Ehler, 2009; Lago et al., 2019; Ferreira et al., 2017; Martínez-López et al., 2019).

The ecosystem services approach often promotes nature-based solutions for coastal management (Motta Motta Zanin et al., 2023). These solutions use natural processes and ecosystems to provide benefits like coastal protection and can be more sustainable and cost-effective than traditional engineering solutions (see also section 3.3.2.6).

Despite the recognised importance of the ecosystem services approach, the literature also indicates challenges to its widespread adoption, including:

- Lack of integration into practice: While the scientific community acknowledges the importance of integrating ecosystem services into planning, this is not commonly done in practice (Floris et al., 2020).
- Data gaps: The assessment, operationalisation, and valuation of coastal and marine ecosystem services face knowledge gaps (Inácio et al., 2018; Potts et al. 2014).
- Overlapping legal jurisdictions: Coastal zones are frequently regulated by various institutions and agencies with overlapping jurisdictions. This often leads to a fragmented and poorly coordinated approach to coastal management (Gonçalves and Pinho, 2024).

3.3.2.4 Conservation & Restoration Actions

One of the broad categories identified in the literature review for the management of coastal areas, and/or ecosystems and/or habitats and/or species management, is the implementation of conservation and restoration measures. Conservation and restoration measures are targeted efforts designed to protect, conserve, restore, or enhance threatened species, ecosystems, and habitat types. Such actions are often important for mitigating biodiversity loss, preserving ecosystem functions, and promoting natural resource sustainability.

An analysis of the literature we reviewed, allowed us to group the most common conservation and restoration measures related to coastal biodiversity into eight categories according to their target ecosystem, habitat, or species. These are described in the following paragraphs.

Seagrass meadows

Seagrass protection and restoration is critically important due to the vital ecological, economic, and social roles that seagrass ecosystems play. Seagrass meadows act as underwater nurseries, providing habitat and shelter for a diverse range of marine species, including commercially valuable fish and invertebrates. They contribute significantly to coastal protection by stabilising sediments, reducing erosion, and buffering wave energy (Pergent-Martini et al., 2006).

A number of projects in the literature we reviewed, implemented seagrass restoration projects in order to rehabilitate degraded habitats. Usually, the first step is identification and mapping of seagrass, such as *Cymodocea nodosa* and *Posidonia oceanica* beds, using aerial and satellite tele-detection, which are particularly suitable for surveying shallow waters, while side-scan sonar provides valuable information for deeper waters. Targeted restoration of vascular plants was then carried out to rehabilitate degraded or threatened seagrass meadow habitats, using techniques, such as transplanting healthy seagrass from thriving areas (Pergent-Martini et al., 2006; Kindeberg et al., 2022; Ribeiro et al., 2022; Krost et al., 2017). Seagrass restoration can counter habitat loss, support fisheries, and ensure the long-term sustainability of marine ecosystems.

A challenge in seagrass protection and restoration efforts, as highlighted by Krost et al. (2017), is that historically aquatic ecosystems were treated as a singular entity, with little focus on the distinct needs of

different biotopes, such as seagrass beds. As a result, the more vulnerable of these ecosystems have often lacked proper protection and management. It was also highlighted that seagrass restoration efforts must be carefully integrated with local human uses and activities to balance both ecological needs and human needs (Krost et al., 2017; Pergent-Martini et al., 2006; Kindeberg et al., 2022; Ribeiro et al., 2022).

Reefs

Reefs are vital ecosystems that deliver a wide range of ecological economic and cultural benefits (Potts et al., 2014). They support primary production and nutrient cycling, forming the backbone of marine food webs, while providing habitats for numerous species, including those of commercial and cultural importance. Reefs also serve as physical barriers, protecting coastlines from erosion and natural hazards, while regulating water and sediment quality (Potts et al., 2014).

Several of the literature we reviewed reported on reef restoration projects in order to conserve and restore threatened reef habitats. According to Potts et al. (2014), the designation of a Marine Protected Area in Lyme Bay highlighted the critical supporting services of reefs, such as habitat provision and nutrient cycling. Following the closure of the area to certain fishing practices, reef structural fauna and scallop densities increased, likely creating additional benefits for adjacent fisheries. This protection also boosted recreational industries, like diving and sea angling, highlighting the socio-economic value of reef conservation.

Additionally, artificial reefs have recently been implemented across Europe, with the majority concentrated in the Mediterranean Sea, though northern European regions are showing growing interest (Fabi et al., 2011; Perkol - Finkel et al., 2012). In the Mediterranean and along the Iberian Peninsula's Atlantic coast, these reefs are primarily used for fish stock enhancement and fisheries management, while in other parts of Europe, they are more commonly used for conservation, restoration, research, and recreation. Cyprus and Greece, for example, use artificial reefs to restore marine environments and enhance small-scale fisheries. Cyprus has implemented a strategy using concrete modules to curb illegal trawling and increase biodiversity. France and Italy also use reefs to protect sensitive areas like seagrass beds and coralligenous habitats, often with anti-trawling designs (Fabi et al., 2011).

The transplantation of juvenile *Cystoseira barbata*, a canopy-forming algae, to both artificial and natural sites has shown higher survival rates on artificial than on native habitats, demonstrating the effectiveness of artificial reefs in hosting biodiversity (Perkol - Finkel et al., 2012). Despite these positive results, the success of artificial reefs relies on careful site selection, pressure control and management, and long-term monitoring to ensure sustainable ecological and socio-economic benefits.

Birds

Bird conservation is vital in coastal management, because birds play key roles in maintaining ecosystem balance and health. Many bird species, including migratory and coastal birds, contribute to nutrient cycling, seed dispersal, and pest control, all of which are essential for ecosystem functioning. Birds are also bioindicators, meaning their presence, abundance, and health reflect the overall condition of coastal habitats, such as wetlands, dunes, and estuaries. Birds also have a cultural, recreational, and economic value, attracting ecotourism and fostering community engagement in conservation efforts. Efforts to conserve birds ensure the resilience and sustainability of coastal ecosystems for both wildlife and humans (Ernoul et al., 2021).

Ernoul et al. (2021) discussed how efforts to conserve the Greater Flamingo *Phoenicopterus roseus* in the Camargue, southern France, have focused on creating and managing breeding habitats in response to ecological challenges. In the 1960s, concerns over declining flamingo populations in the Mediterranean basin led to the construction of an artificial breeding island in the Fangassier Lagoon in the Camargue. This initiative successfully increased the flamingo population. However, recent changes in land ownership disrupted traditional management practices, causing breeding rates to decline due to fluctuating water levels and increased predation. To address these issues, an alternative breeding site in the nearby salt pans of Aigues-Mortes was developed, which has provided a reliable habitat during challenging periods. These actions highlight the importance of adaptive management and proactive measures in ensuring the long-term conservation of this iconic species.

Additionally, several papers we reviewed highlighted that land protection and management projects contribute to an increase in breeding wading birds (Ducrotoy & Dauvin, 2008; Rannap et al., 2017; Kaasiku et al., 2019).

Wetlands

Coastal wetlands, such as salt marshes, mangroves, and estuaries, are vital ecosystems providing exceptional ecological, recreational, and commercial value. Protected under various legislative documents (Natura 2000, WFD, Ramsar Convention), they are critical for biodiversity and serve as buffers against pollution and habitat degradation. They support unique salinity gradients that sustain diverse plant and animal communities, regulate water quality, and provide essential ecosystem services like flood protection and nutrient cycling (Spearman et al., 2014; Martínez-López et al., 2019; Boscolo Brusà et al., 2022)

An example of management practices on coastal lagoons is the LIFE Lagoon Refresh project in the Venice Lagoon. This aimed to restore habitats and biodiversity by addressing salinity imbalances caused by historic human interventions (Boscolo Brusà et al., 2022). Key actions included diverting freshwater from the Sile River to re-establish the salinity gradient, restoring intertidal morphology, and transplanting reeds and aquatic plants with community involvement. Hunting and fishing pressures were also reduced to protect the area. The project included combined planning with local institutions, stakeholder engagement, ecological engineering, numerical modelling, and environmental monitoring. This multidisciplinary and integrated approach ensured effective outcomes and can serve as a model for future coastal restoration efforts (Marques et al., 2013; Boscolo Brusà et al., 2022).

Another wetland restoration example is described by Ducrotoy (2010) on the Elbe estuary in Germany. The estuary is characterised by historical ecological degradation, particularly from canalization and sediment management to facilitate shipping activities. These human activities altered the hydrodynamics and morphology of the estuary, contributing to the loss of floodplains and intertidal areas. Several restoration measures took place, including the creation of intertidal areas like salt marshes, the construction of flood polders for storm surge protection, and the conservation of shallow water zones. These practices aimed to improve ecological conditions by restoring vital habitats for biodiversity, such as spawning areas for fish, and reducing the environmental impacts on navigation. Moreover, sediment management strategies have been implemented to optimise sediment relocation, preventing further degradation, and improving water and sediment quality (Ducrotoy, 2010; Scarton et al., 2012; Cozzoli et al., 2017).

Sand Dunes

Sand dunes are critically important habitats, because they act as natural barriers, protecting coasts from erosion, storm surges, and flooding. They provide valuable habitats for many organisms, which often are specially adapted to these unique environments. Also, sand dunes help stabilize the coastline by trapping and storing sand, supporting coastal resilience, and reducing the impact of climate change on coastal communities (Fiorini et al., 2017; Pinna et al., 2022). Sand dune habitats are threatened by tourism, coastal development, coastal erosion, and climate change. Many studies emphasize that sand dune restoration is one of the most effective management strategies for coastal areas, with numerous articles advocating for its importance in coastal management (Arens et al., 2013; Fiorini et al., 2017; de Andrés et al., 2017; Pye et al., 2020; Nunes et al., 2020; Acciarri et al., 2021; Garcia-Lozano et al., 2022; Kindeberg et al., 2022; Pinna et al., 2022).

Some scholar articles report the construction of new dunes, or beach enhancement using sand from nearby areas, which have shown high success rates (Arens et al., 2013; van der Meulen et al., 2015; Pye et al., 2020; Acciarri et al., 2021; Ballesteros-Pelegrín et al., 2022).

A common practice for the restoration and conservation of sand dunes is the installation of fences and designated pathways to regulate visitor access. Sand fences stabilize dunes by trapping windblown sand, promoting the formation of natural barriers that protect against coastal erosion. Also, managed access through well-defined paths minimizes trampling and habitat degradation, ensuring the preservation of vegetation, which is important for dune stability (Muñoz-Vallés & Cambrollé, 2014; Cambrollé et al., 2018; Acciarri et al., 2021; Garcia-Lozano et al., 2022; Faelga et al., 2023). Elevated boardwalks are also recognized as an appropriate measure that facilitates beach access, as well as sediment transfer and biodiversity recovery (Ferreira, 2023).

Revegetation with native plants is also a common action mentioned in the literature. It helps stabilize sand dunes by preventing erosion and can act as a barrier against wind and wave spray, which further prevents sand loss. Like sand fences, revegetation contributes to the gradual build-up of sand dunes. Plant species adapted to the unique conditions of sand dune habitats are particularly effective in reinforcing dune dynamics and fostering biodiversity (Muñoz-Vallés & Cambrollé, 2014; Pye et al., 2020; Acciarri et al., 2021; Garcia-Lozano et al., 2022; Faelga et al., 2023).

Fisheries

Small-scale fisheries often focus on local, artisanal practices, utilising small boats and basic equipment to harvest resources sustainably within coastal ecosystems. These fisheries typically target diverse species, supporting local communities and preserving traditional practices (Corrales et al., 2020).

Corrales et al. (2020) highlighted that one of the best practices for sustainable fisheries is the application of multi-zone MPAs. Key strategies include zoning, with fully protected areas (FPAs) prohibiting all extractive activities and partially protected areas (PPAs), allowing regulated small-scale and recreational fishing to minimize ecological impact. Effective enforcement and monitoring ensure compliance, while the spillover effect from FPAs enhances fish stocks in surrounding areas, benefiting fisheries. Additionally, along with other authors, Corrales et al. (2020) emphasised the involvement of local fishers and communities in decision-making to foster compliance, reduce conflicts, and integrate socio-economic considerations into sustainable fisheries management (Cardinale et al., 2017; Afonso et al., 2018).

A sustainable fishing practice suggested by Dereli et al. (2022) included adopting the Ecosystem Approach to Fisheries (EAF) as a framework for sustainable marine biodiversity management, ensuring resource exploitation aligns with ecosystem conservation. This approach involves reconsidering activities such as

sponge and coral collection in Greece, due to the ecological importance of the species harvested, and protecting overexploited species and key habitats like *Posidonia oceanica* meadows, coralligenous formations, and marine caves. Establishing networks of MPAs focused on sensitive ecosystems is recommended to enhance resilience against environmental changes. Adaptive co-management plans, involving fishers, scientists, and managers, were also highlighted as essential to address overfishing, while ensuring active participation by fishers. Given that many pelagic fish stocks are shared across state boundaries, the authors advocate for collaborative, harmonized management measures, and the sharing of knowledge to ensure sustainable fishing practices (Ferreira et al., 2017; Kyvelou & Ierapetritis, 2020; Dereli et al., 2022).

Oysters

The European flat oyster (*Ostrea edulis*), has a rich history as a habitat-forming species that once thrived across Europe's coasts and seas, forming extensive reefs that supported diverse ecosystems and fisheries (Herbert et al., 2016). However, overfishing, habitat destruction through dredging, pollution, sedimentation, invasive species, and disease had driven this species and its habitats to near extinction (Ermgassen et al., 2023). Today, restoration projects aim to revive this keystone species to enhance biodiversity, restore ecosystem services like nutrient cycling and water clarity, and reconnect communities with their cultural maritime heritage (Ermgassen et al., 2023). Despite challenges, such as limited seed supply and funding constraints, the rapid increase in restoration projects across Europe demonstrates promising progress, supported by international commitments to sustainable development and ecosystem restoration goals. Habitat restoration efforts have expanded significantly, with projects increasing from five in 2015 to over 33 by 2021. Strategies include scaling up the production of oyster seed using spatting ponds, hatcheries, and wild sea-based collection, with an emphasis on maintaining genetic diversity and biosecurity by utilizing local brood stock. These measures help ensure that oysters used in restoration projects are disease-free and genetically appropriate for the habitat. Additionally, restoration projects increasingly integrate "spat-on-shell" techniques, which promote habitat formation. Such actions not only address the seed supply bottleneck, but also enhance the ecological functions of oyster habitats, including water filtration, nutrient cycling, and biodiversity support. Long-term funding, strategic planning, and collaboration between restoration practitioners and producers are critical for sustaining these efforts and meeting restoration targets (Herbert et al., 2016; Ermgassen et al., 2023).

Invasive Alien Species

Invasive alien species (IAS) are non-native plants or animals introduced to habitats where they do not naturally occur, often through human activities such as trade, travel, or shipping. These species can outcompete native species, leading to biodiversity loss and altering the balance of ecosystems. In coastal habitats, IAS can significantly degrade ecosystems by displacing native species, altering habitats, and disrupting natural processes such as nutrient cycling and sand dune stabilization (Lazzaro et al., 2023). Additionally, IAS can have economic consequences, impacting fisheries, tourism, and other coastal industries that rely on healthy, functioning ecosystems (Lazzaro et al., 2023).

Many authors argue that in projects aimed at targeted habitat restoration or conservation, one of the primary management objectives should be to identify and control invasive species. This approach favours the development of natural vegetation and helps prevent the further spread of IAS (Lehtiniemi et al., 2020; Nunes et al., 2020; Gianni et al., 2022; Kindeberg et al., 2022; Mirauda et al., 2022).



Among the most discussed IAS in the literature we reviewed were invasive plant species that threaten sand dunes or other coastal terrestrial habitats, such as *Carpobrotus spp.* Managing IAS often involved different strategies, depending on the habitat. For mosaic rocky cliff coastal vegetation and disturbed areas with loose soil near cliffs, common methods included manual removal and covering the area with mulching sheets (Lazzaro et al., 2023). For accessible sand dunes, hand-pulling has shown the best results, according to Duarte et al. (2023), but due to its high cost, this method is not preferred for large areas. When larger areas are affected, mechanical cutting with tools such as brush hogs, brush cutters, and chainsaws can be effective. However, because most IAS are robust and capable of resprouting, follow-up treatments are necessary, either using mechanical methods or chemical treatments (Duarte et al., 2023).

Overview of Challenges

Conservation and restoration projects face several critical challenges that can hinder their success. One key issue is insufficient long-term funding, which limits the scope of projects with targeted actions, and long-term monitoring programs (Ermgassen et al., 2023). The monitoring is essential for tracking progress and adapting strategies over time. Another significant challenge is the inefficient, on-the-ground management in designated areas, which leads to non-compliance with regulations. Local stakeholders or users, such as fishers or tourists, frequently fail to adhere to regulations, undermining conservation efforts (Corrales et al., 2020). Also, the lack of adaptive management approaches, which are crucial for responding to dynamic environmental and socio-economic conditions is also a challenge in long-term conservation and restoration actions (Rannap et al., 2017). Another issue is changes in land ownership, which can disrupt traditional management practices. For instance, according to Ernoul et al., (2021), shifting land-use priorities in flamingo breeding habitats have led to habitat degradation and breeding failures. Additionally, the lack of awareness of biodiversity values by society, stakeholders, and users undermines any conservation and restoration actions. Promoting awareness of biodiversity values, including ecosystem services, and involving residents and visitors in management activities, through educational activities and citizen science initiatives, is crucial in the success of conservation efforts (Ferreira, 2023).

Addressing these challenges requires an integrated approach that includes secure long-term funding, robust on-going monitoring systems, improved and adaptive habitat management, sources for on-going maintenance of conservation and restoration actions, effective enforcement, and inclusive approaches for stakeholders and communities. Building trust with local communities is considered essential to ensuring the long-term sustainability of conservation efforts (Crowley et al., 2020).

3.3.2.5 Education/ Awareness/ Citizen Science

Educational actions, raising public awareness, and encouraging citizen involvement are essential for the effective management and conservation in general, as well as for coastal biodiversity. These initiatives that are targeted both at groups of stakeholders, e.g., local communities, resource users, schools, and also at the general public, encourage sustainable behaviours, promote a deeper understanding of environmental values and challenges, and encourage active participation in conservation efforts. They are crucial for building long-term conservation, as well as motivating collective action and responsibility (Navaro Perez et al., 2012).



Public awareness

Public awareness campaigns and actions aim to promote better understanding, inform, and engage the public on the value of coastal ecosystems, species, and habitats, as well as on management issues and challenges. Additionally, authors commonly highlighted public awareness campaigns as one of the most effective practices for promoting conservation, sustainable practices and behaviours and long-term sustainable use of marine and coastal resources (Schernewski et al., 2017; Marques et al., 2013; Floris et al., 2020; Kayal et al., 2020; Maestro et al., 2022; Rettig et al., 2023; Motta Zanin et al., 2023; Cantaluppi et al., 2023).

Ernoul et al., (2021) highlight the importance of using flagship species, such as flamingos, to raise public awareness about sensitive species, habitats, and threats, while at the same time promoting broader conservation policies. The Greater Flamingo *Phoenicopterus roseus*, an iconic and culturally significant species, serves as a powerful tool to engage with both tourists and the local population on the French coast. Their prominence helps draw attention to critical issues, such as agricultural changes, water management challenges, and pollution, encouraging support for sustainable practices. Moreover, using flamingos as a focal point improves communication strategies by fostering a deeper understanding of wetland dynamics and conservation needs, ultimately strengthening the legitimacy of management actions, and fostering long-term community engagement (Ernoul et al., 2021).

According to Schernewski et al. (2017), it is important to use social media and local media outlets, such as newspapers and free advertisers, to effectively raise public awareness and shape public perception. These platforms serve as primary sources of local information to many and should be actively engaged with well-prepared articles and updates throughout planning processes. By maintaining an anticipatory communication strategy, public awareness initiatives, and conservation efforts can provide consistent and accurate information, maintaining a consistent and accurate narrative. This approach helps prevent the spread of misinformation among the public and fosters a greater sensitivity to environmental issues. Providing accurate and consistent information, it ensures that the public remain informed and engaged, reducing the risk of confusion or misrepresentation that could undermine conservation efforts (Ducrotoy & Dauvin, 2008; Schernewski et al., 2017; Gianni et al., 2022; Cantaluppi et al., 2023).

Education

Environmental educational programs and actions to groups of society not directly involved with the management of coastal areas contributes to better knowledge and understanding about coastal ecosystems (e.g., environmental programs addressed to schools, environmental information centres, etc.) and plays an important role in the conservation of coastal habitats. Educating local communities, tourists, and other stakeholders about the ecological importance of these ecosystems, encourages sustainable practices that help reduce human impacts, such as minimising trampling, pollution, and other threats. Education also empowers people to participate in conservation efforts, leading to better-informed decisions and stronger public support for protective policies. This helps ensure that these valuable ecosystems continue to thrive and provide essential services for future generations (May, 2014; Nunes et al., 2020; Mirauda et al., 2022; Alcorlo et al., 2023).

Various authors highlighted that educational activities, where visitors can learn about the environmental significance of the area they are exploring are crucial for successful conservation (May, 2014; Alcorlo et al., 2023). The creation and maintenance of museums and environmental centres focusing on environmental conservation can play a crucial long-term role in promoting environmental education. Unfortunately, regional governments often show limited interest in supporting such initiatives, leading to



the closure of many centres over time. For example, in Andalucía, Southern Spain, the number of centres declined from six in the late 1990s and early 2000s to just one remaining today (Alcorlo et al., 2023).

Educational campaigns need to highlight not only the ecological importance of preserving natural resources, but also the economic and social benefits of sustainable practices, encouraging residents, visitors, and users to contribute to the protection of coastal environments (Nunes et al., 2020; Mirauda et al., 2022).

Citizen Science

Citizen science, i.e., the involvement of non-professional volunteers in scientific research and data collection to support coastal monitoring, conservation, and management efforts, plays an important role in biodiversity conservation. Citizen science can be used as a tool for overcoming insufficient monitoring and inadequate stakeholder buy-in for adaptive management. Citizen involvement can help bridge gaps in data collection and promote greater community investment in conservation efforts (Mirauda et al., 2022).

Volunteers' participation can contribute to research and data collection, as well as conservation tasks. Engaging local communities in conservation efforts can be highly effective, especially when they participate in practical activities, such as monitoring IAS on local sand dunes (Ferreira, 2023). For example, Lehtiniemi et al. (2020) highlighted the use of citizen observations to monitor the spread of non-indigenous species, such as the invasive Harris mud crab *Rhithropanopeus harrisii* in Finnish waters. Coastal monitoring in these areas has been limited, but citizen involvement has significantly helped fill this gap. Through online databases and mobile technology, citizens have provided critical insights into the species' distribution (including photos, videos, field notes, and exact location information), allowing authorities to report to national and European bodies and plan for eradication efforts. This approach not only supplements official monitoring programs, but also enables species distribution assessments that would otherwise require excessive resources (Ferreira et al., 2017). Additionally, it raises public awareness about environmental issues, encouraging more sustainable practices, and greater support for biodiversity protection.

In addition, Ferreira et al. (2015) in the Avenças Biophysical Interest Zone, Portugal, used young volunteers from the Municipal Volunteer Program, which takes place every summer, to conduct visual censuses and visitor interviews.

The benefits of citizen science initiatives in data collection are several, such as: a) larger scale of monitoring (more observations, larger spatial, and temporal scale), b) cost-efficient, c) early detection (often public members are the first to discover ecosystem changes, Lehtiniemi et al., 2020).

Moreover, citizen science can increase public awareness and compliance with regulations, it can lead to greater stewardship and ownership of nature conservation issues by local communities, and it can foster a sense of responsibility and connection to the environment (May, 2014; Ratcliffe & Bateson, 2014; Ernoul et al., 2009; Ferreira et al., 2015). Citizen science can also lead to the development of social networks between residents, and between residents and scientists. These collaborations are an opportunity for learning and building trust between different groups (Ferreira et al., 2015).

However, there are some limitations that need to be considered in the planning and results analyses of such initiatives: a) citizen science observations can be limited by the precision of observations, b) uneven spatial distribution of potential observers and c) identification issues, especially in cases where observed species cannot be easily identified or quantified (photo attachments however can help in the verification of observations, Lehtiniemi et al., 2020).

3.3.2.6 Other Practices – Solutions

Suitable & sufficient size and boundaries of MPAs

This sub-category refers to the designation of suitable & sufficient size and boundaries of Marine Protected Areas for efficient protection, conservation and management of coastal and marine ecosystems, habitats, and species. There are various scholarly references in our review which highlighted that the design of MPAs', including their size and boundary, are essential components for success in achieving conservation and management goals (Afonso et al., 2018). The effectiveness of MPAs can be limited by their size, and studies show that many MPAs are too small to provide adequate protection (Alcorlo et al., 2023), especially for those species with large home ranges (Afonso et al., 2018). MPA size should also be large enough and close enough to one another to guarantee connectivity among populations, avoiding mortality of individuals that cross between them (Alcorlo et al., 2023). Additionally, networks of MPAs can provide greater benefits than individual MPAs, but the system of MPAs needs to operate synergistically to achieve ecological objectives more effectively (Corrales, et al., 2020).

Nature Based Solutions (NbS)

The definition provided by the International Union for the Conservation of Nature (IUCN) on Nature Based Solutions (NbS) is that these are “*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*”. This definition was adopted during the World Conservation Congress (Hawaii, USA) in September 2016 (WCC-2016-Res-069-EN; Cohen-Shacham, 2016). The same definition has been accepted by the United Nations Environmental Programme and the European Commission.

However, the scientific literature we considered, other terminology may be used and similarly refers to ecosystem-friendly techniques or strategies which rely on some combination of natural or living materials and built infrastructure, or uses natural processes, habitats, or ecosystems to address challenges for protection and restoration projects, that will benefit both the ecosystems and human communities. This is clearly investigated either in articles concerning this specific topic, such as the protection and restoration of coastal zones (Smith et al. 2020) or in articles about NbS in general (Sowińska-Świerkosz & Joan García 2022).

The IUCN also provided a list of principles which should be considered in combination with the definition of NbS (WCC-2016-Res-069-EN; Cohens-Shacham 2016):

- I. NbS embrace nature conservation norms (and principles).
- II. NbS can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g., technological and engineering solutions).
- III. NbS are determined by site-specific natural and cultural contexts that include traditional, local, and scientific knowledge.
- IV. NbS produce societal benefits in a fair and equitable way in a manner that promotes transparency and broad participation.
- V. NbS maintain biological and cultural diversity and the ability of ecosystems to evolve over time.
- VI. NbS are applied at a landscape scale.
- VII. NbS recognise and address the tradeoffs between the production of a few immediate economic

benefits for development, and future options to produce the full range of ecosystems services.

- VIII. NbS are an integral part of the overall design of policies, and measures or actions, to address a specific challenge.

During the 1970s the idea of environmental or ecosystem services began to establish itself in the modern scientific literature (Cohen-Shacham et al., 2016). The fundamentals of NbS are derived from established practices, such as forest landscape restoration, integrated water resource management, ecosystem-based adaptation and mitigation, and ecosystem-based disaster risk reduction, several of which were first developed and promoted by IUCN in the late 1990s and early 2000s (IUCN, 2020). A decade later the term 'Nature Based Solutions' emerged, marking a subtle yet important shift in perspective: not only were people the passive beneficiaries of nature's benefits, but they could also proactively protect, manage, or restore natural ecosystems as a purposeful and significant contribution to addressing major societal challenges (Cohen-Shacham et al., 2016).

IUCN actively promoted the NbS concept in its 2009 position paper on the United Nations Framework Convention on Climate Change (UNFCCC) COP 15, and in 2012 IUCN formally adopted NbS as one of the three areas of work within its 2013-2016 Programme (Cohen-Shacham et al., 2016). IUCN coined the first global definition of NbS in 2016 (Cohen-Shacham et al. 2016; IUCN 2020). Largely based on the IUCN definition of NbS, the United Nations Environment Assembly at its fifth meeting (UNEA-5i) adopted a global definition of NbS, the culmination of years of collaboration among countries and civil society and providing an official reference to be used by Parties to the Convention on Biological Diversity (CBD) and other international agreements (IUCN 2022). As an addition to all the above, the European Commission has made NbS part of its Horizon 2020 Research and Innovation Programme and is investing in a series of projects to strengthen the evidence base on NbS (Maes & Jacobs, 2015 in Cohen-Shacham et al. 2016). NbS are also closely aligned with the first draft of the Post 2020 Global Biodiversity Framework (GBF) since focusing on the improvement of human well-being through the adaptive and resilient characteristics of biodiverse ecosystems directly supports the 2050 Vision (IUCN 2022).

NbS are actions aimed at addressing key societal challenges -such as climate change, food and water security, natural disasters, public health, and desertification- by protecting, sustainably managing, and restoring natural and modified ecosystems. These actions benefit both biodiversity and human well-being.

NbS are considered by a wide range of stakeholders as an essential mechanism for achieving sustainable development. Thus, the IUCN developed the NbS Standard to guide the design, implementation, and evaluation of NbS and ensure that NbS initiatives effectively address societal challenges, promote biodiversity, and foster sustainable development. Additionally, the Standard aims to ensure the application of this approach is credible, and its uptake tracked and measured for adaptive management so that its contributions can inspire others (IUCN 2020).

Cohen-Shacham et al. (2016) provide a synopsis of NbS categories and examples (as shown in Table 3.3-2).

Table 3.3-2: Categories and examples of Nature Based Solutions (from Cohen-Shacham et al. 2016),

Category of NbS approaches	Examples
Ecosystem restoration approaches	Ecological restoration Ecological engineering Forest landscape restoration
Issue-specific ecosystem-related approaches	Ecosystem-based adaptation Ecosystem-based mitigation Climate adaptation services Ecosystem-based disaster risk reduction
Infrastructure-related approaches	Natural infrastructure Green infrastructure
Ecosystem-based management approaches	Integrated coastal zone management Integrated water resources management
Ecosystem protection approaches	Area-based conservation approaches including protected area management

Based on our literature review, NbS in coastal areas offer sustainable approaches to managing coastal risks, like coastal erosion, flooding, and habitat loss, while enhancing ecosystem services. For example, restored and conserved wetlands and salt marshes can act as natural buffers, absorbing wave energy and reducing storm surge impacts, while also providing important habitats for marine biodiversity. The creation of living shorelines, which use plants, sand, and natural materials, helps stabilize coastlines and promote sediment deposition, improving resilience against sea-level rise. Additionally, seagrass restoration can protect coastlines by breaking waves before they reach the shore, reducing erosion, and safeguarding coastal communities. These approaches also support local economies through tourism, fisheries, and carbon sequestration. Table 3.3-3 provides examples of NbS that were implemented in European coastal areas identified in our literature review.

Table 3.3-3: Examples of Nature Based Solutions in European coastal areas from our literature review.

Title	Main problem to address	Description
Beach Nourishment	Coastal erosion	Beach nourishment involves adding sand to beaches to restore them, acting as a buffer against erosion. It is considered a less intrusive, cost-effective alternative to hard structures. It requires periodic, repeated action. (Kindeberg et al. 2023; Motta Zanin et al., 2023; van Wesenbeeck et al., 2014)
Dune Restoration	Coastal erosion & biodiversity loss	Dune restoration involves restoring or creating sand dunes to provide a natural barrier against coastal erosion. (Fernandez-Montblanc et al. 2020, Motta Zanin et al., 2023)
Sand Trapping Fences	Coastal erosion	Porous fences made of materials like brushwood bundles, wood, plastic, or jute can be used to trap sand and build up dunes, thereby protecting the coast. The effectiveness depends on the material used and the porosity of the fence. (Eichmanns et al., 2021)
Forest Restoration	Coastal erosion & biodiversity loss	Forest restoration can help to stabilize the coast and improve habitats. (Motta Zanin et al., 2023)
Seagrass Conservation and Restoration	Coastal erosion & biodiversity loss	Seagrass conservation and restoration, such as with <i>P. oceanica</i> , involves protecting and restoring seagrass meadows, which provide habitat and help stabilize sediments. (Oliveira et al. 2024; Toledo et al., 2024; Motta Zanin et al., 2023)
Shellfish Beds	Coastal erosion & biodiversity loss	Creation of new shellfish banks (placing shellfish on the seabed, constructing artificial reefs, and leveraging natural processes to create self-sustaining ecosystems) contributes to coastal protection, sediment balance and biodiversity enhancement. There are limitations associated

Title	Main problem to address	Description
		with their implementation, such as uncertainties around sand retention capacity, need for sustainable farming practices, etc. (Maas & Rousseau, 2024)
Woodchip Bioreactors	Eutrophication (Nitrate pollution)	Woodchip bioreactors are applied by constructing a bed of woodchips through which polluted water is passed, allowing microorganisms to reduce nitrate levels. (Alvarez-Roger et al., 2020)
Blue Green Infrastructure	Flooding & droughts	Blue-green infrastructure systems in urban/ semi-urban systems that can include trenches, ditches, ponds, and wetlands for retention of flows from roofs, roads, and car parks, and also, green roofs and spaces. Also contribute to purification of water, flood control, water storage, and heat control. (Keestra et al., 2018; Motta Zanin et al., 2023)
Wetland Construction & Restoration	Land degradation, flooding, pollution & biodiversity loss	Creation and restoration of wetlands to manage water flow, improve water quality, and provide habitat. (Keestra et al., 2018; Motta Zanin et al., 2023; Álvarez-Rogel, 2020)

A deep understanding of nature's processes and functions is essential for the successful implementation of NbS. When well-designed measures align with natural forces, they require less maintenance, are more cost-effective, and can become more effective over time as nature enhances their efficiency (e.g., the build-up of terrace-like structures upslope from vegetation lines, naturally meandering rivers, wetlands, or resprouting species in wildfire-affected areas). This approach also contributes to the sustainable economy and society of the region (Kabisch et al., 2016; Villegas-Palacio et al., 2016; Schaubroeck, 2017 from Keestra et al., 2018).

From our literature review, there are various lessons from the implementation of NbS, which highlight key considerations for successful implementation. In terms of planning, an integrated approach, linking benefits to ecosystem services is important (Keestra et al., 2018). Additionally, adaptive management principles are crucial in terms of monitoring, indicators, evaluation, and adjustment (van der Meulen, 2023). Engaging stakeholders from the beginning of a project and throughout, is crucial for securing financing, community acceptance, and support (van der Meulen, 2023; Moraes et al, 2022). Moreover, long-term funding is needed to ensure the full realization of NbS outcomes, which may accrue over extended periods (O'Leary et al., 2024). The effectiveness of NbS is highly associated with site conditions; NbS require a good understanding of the local systems and should be location-specific (Moraes et al, 2022; Kok et al., 2021). Finally, NbS need to be assessed in the context of climate change impacts, as these can affect their performance and effectiveness (Motta Zanin et al., 2023).

3.4 Considerations

The literature review presented in this section on coastal ecosystem management practices, despite its systematic approach, includes some inherent limitations.

One potential limitation is the reliance on existing literature, which may introduce biases by predominantly highlighting findings from well-researched areas, while potentially overlooking less-studied regions or emerging issues that have not yet been widely documented.

Furthermore, the geographic focus was primarily on European coastal regions, which reflects the scope of the project's funding. This may limit the broader applicability of the findings to non-European contexts, where different environmental, socio-economic, and governance conditions, may exist.

The indicative quantitative overview of management practices, as presented in section 3.3.2, shows that quantitatively the main management strategies that were implemented relate mostly to issues of “Better knowledge and Understanding”, such as data analyses, assessments, evaluations, and monitoring campaigns. These aspects are often addressed more frequently in academic studies and research projects due to their measurable outcomes and the ease with which they can be reported, compared to other management aspects, such as governance, policy development, community engagement, and educational practices. The successful implementation of these other management aspects includes diverse groups of stakeholders, decision-makers, and longer time scales – more difficult to achieve in time limited academic-led projects.

While this review covers a broad spectrum of methodologies and practices, it does not claim to be exhaustive in reporting all possible management policies and strategies for coastal ecosystems. Instead, it seeks to underscore dominant trends, identify key challenges, and propose potential future directions for coastal management practices.

4 CONCLUSION – KEY MESSAGES

The aim of this report is to review current practices implemented across Europe to manage coastal ecosystems, to identify what are the key characteristics of successful management practises, as well as the challenges that, if not addressed, lead to ineffective or failed management systems.

To achieve this aim, the evolution of coastal ecosystem management policies in the EU is presented, through the key legislative frameworks. This analysis highlights the main directions and thematic areas of these frameworks and explores how these have influenced the management design, implementation and practices of coastal areas and ecosystems at various levels.

Additionally, the key messages of the 2024 IPBES “*Thematic Assessment of the Interlinkages among biodiversity, water, food and health (nexus assessment)*” and “*Thematic assessment of the underlying causes of biodiversity loss and the determinants of transformative change and options for achieving the 2050 Vision for Biodiversity*” are presented in order to identify opportunities for collaboration across sectors and scales, which in turn can contribute to synergistic and holistic management and governance.

Finally, a review was made based on the available scientific literature and relevant projects on implemented management practices for coastal areas, ecosystems, habitats, and species in Europe, identifying best practices and complexities involved in coastal ecosystem management. At the same time, this review aims to uncover the various interconnected components of management systems, each playing a crucial role in the overall success of coastal ecosystems management.

Through this multi-level analysis, there are key messages and trends that keep coming up at various levels (international, European, national, regional, and local) related to the achievement of transformative change, to successfully address biodiversity loss. These are depicted in Figure 4-1 and summarised in the following paragraphs.

The **EU policy framework for coastal ecosystem management**, developed through the years, has achieved notable progress in addressing the complexities of managing coastal environments. The EU policy framework is important in shaping national policies and in providing guidance and direction to management strategies at national, regional, and even local level. The key trends and successes relate to:

- **Policies integration among different sectors and levels** --> EU policies have made a significant shift from sectoral management and fragmented legislation to a more holistic and interconnected policy framework (e.g., WFD, MSFD, ICZM, MSP, Natura 2000, etc.).
- **Promotion of adaptive management** --> Adaptive management mechanisms, based on new data and changing conditions, allows flexibility in dealing with the dynamic nature of coastal ecosystems and addressing unforeseen challenges, such as climate change impacts.
- **Adoption of more inclusive governance structures that involve stakeholder participation in decision-making processes** --> Local communities, NGOs, private sector representatives, and other groups now have a more significant role in shaping policies, ensuring that diverse perspectives are considered in coastal management.
- **Shift towards Ecosystem-Based Approaches** --> This approach fosters better integration of biodiversity conservation into sectoral policies and ensures that the ecological health of marine and coastal ecosystems is prioritised, alongside economic activities, to maintain the balance between development and environmental protection.
- **Balancing and planning for multiple uses** --> Through tools like Marine Spatial Planning (MSP), the EU has promoted the coexistence of these activities, aiming to minimize conflicts, and ensuring

sustainable resource use.

- **Formal designation of Protected Areas** --> The establishment of Natura 2000 Protected Areas and the expansion of Marine Protected Areas (MPAs) has been a significant achievement, contributing significantly to the protection of vulnerable habitats and species.
- **Data Collection and Standardization** --> Most EU policies require monitoring programs to serve as implementation progress indicators and to provide better feedback to decision-making processes, i.e., adaptive management. This approach supports evidence-based resource management and enhances the overall effectiveness of the policies.
- **Public Awareness Raising** --> Public awareness campaigns and education initiatives have been an integral part of the EU direction, aiming at increasing the public understanding of the importance of coastal ecosystems. This has helped to gain support for conservation measures and to foster more sustainable practices among local communities, businesses, and society.
- **Financial Support** --> The EU has provided substantial financial support through mechanisms like the EMFF, LIFE, and European Cohesion Fund, helping coastal communities and industries transition to more sustainable practices and at the same time supporting ecosystem restoration projects, biodiversity conservation, and climate adaptation initiatives.
- **Fostering Partnerships** --> Collaborative efforts between Member States, local authorities, NGOs, research institutions, and the private sector have been the foundation of the EU's success. Partnerships have facilitated the sharing of knowledge, resources, and expertise, leading to more cohesive and integrated coastal management policies and strategies.
- **Legally binding nature restoration targets** --> Through the Biodiversity Strategy for 2030 and the Nature Restoration Law, the EU introduced, for the first time, legally binding nature restoration targets to restore degraded ecosystems, aiming for the long-term recovery of nature in Europe.

At the same time, the key direction for future actions by the 2024 IPBES “*Thematic Assessment of the Interlinkages among biodiversity, water, food and health (nexus assessment)*” and “*Thematic assessment of the underlying causes of biodiversity loss and the determinants of transformative change and options for achieving the 2050 Vision for Biodiversity*” relate to:

- **Integrated Governance** --> Promotion of holistic governance structures that incorporate biodiversity, water, food, health, and climate change. Policies must be coordinated across sectors and scales to avoid siloed decision-making and reduce negative trade-offs.
- **Collaborative Approaches** --> Engagement of a wide range of stakeholders, including Indigenous and local communities, through inclusive and participatory governance. Co-designing response options fosters greater legitimacy, adoption, and effectiveness.
- **Restoration and Conservation** --> Prioritisation of conserving ecosystems of high ecological integrity and restoring degraded ecosystems, especially in coastal and marine areas. Ecosystem restoration efforts, like mangroves and seagrass, can simultaneously benefit biodiversity, climate resilience, and livelihoods.
- **Sustainable Resource Use** --> Shifting towards sustainable consumption and production, reduction of pollution and waste, promotion of sustainable agriculture, fisheries, and forestry. Key sectors contributing to biodiversity loss, such as agriculture and infrastructure, must undergo systemic change.
- **Equitable Economic Transformation** --> Transformation of economic systems to prioritise biodiversity and social equity. Economic incentives like green bonds, payments for ecosystem services, and reforms of harmful subsidies are crucial for redirecting resources towards sustainable development.
- **Strengthening Financial Support** --> Address disparities in funding allocation by ensuring low-



income countries and marginalized groups have access to resources. Increasing financial flows for biodiversity and climate resilience is essential for achieving the global goals.

- **Long-term Vision and Whole-of-Society Engagement** --> Promotion of shared visions that acknowledge interdependencies between humans and nature. Governments, civil society, and the private sector must collaborate to drive transformative change towards regenerative economies, community rights, and ecosystem health.
- **Urgency in Action** --> Delaying action will lead to significantly higher economic costs. Immediate and bold interventions are needed to reverse biodiversity loss and address the climate crisis effectively.

Finally, the **review of implemented management practices** for coastal areas, ecosystems, habitats, and species in Europe, uncovered the various interconnected and key components of management systems, which play a crucial role in the overall success of coastal ecosystems management.

- **Holistic and integrated governance approaches** --> Successful management of coastal areas can only be achieved through a holistic and integrated governance approach, which combines several key aspects. These include institutional coordination and collaboration, inclusive and participatory processes, political will, diversity of expertise, resource allocation, dedicated local/regional management structures, and strong capacity building. These elements interact constructively to address the complex challenges of coastal environments, which involve both ecological and socio-economic dimensions.
- **Conservation & Restoration** --> Conservation and restoration targeted efforts aiming to protect, conserve, restore or enhance threatened species, ecosystems, and habitat types, are crucially important for mitigating biodiversity loss, preserving ecosystem functions and promoting natural resource sustainability.
- **Promotion of practices that enhance understanding of systems, processes, and their interlinkages** --> Practices such as systematic and continuous monitoring systems, supplemented by ad-hoc monitoring to fill data gaps, along with dataset analysis through various methods and refinement of conceptual definitions, improve our understanding of the multifaceted interactions between environmental, social, and economic factors in coastal areas. They also shed light on the intricate interactions between species, habitats, and ecosystem processes. These efforts help to address current and emerging challenges, while promoting adaptive and informed management cycles. The use of innovative technologies offers new insights into these systems.
- **Education and raising public awareness** --> Educational actions, raising public awareness, and encouraging citizen involvement are essential for effective management and conservation in general, as well as for coastal biodiversity. These initiatives, which are targeted both at groups of stakeholders, e.g., local communities, resource users, schools, and at the public, encourage sustainable behaviours, promote a deeper understanding of environmental values and challenges, and encourage active participation in conservation efforts. They are crucial for building long-term conservation, as well as motivating collective action and responsibility.
- **Policies Integration & Coordination** --> Integration and alignment of a variety of sectoral policies are crucial for effective coastal areas management, helping decision-makers to better address cross-cutting issues like biodiversity conservation, disaster risk reduction, and pollution control, while also considering the livelihoods of coastal communities.
- **Ecosystem-Based Approaches** --> Incorporation of an ecosystem services approach into development and implementation of policies for coastal areas, as well as the promotion of nature - based solutions, promotes the understanding and assessment of the ecosystem services provided by coastal ecosystems and fosters better integration of biodiversity conservation into sectoral

policies.

- **Designation of Protected Areas** --> The legal designation of protected areas, as well as their appropriate design is a fundamental tool for the protection of ecosystems, habitats, and species by restricting, prohibiting and/or better managing activities that negatively impact biodiversity and creating a space for more sustainable practices.



Figure 4-1: Recurring key messages and trends at various levels (international, European, national, regional and local) to achieve transformative changes to successfully address biodiversity loss in coastal areas

The recurring key directions, messages, and trends described above highlight the essential elements of effective policies and practices for coastal management systems at various levels, aimed at successfully addressing biodiversity loss. These elements form the foundation for creating adaptive, integrated, inclusive, and informed management strategies that promote sustainable use of coastal resources, while tackling environmental and socioeconomic challenges. These are schematically depicted in Figure 4-2, as they were identified and categorised in this report.

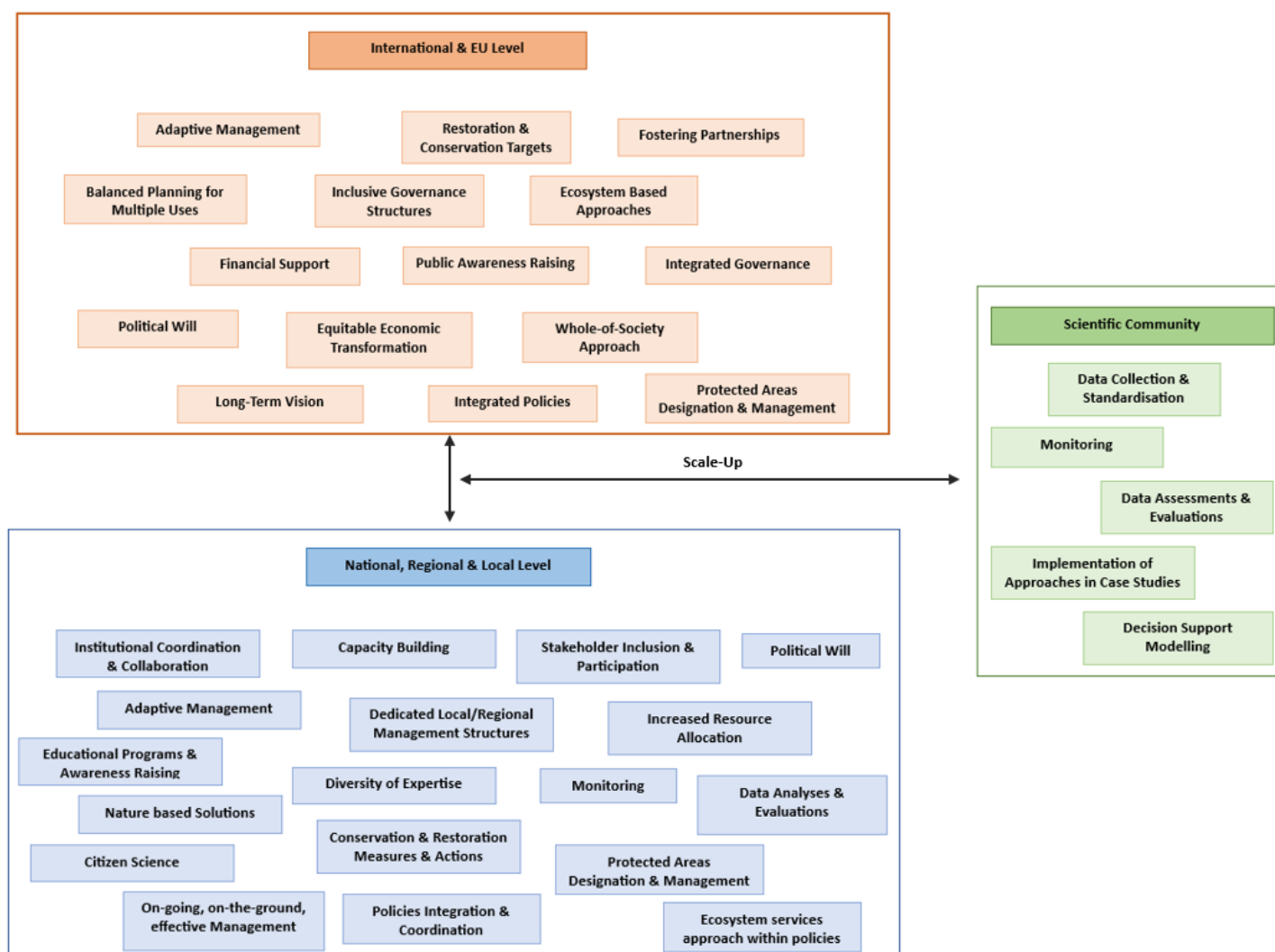


Figure 4-2: Essential elements of effective policies and practices for coastal management systems at various levels, aimed at successfully addressing biodiversity loss as decoded in the frame of this report.

Looking towards the future, significant challenges remain at all levels, to drive the transformative change required to address global biodiversity loss and achieve a just and sustainable futures. As identified in IPBES (2024)¹⁰, one of the key barriers is the disconnection from and domination over nature and people, where humans are often perceived as separate from and superior to the natural world, treating it primarily as a resource to be exploited. Moreover, prioritization of short-term, individual, and material gains over the long-term well-being of communities and ecosystems creates systemic challenges. Persistent inequalities -both economic and political- further impede conservation efforts, as these inequalities stem from historical legacies such as colonialism, which continue to dominate modern relations. Unsustainable consumption and production patterns, coupled with inadequate policies and institutions that fail to address the true scale

¹⁰ IPBES (2024) Thematic Assessment Report on the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity, Summary for Policymakers, 2024
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of biodiversity loss, can hinder progress. Limited access to clean technologies and a lack of coordinated knowledge systems also hinder innovation, making it difficult to achieve the global goals necessary to safeguard biodiversity and promote equitable development.

However, over the last 30 years, the global community has made remarkable progress by uniting at every level (global, regional, national, local and individually) and across diverse sectors (policy, science, NGO, the public and private sectors, local communities, etc) to propose and implement solutions to address biodiversity loss and foster sustainable human coexistence with and within nature. Innovative technologies, emerging nature-based solutions, numerous conservation and restoration actions and initiatives, better integration and coordination within policies, institutions and stakeholders, ecosystem-based approaches, and participatory governance are few examples that demonstrate that transformative change is within reach. Local coastal communities, if empowered by collective action, scientific support, coupled with strategic policy interventions and increased resource allocation, can lead -and in many cases are already leading- the effort to restore and protect their environments and reshape their path to a more sustainable future.

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