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Environmental and Social Impact Assessment of

OFFSHORE WIND ENERGY

Development in Tropical Environments



ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF OFFSHORE WIND ENERGY DEVELOPMENT IN TROPICAL ENVIRONMENTS

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PRESENTATION

Offshore wind energy is quickly expanding globally, driven by growing demand for renewable energy and technological advances that enable larger, more efficient projects. To date, its development has occurred predominantly in temperate regions, which already have accumulated experience and well-established guidelines for assessing the environmental and social impacts of these projects. However, the growing interest in expanding the sector in tropical and subtropical regions requires adapting good practices to diverse and different ecological, social, and regulatory contexts.

The objective of this Guide is to propose good practices for Environmental Impact Assessment (EIA) processes in the offshore wind energy sector in tropical environments. The document offers guidance to improve the quality of environmental and social impact studies and to strengthen decision-making on licensing, financing, and investment in these projects.

Harnessing energy resources in tropical environments poses specific socio-environmental challenges, due, among other factors, to the high biological diversity, the strong presence of artisanal fishing, and still-evolving regulatory frameworks. The focus of this Guide on tropical environments does not imply a rigid geographical delimitation, but reflects the intention to recommend practices appropriate to the particularities of these environments.

Another difference from existing technical guides is the integration, at each stage of the EIA, of Ecosystem-Based Management (EBM) principles, an approach aligned with the objectives of international agendas focused on the ocean and biodiversity.

The Guide is primarily aimed at staff from agencies responsible for conducting the EIA process and consultants involved in preparing environmental and social assessments. However, it can also be useful for professionals from companies in sectors such as energy and infrastructure, civil society organizations, legislators, oversight bodies, and researchers interested in the subject. The content can be used as a technical reference for defining legal frameworks and regulations in countries where the offshore wind sector is in its early stages.

The preparation of the Guide involved extensive literature and documentary review of legal frameworks and international guides, analysis of cases, and participatory development of the content through workshops and consultations with specialists, officials from EIA agencies, consultants, community representatives, and researchers from different Brazilian institutions. Although professionals who work primarily in Brazil were consulted, the Guide is international in scope, containing recommendations applicable to other tropical marine and coastal environments worldwide.

The Guide provides practical recommendations supported by a solid conceptual foundation and grounded in scientific knowledge. The first three chapters present international guidelines for ocean protection (Chapter 1), guidelines to strengthen the relationship between project-level EIA and its planning context (Chapter 2), and the role of public participation throughout the EIA process (Chapter 3). The Guide addresses essential aspects of current construction technologies for this type of project (Chapter 4), followed by the presentation of causal chains linking planning, construction, operation, and decommissioning activities to project aspects, environmental and social impacts, and mitigation measures (Chapter 5).

The main steps of the EIA process are covered, with guidelines for scoping (Chapter 6), establishing baselines, and predicting and determining the significance of impacts (Chapters 7 and 8). Impact mitigation measures are also presented (Chapter 9). A chapter is devoted to presenting the step-by-step process for assessing cumulative impacts as part of an Environmental Impact Study (Chapter 10). Finally, general guidelines for follow-up and recommendations for environmental and social monitoring are presented (Chapter 11).

A glossary of the main terms used complements the Guide.

We hope that this Guide will contribute to an offshore wind energy development model that effectively adheres EIA best practices, is fully aligned with global commitments to protect the ocean and biodiversity, and respects local communities.

São Paulo, Austral autumn 2026

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The content and recommendations of this Guide are based solely on the academic and professional experience of the authors, and in no way may be interpreted as opinions or recommendations of the sponsors of the research project, IBAMA, or any other public, private, or third sector entity that has been consulted.

SYNOPSIS

This Guide is organized into three parts. The first, with three chapters, presents the conceptual framework used in its preparation. The second part, with two chapters, provides the basis for assessing the environmental impact of offshore wind projects, and the third part, with six chapters, offers recommendations for assessing these projects' impacts.

Chapter 1. Ecosystem-Based Management in Environmental Impact Assessment

Among recent advances in the Environmental Impact Assessment (EIA) process, the progressive incorporation of a more comprehensive approach aligned with the principles of Ecosystem-Based Management (EBM) stands out. Although this represents an important conceptual and methodological improvement, progress remains slow and fragmented. In this context, this chapter aims to deepen understanding of EBM and outline how its principles can enhance and strengthen EIA practice.

This chapter presents:

1. What is Ecosystem-Based Management?
2. Why integrate Ecosystem-Based Management and Environmental Impact Assessment?
3. How to integrate Ecosystem-Based Management and Environmental Impact Assessment, and the Ocean Agenda

Chapter 2. Tiering Environmental Impact Assessment with Other Planning Instruments

The marine space with potential for wind energy installations is used for various purposes, such as fishing, navigation, tourism, extraction of mineral and oil and gas resources, and environmental conservation. To reconcile various current and potential uses of marine and coastal spaces, many governments adopt instruments to plan the use of

resources. This chapter shows the importance of considering the planning framework in impact assessment and the key linkages among the instruments.

This chapter presents:

1. Planning instruments: why and what to consider?
2. Key linkages: how to integrate the relevant information?

Chapter 3. Social Participation and Engagement

Social participation in decision-making processes not only enhances legitimacy and gives voice and visibility to affected communities and stakeholders, but also helps mitigate investment risks and create spaces for dialogue that extend throughout the project's operational phase. Drawing on concepts, good practices, and examples, this chapter shows how different forms of participation can contribute to more equitable, inclusive, and effective processes throughout the various stages of the environmental impact assessment.

This chapter presents:

1. Social participation and meaningful engagement: what is the difference?
2. How to plan social participation to promote meaningful engagement?
3. How to follow? Participation and engagement as strategic processes

Chapter 4. Offshore wind farms and associated facilities

To identify and assess impacts of an offshore wind farm, it is necessary to describe and characterize the activities to be carried out, both offshore and onshore, including transportation of equipment and materials and building up power transmission facilities. The adequate characterization of the project's activities - and their alternatives - is the starting point for identifying the potential impacts to support EIA scoping and the preparation of the environmental impact statement.

This chapter presents:

1. Main types of offshore wind projects and associated facilities
2. Technology perspectives for offshore wind projects and their associated facilities

Chapter 5. Impacts and Causal Relationships

The starting point for structuring an Environmental Impact Study (EIS) involves describing activities related to the planning, construction, operation, and decommissioning stages of projects and connecting them to their environmental and social impacts. The preliminary identification of potential impacts underpins the definition of the study scope and the planning of the surveys needed to establish the baseline for impact assessment.

This chapter presents:

1. Causal relationships in project environmental impact assessment
2. Environmental impacts of offshore wind projects
3. Social impacts of offshore wind projects

Chapter 6. Scoping

The preparation of an Environmental Impact Study (EIS) is preceded by a planning stage known as scoping, during which the boundaries and focus of the study are established. At this stage, the relevant information to be collected and analysed is identified, along with the main questions the EIS is expected to address. Careful scoping is essential to ensure an EIA focused on the issues most relevant to decision-making.

This chapter presents:

1. What is Environmental Impact Assessment scoping?
2. Stakeholder engagement during scoping
3. Recommendations for defining the minimum content of an environmental impact study

Chapter 7. Baseline

The impacts of a project are evaluated in relation to a reference condition, generally understood as a description of the current conditions of the social and environmental components and processes that may be affected by the activities developed during the construction, operation, and decommissioning of a project. This chapter explains the objective and importance of constructing a baseline – a reference condition for assessing impacts – as well as the main components to be addressed and the indicators to be generated at this stage for subsequent identification, prediction, evaluation, mitigation, and monitoring of impacts.

This chapter presents:

1. Why develop a baseline?
2. How to select the components and indicators for the baseline?
3. How to define the spatio-temporal scale for the baseline?
4. Marine environment baseline
5. Coastal and terrestrial environments baseline
6. Social baseline

Chapter 8. Determination of the significance of impacts

Offshore wind energy projects generate multiple impacts, both adverse and positive. However, not all of them are important for decision-making. Distinguishing significant impacts from other impacts is one of the main functions of project impact assessment. This chapter aims to present the basic concepts of determining the significance of impacts and their relationship with the stages of the Environmental Impact Assessment (EIA) process. Practical examples are also presented that illustrate how this determination can be accomplished.

This chapter presents:

1. What is a significant impact?
2. What is the purpose of determining impact significance?
3. What are the essential elements to determine the significance of impacts?
4. How to properly communicate the significance of impacts?

Chapter 9. Mitigation measures

The management of environmental impacts in development projects requires not only the accurate analysis of adverse impacts, but also the systematic application of strategies that prevent, reduce, or neutralize these impacts. In this context, mitigation measures constitute a fundamental pillar of the Environmental Impact Assessment, guided by the hierarchy that prioritizes avoiding adverse impacts, followed by measures to minimize, restore, and, only as a last resort, compensate for residual adverse impacts. This chapter presents the conceptual and operational foundations of mitigation measures, with an emphasis on their application in the offshore wind energy sector, showing how these measures can be planned, selected, and implemented effectively, ensuring not only legal compliance but also concrete benefits for biodiversity, ecosystem services, and affected communities. Throughout the chapter, practical examples, scientific evidence, and international guidelines are used to illustrate best practices in mitigating impacts on marine environments.

This chapter presents:

1. What are mitigation measures?
2. Choosing the best measures using the Mitigation Hierarchy
3. Examples of mitigation measures
4. Monitoring and effectiveness of biodiversity offset measures

Chapter 10. Cumulative Impacts

When multiple projects are constructed and operate in the same area, their impacts can add up or interact, resulting in additive or synergistic cumulative impacts, respectively. If these impacts are not considered during the environmental assessment

and decision-making process for a proposed project, the project's acceptability may be compromised. Integrated into Environmental Impact Assessment (EIA), Cumulative Impact Assessment (CIA) analyzes the incremental contribution of the proposed project to changes in the condition of selected environmental and social components, considering the existing impacts as well as those that may occur in the future from other activities. This chapter presents the fundamentals and provides practical guidance on CIA within an Environmental Impact Study (EIS).

This chapter presents:

1. What are cumulative impacts?
2. What is the importance of assessing cumulative impacts on project Environmental Impact Assessment?
3. How to assess cumulative impacts at the project level?

Chapter 11. Follow-up

The main impacts of a project occur after its approval, when preparatory works, the establishment of construction sites, and construction itself begin, and continue through operations until the project's eventual decommissioning and closure. This chapter addresses the implementation of the mitigation measures defined in the Environmental Impact Study, monitoring, and other activities in the follow-up stage of the Environmental Impact Assessment.

This chapter presents:

1. What is the follow-up stage in Environmental Impact Assessment?
2. Monitoring as the centerpiece of the follow-up stage
3. Environmental monitoring
4. Social monitoring

IMPACT ASSESSMENT OF OFFSHORE WIND PROJECTS: AN INTRODUCTION

Luis Enrique Sánchez
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Offshore wind energy development began in 1991 with the installation of the world's first offshore wind farm, the 5 MW Vindeby Offshore Wind Farm in Denmark. Since then, the sector has undergone major technological and regulatory advances, becoming one of the leading large-scale renewable energy sources. According to the annual industry report published by the Global Wind Energy Council, global installed offshore wind capacity reached 83.2 GW by the end of 2024 (GWEC, 2025).

Replacing non-renewable energy sources with renewable ones is widely regarded as one of the most important actions for addressing climate change under the United Nations Framework Convention on Climate Change. To remain on a pathway consistent with limiting the increase in global average temperature to 1.5 °C by 2100, the International Renewable Energy Agency projects that offshore wind capacity would need to reach 380 GW by 2030 and 2,000 GW by 2050 (IRENA, 2023). This would require an increase of approximately 405% in just seven years (2023-2030) and 2,560% over 27 years, representing an exceptionally rapid expansion.

Moving in this direction will require governments around the world to process, assess, and approve hundreds of new offshore wind projects. This includes, for example, permits to use marine and coastal space, environmental authorisations, and demonstration of compatibility with other uses, so as to safeguard broader social and environmental interests. A rapid energy transition that remains aligned with these interests therefore depends not only on technological advances and investment, but also on stronger decision-making processes and more robust technical assessment.

To date, the expansion of offshore wind energy has been concentrated mainly in European and East Asian countries located in temperate regions. China (50.3%), the United Kingdom (19.2%), Germany (10.9%), the Netherlands (5.9%), Taiwan (3.7%), Denmark (3.2%), and Belgium (2.7%) accounted for the largest offshore wind markets in 2024 (GWEC, 2025).

However, a large number of projects have been announced or are at early stages of development in tropical and subtropical regions, according to data from Global Energy Monitor[1]. As a result, while temperate regions benefit from greater accumulated experience, established regulatory frameworks, stronger technical capacity, and more consolidated infrastructure, development in tropical regions is still at an early stage. It is therefore expected that many tropical countries will move quickly to put in place the conditions needed for the sector to grow. Although temperate regions also encompass highly biodiverse marine ecosystems, the expansion of offshore wind energy into tropical regions demands particular attention because of the presence of distinct and sensitive ecological configurations, such as tropical coral reefs, rhodolith beds, and other coastal and marine habitats that remain insufficiently studied in relation to this sector.

In Latin America, Brazil and Colombia are the main countries attracting attention, both of which have relevant offshore wind initiatives, although these are still at an early stage and neither country has operating wind farms. Brazil, in particular, has more than 50 projects submitted to the competent EIA authority (IBAMA, 2026) and is identified as the region's main emerging market.

In Africa, Morocco and South Africa stand out because of their strong technical potential and ongoing efforts to structure governance for the sector. In South and Southeast Asia, there is a growing concentration of projects under development, especially in India, Sri Lanka, Vietnam, and the Philippines. In Oceania, Australia stands out as an emerging market, with designated project areas and auctions already scheduled or underway (GWEC, 2025).

The regulatory process for offshore wind development is complex and varies across jurisdictions, but it generally requires impact assessment to be conducted to inform project approval decisions.

Fundamentals of Environmental Impact Assessment and its application to the offshore wind energy sector

EIA is an environmental policy instrument embedded in the legislation of approximately 191 countries (Yang et al., 2019). It is applied before the approval of projects that may cause significant adverse environmental and social impacts. This preventive approach is applied during the planning phase, before projects are implemented, allowing technological, locational, and other alternatives to be considered, as well as measures to be identified to avoid, minimize, restore, or compensate for adverse impacts.

> **What is Environmental Impact Assessment?**
> It is a process of examining the future consequences of a proposed action.

1 https://globalenergymonitor.org/projects/global-wind-power-tracker/tracker-map/

EIA is an essential instrument for ensuring that offshore wind energy projects are developed in a responsible, transparent, and informed manner. By providing an in-depth analysis of a proposed project or expansion, as well as of the specific location in which it is to be developed, EIA contributes to decision-making on new projects in several ways. Table I.1 highlights these contributions.

EIA has also played an important role in the production and circulation of technical and scientific knowledge, as it generates, systematises, and makes accessible relevant information about territories. In doing so, it helps expand knowledge about a region, reduce uncertainties, and improve the quality of both technical and public debate. This role is particularly strategic in coastal and marine contexts, where data and information are often scarce or fragmented. Taken together, these functions make EIA an essential tool for addressing the complex challenges of ocean governance.

Table I.1. Functions of Environmental Impact Assessment.

1. Project Design Support	2. Stakeholder Engagement Instrument
When applied from the earliest stages of project planning, EIA helps integrate environmental and social considerations into project design and decision-making. In particular, the comparison of alternatives, including technology, location, and other options, is often one of the most important ways in which EIA can help avoid and minimize adverse impacts. EIA can also help align a project with public policies, territorial and sectoral planning and regional sustainability commitments, as well as position the project and its measures within the broader planning and environmental context.	EIA promotes transparency and inclusion by involving different stakeholders throughout the assessment and decision-making process. By supporting stakeholder engagement and effective dialogue, EIA helps ensure that social concerns are considered in decisions and enables the incorporation of local knowledge, cultural values, and relevant social perspectives. This can support context-appropriate responses and improve project design. In addition to helping prevent conflict, adequate engagement processes contribute to the legitimacy of decisions and strengthen environmental governance.
3. Decision-Making Support	**4. Environmental Management Instrument**
EIA is a forward-looking instrument that anticipates the environmental and social consequences of a project and provides decision-makers with a sound basis for more balanced choices. By bringing together multiple factors within the decision-making process, EIA supports the promotion of positive outcomes, the avoidance, mitigation, or compensation of adverse impacts, and the explicit consideration of trade-offs, including the gains and losses associated with decisions on whether to proceed with a project.	The contribution of EIA does not end with the project approval decision. Throughout the follow-up stage (implementation and operation), EIA supports the application of mitigation measures, as well as the monitoring and adaptive management of impacts and risks, including those not initially foreseen. In this way, it reinforces the responsibilities of both the project proponent and public authorities after the issuance of licences or other authorisations, helping to ensure that commitments made during the assessment process are translated into effective practices throughout the project life cycle.

Source: Prepared using information from IAIA (2009); Morrison-Saunders et al. (2024); Morrison-Saunders and Sánchez (2024); Sánchez (2020); Sinclair et al. (2022).

Learn more

The EIA process may be conducted in parallel with other approval processes for offshore wind energy projects. One internationally recommended practice to enhance administrative efficiency and reduce processing times is to consolidate approval procedures under a single coordinating body. Known as a one-stop shop, this approach has been adopted in countries such as the United Kingdom, Denmark, the Netherlands, and South Korea. Under this model, proponents engage with a single regulatory authority responsible for coordinating all required approvals, including those related to the EIA process. However, careful implementation is needed to ensure that affected communities are adequately considered, and that energy justice, democratic legitimacy, and long-term social acceptance are not compromised. For further details on this approach, see:

GWEC, & IRENA. (2023). Enabling frameworks for offshore wind scale up: Innovations for permitting. Available at: <https://www.irena.org/Publications/2023/Sep/Enabling-frameworks-for-offshore-wind-scale-up>

Gulbrandsen, L. H. (2025). The limitations of the one-stop-shop approach: How local experiences shaped opposition to the Norwegian wind power permitting system. Energy Research & Social Science, 123(March), 104048. https://doi.org/10.1016/j.erss.2025.104048

Although EIA processes vary across countries, their core stages are broadly similar. Table I.2 summarises the main characteristics of each stage, highlighting the specificities of the offshore wind sector.

The EIA process spans the entire project life cycle. It starts with the decision on whether EIA is required, followed by scoping of the Environmental Impact Study (EIS) and preparation of its non-technical summary. With opportunities for public participation, the process then moves towards a decision on whether to approve the proposal. If approved, follow-up and monitoring continue to ensure compliance with the approval conditions.

Table I.2. Stages of the Environmental Impact Assessment and the particularities of its application to the offshore wind energy sector.

EIA stage	Definition and particularities of its application to the offshore wind energy sector
Screening	Determines whether a project is subject to EIA and what type of study is required. For offshore wind farms, screening criteria may take into account the size of the project, its proximity to sensitive areas (such as reefs, mangroves, or migratory routes), and the presence of potentially conflicting uses in the area. Screening may also be informed by zoning and by studies related to Marine Spatial Planning. In some countries, the EIA process is integrated into auction or concession procedures for offshore energy areas, helping to make more suitable areas available for projects in this sector.
Scoping	The main functions of scoping are to focus the assessment on the issues that are most relevant, such as marine biodiversity, fisheries, navigation routes, and coastal communities; to define the boundaries and content of the EIS; to plan the baseline studies and data collection required; and to identify the project alternatives to be assessed. It also defines the key themes and methods to be adopted. In some jurisdictions, scoping is formalised through Terms of Reference; in others, no specific scoping document is issued. Good practice recommends that scoping should allow for public participation and involve relevant public authorities and institutions that interact throughout the EIA process. It may also include a requirement to assess cumulative impacts.
Preparation of the Environmental Impact Study	The EIS should address all elements defined during scoping. It usually includes project description, environmental and social baseline characterisation of the study area, impact analysis, and the proposal of mitigation and compensation measures. It should cover the physical, biotic, and socioeconomic environments, taking into account the activities expected in each phase of the project life cycle. Impact analysis should include the identification, prediction, and evaluation of impact significance, and should indicate which impacts require measures to avoid, minimize, restore, or compensate for adverse impacts, as well as opportunities to enhance positive ones. The study may also be developed using methods that involve affected communities. A non-technical summary should be prepared to support public participation.
Review	This stage involves the competent authority legally responsible for reviewing the EIA, together with other institutions that may contribute to the assessment. In addition to the technical review carried out by the competent EIA authority, the analysis should also consider information arising from stakeholder participation and from institutions with relevant responsibilities for the decision. Additional information or complementary studies may be requested. The outcome of this stage is usually a technical opinion or review report, including a recommendation for approval or rejection and/or conditions for approval.
Decision-making	At this stage, the competent EIA authority decides whether to approve the project, approve it with conditions, or reject it, based on the information presented in the study, the outcomes of public participation, and the technical opinions issued during the review. The acceptability of residual impacts should be assessed in light of the proposed measures to avoid, minimize, restore, and compensate for them. Where the project is approved, the conditions for implementation and operation are established. Depending on the jurisdiction, the decision-maker may or may not be the same authority responsible for the technical review.
Follow-up	Following the approval conditions, the proposed measures are detailed, implemented, and monitored. It is necessary to periodically verify the effectiveness of mitigation and compensation measures, as well as to identify unforeseen impacts and the actual residual impacts. Offshore wind energy projects generally require ongoing monitoring of issues such as marine fauna, underwater noise, and water turbidity, among others. They should also include mechanisms for adaptive management, allowing measures to be improved and adjusted over time. It is essential to ensure transparency and stakeholder engagement throughout all stages of the EIA process, including follow-up.

Source: Prepared using information from Duarte and Sánchez (2020); Sánchez; Duarte (2022); Sánchez (2020); Morrison-Saunders (2023).

In EIA, the assessment of impacts on ecosystem services and the integration of climate change as a cross-cutting issue have emerged as important themes. Other topics, although already well recognised, still require strengthening in practice, such as cumulative impact assessment (CIA), the assessment of social and health impacts, and stakeholder engagement.

The follow-up stage, which is the longest stage in EIA, has also been identified as a weak point, often lacking adequate arrangements to ensure that mitigation measures are implemented and adjusted as necessary to support the effective management of significant project impacts (Dias et al., 2019; Noble and Birk, 2011).

Effective application of EIA can therefore be considered one of the pillars for ensuring that the energy transition takes place in a fair and responsible manner, delivering real benefits to society. High-quality environmental and social studies should not only inform decision-making, but also improve the decision-making process by grounding it in the best available knowledge and by helping to recognise and monitor significant impacts, the trade-offs involved, and the measures needed to manage them. By linking specific projects to concrete socio-environmental contexts, EIA can help generate solutions that reconcile development and environmental protection.

For this reason, this Guide seeks to provide a technical and ethical reference for those involved in this process, offering good practices that help address recurring weaknesses and strengthen social trust in EIA as a strategic instrument for a more sustainable energy transition.

The Guide is limited to the assessment of impacts arising from the planning, construction, operation, and decommissioning of offshore wind farms and their associated facilities. Impacts related to other activities, such as the manufacture of wind turbines and other wind farm components, as well as impacts resulting from activities that may be enabled by increased electricity availability ("Energy for X"), are outside its scope.

Figure I.1 shows the boundaries and themes covered by the Guide. This Guide also addresses CIA, covering its use in regional approaches in **Chapter 2** and as part of project-level EIA in **Chapter 10**. In the latter case, CIA assesses the impacts of multiple sources on the same component and uses methods that differ from those applied to the assessment of direct and indirect impacts of individual projects, as discussed in the chapters of Part 3 of this Guide.

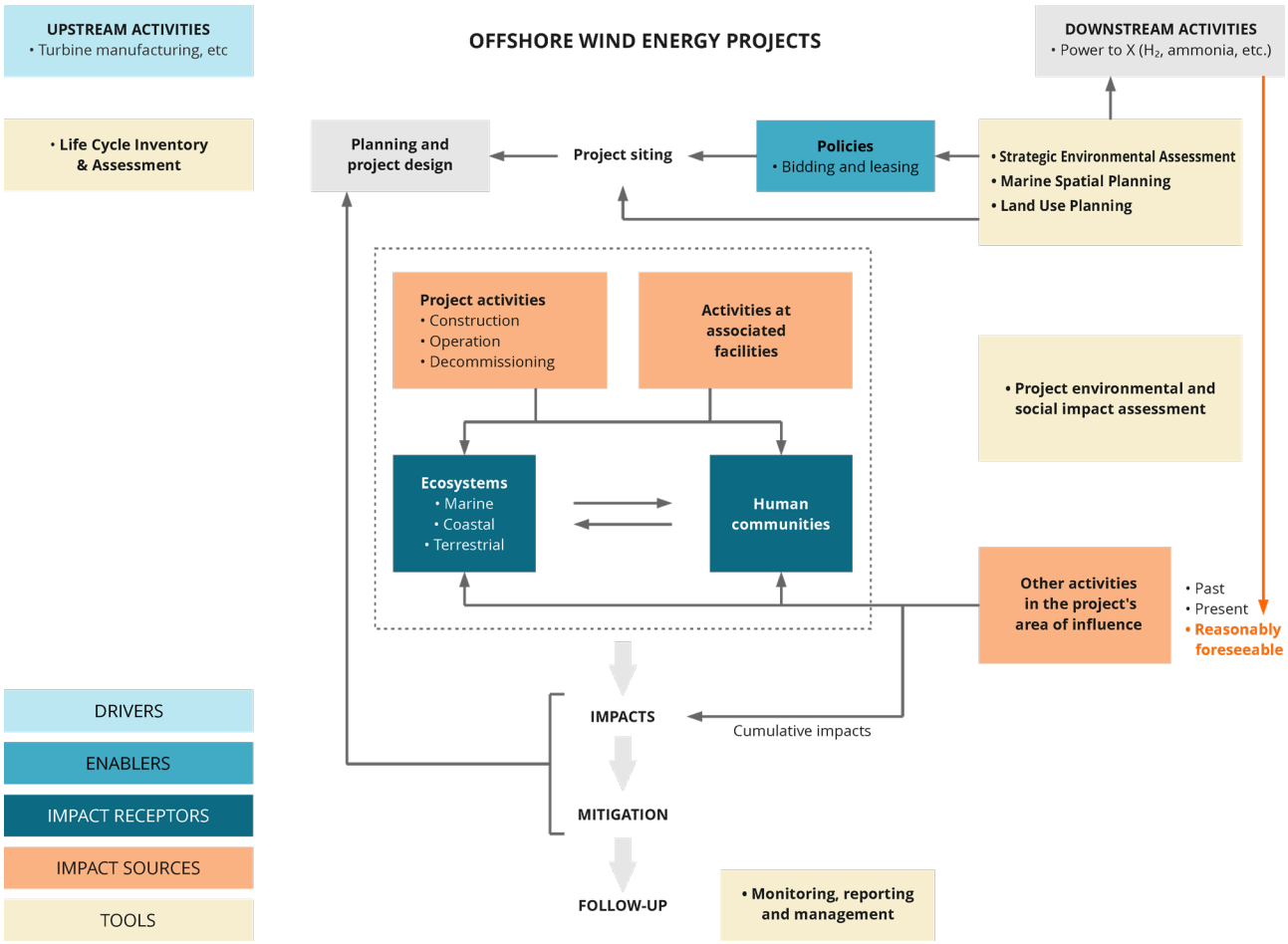


Figure I.1. Relationship between the impact assessment of offshore wind projects, which is the focus of this Guide, and other areas of impact assessment.

Learn more

Several resources with guidelines and good practices for EIA are made available free of charge by the International Association for Impact Assessment (IAIA), in <https://iaia.org/> and also by the International Finance Corporation (IFC), with its performance standards on environmental and social sustainability <https://www.ifc.org/en/insights-reports/2012/ifc-performance-standards>

Some countries also have their own associations, such as Brazil (ABAI - Brazilian Association of Impact Assessment), South Africa (IAIAsa - International Association for Impact Assessment South Africa), and South Korea (KSEIA - Korean Society of Environmental Impact Assessment). These associations may provide materials already adapted to the legal context of each EIA system.

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CONCEPTUAL FRAMEWORK



Chapter 1

ECOSYSTEM-BASED MANAGEMENT IN ENVIRONMENTAL IMPACT ASSESSMENT

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Among recent advances in the Environmental Impact Assessment (EIA) process [see the definition in the Introduction section], the progressive incorporation of a more comprehensive approach aligned with the principles of Ecosystem-Based Management (EBM) stands out. Although this represents an important conceptual and methodological improvement, progress remains slow and fragmented. In this context, this chapter aims to deepen the understanding of EBM and to outline the way in which its principles can contribute to enhancing and strengthening EIA practice.

THIS CHAPTER:

1. What is Ecosystem-Based Management?
2. Why integrate Ecosystem-Based Management and Environmental Impact Assessment?
3. How to integrate Ecosystem-Based Management and Environmental Impact Assessment?
4. Challenges, opportunities, and recommendations
5. Perspectives

1.1 What is Ecosystem-Based Management?

Ecosystem-Based Management (EBM) is recognized as a comprehensive and effective approach for addressing contemporary socio-environmental challenges (Andrade & Turra, 2021; Haugen et al., 2024). It emphasizes the integrated management of interactions between human activities (the social dimension) and the processes, dynamics, and natural resources of the non-human system (the ecological dimension), with the aim of ensuring harmonious coexistence.

> **Ecosystem-Based Management** is a **holistic, integrated, and participatory management approach** that considers the interactions between the social and ecological dimensions of a given system, across multiple scales, to promote the sustainable use of its resources. (Haugen *et al.*, 2024).

While it analytically distinguishes the human sphere and ecological processes and resources, EBM incorporates the concept of socio-ecological systems, acknowledging the inseparability of these dimensions and the influence of social values and interests on the management of natural resources (Long et al., 2015).

> **Socio-ecological systems** are **complex, adaptive** systems in which social and ecological components interact **dynamically** and **interdependently, mutually influencing one another** (Berkes *et al.*, 2008).

EBM is structured around a set of principles that guide decision-making in complex and dynamic contexts, such as coastal and marine systems (**Box 1.1**). These principles provide the conceptual and operational foundations for promoting sustainability, integrating ecological and social dimensions, and addressing the uncertainties inherent in environmental processes.



Box 1.1. Principles of Marine Ecosystem-Based Management

Promotes sustainability
The process is oriented to promote sustainability, understood as the capacity of an ecosystem to meet the needs of present populations without compromising its ability to meet the needs of future generations. Sustainability-oriented objectives must consider the economic, environmental, and social pillars.

Considers the dynamic nature of ecosystems
Ecosystems are recognized as intrinsically dynamic and subject to natural change. Recognizing the natural dynamics and variability of ecosystems allows for distinguishing natural changes from impacts resulting from external factors (e.g., climate change, urbanization, development projects) or other human actions.

Considers ecosystem connections
The internal and external connections between the biotic and abiotic components of ecosystems are considered. This includes considering the links between ecosystem structure, processes, functions, and services, both within ecosystems and with adjacent ecosystems, and how human activities can impact them.

Protects ecological integrity and biodiversity
The process is oriented to the restoration and/or maintenance of the ecological integrity and biodiversity of ecosystems. This entails maintaining ecosystem structures, processes, and functions.

Strengthens adaptability
The EBM process is carried out in an adaptive manner, promoting learning and improvement through iterative cycles of (1) problem identification, (2) action planning, (3) implementation, (4) monitoring, and (5) evaluation and adaptation.

Performs proper monitoring
Changes in the biotic, abiotic, and human components of the ecosystem are monitored. The recorded changes are evaluated, allowing for responses and adaptations as needed.

Recognizes socio-ecological systems
Humans, their well-being, and social processes are recognized as part of ecosystems, acknowledging the strong interrelationship and interdependence of ecological and social processes (including management and economic processes)

Promotes integration
The EBM process adopts an integrated approach that ensures the internal consistency of proposed actions and integrates different elements/uses/institutions of the environment within a single system. It includes sectoral, spatial, governmental, interdisciplinary and international integration.

Supports decisions that reflect social choices
EBM recognizes that its goals are a matter of social choice, determined by negotiations and trade-offs between stakeholders with different perceptions, interests, and intentions. The diversity of views must be considered, and social choices must be clear and accessible to all.

Promotes social participation
The process involves stakeholders at all stages of management, considers their views, and seeks to balance local interests with those of the general public in an equitable and transparent manner.

Recognizes uncertainties
EBM recognizes uncertainties related to (1) the natural dynamics of the ecosystem, (2) limited knowledge of certain aspects of the ecosystem, and (3) the possible outcomes of management strategies.

Considers interdisciplinary scientific knowledge
EBM treats interdisciplinary scientific knowledge as necessary information to guide actions.

Considers different knowledge systems
EBM incorporates different knowledge systems, including local and traditional knowledge.

Recognizes distinct boundaries
The EBM process is spatially defined and considers the particular attributes (ecological and social) of the ecosystem in question. Boundaries are to be operationally defined by those involved in the process and are not limited to existing geopolitical boundaries.

Considers appropriate spatial and temporal scales
EBM considers different spatial and temporal scales that influence the system's socio-ecological characteristics and processes and that are appropriate to decision-making objectives.

Source: Based on Xavier et al. (2022); Long et al. (2015)

1.2 Why integrate Ecosystem-Based Management and Environmental Impact Assessment?

EBM has gained increasing prominence in international debates promoted by multilateral organizations such as the United Nations (Box 1.2). It is part of the 2030 Agenda for Sustainable Development (United Nations, 2015); in the discussions of the International Seabed Authority on seabed mining (Guilhon et al., 2023); and Marine Spatial Planning (MSP) initiatives advanced by the Intergovernmental Oceanographic Commission (Ehler & Douvere, 2009). EBM has been presented as particularly relevant for the management of coastal and marine systems (Haugen et al., 2024; Long et al., 2015).

Box 1.2. Ecosystem-Based Management and Environmental Impact Assessment in the global ocean agenda

The importance of applying Ecosystem-Based Management to ocean sustainability is also highlighted in international agendas addressing the ocean. Among the various multilateral processes focused on ocean issues, three stand out as pillars of a global agenda:

- The United Nations 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 14 – Life below water (SDG 14), which is directly linked to the ocean [https://sdgs.un.org/goals/goal14];
- The Ocean Decade, which highlights ten key challenges specifically related to the ocean sustainability agenda, including ambitious actions such as tackling marine pollution, restoring ocean ecosystems, protecting marine biodiversity, as well as addressing climate change, and producing high-quality, accessible ocean science data [https://oceandecade.org];
- The High-Level Panel for a Sustainable Ocean Economy, as consolidated in the document 'Transformations to a Sustainable Ocean Economy: A Vision for Protection, Production and Prosperity', which aims, among other goals, to achieve 100% sustainable management of ocean areas under national jurisdiction by 2025. The challenges associated with the transformation desired by the High-Level Panel are organized into five key areas of action: (1) ocean wealth, (2) ocean health, (3) ocean equity, (4) ocean knowledge, and (5) ocean finance (Ocean Panel, 2023) [https://oceanpanel.org/]

EBM and EIA are considered essential to promote sustainability (Morrison-Saunders et al., 2019). One of the main challenges for its implementation lies in the ability of its practices to incorporate the complexity of socio-ecological systems, both at the planning and project levels (Nita et al., 2022). Addressing these challenges requires more holistic approaches, which can be achieved through integration with EBM.

Thus, by integrating EBM and EIA within ocean governance, decision-making organizations can proactively address risks and enhance socio-ecological resilience. Integration enables a balance between competing interests, ultimately safeguarding marine ecosystems for future generations while supporting the development of a fair and sustainable ocean economy. Many sectors and activities, such as conservation, fisheries, aquaculture, biotechnological applications, and seascape conservation, have already been implementing strategies based on EBM principles. However, it remains necessary to strengthen and promote their application in sectors such as oil and gas, tourism, maritime transport, and renewable energy (Haugen et al., 2024).

1.3 How to integrate Ecosystem-Based Management and Environmental Impact Assessment?

EBM and EIA share several principles that not only complement each other but also reinforce one another, such as the promotion of integrated, participatory, adaptive approaches based on the best available knowledge. Integration strengthens the importance of stakeholder engagement and enhances transparency throughout the process, adding value and objectivity to decision-making.

EBM has the potential to enhance the substantive effectiveness[1] of EIA by promoting a holistic view of socio-ecological systems. Adopting an integrated approach to social and ecological dimensions fosters a systemic perspective that enriches impact analysis, facilitating the identification of ecologically, socially, and economically justifiable gains and losses in balancing biodiversity conservation and development imperatives.

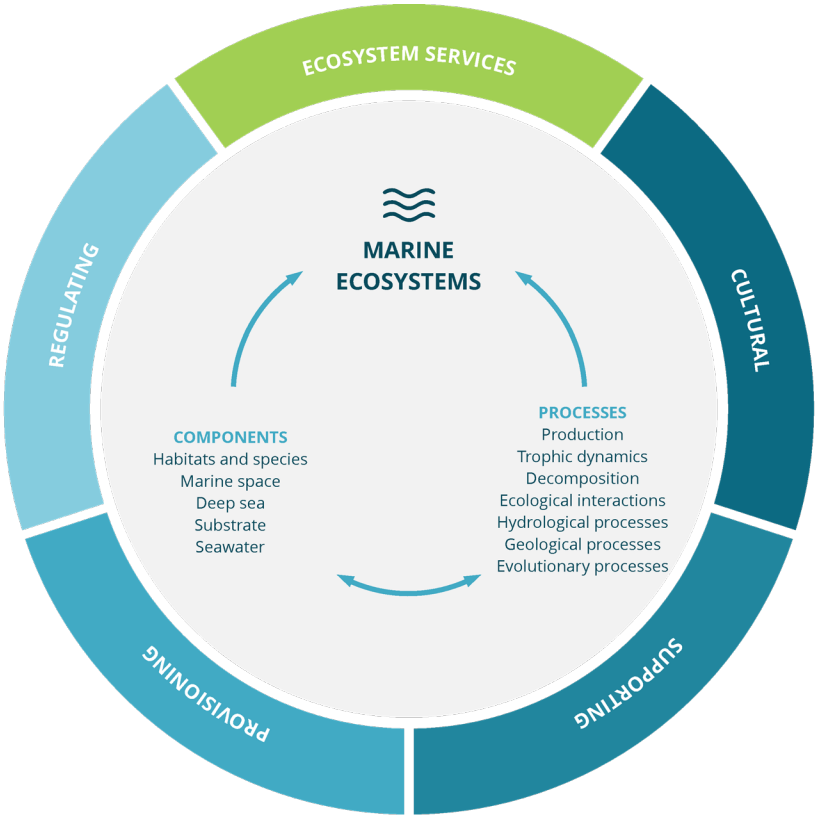
In the social dimension, the inclusion of socioeconomic factors as drivers in EIA enables a more systemic understanding of environmental changes and enhances sensitivity toward local factors (Andrade & Turra, 2021). In the ecological dimension, the approach broadens the understanding of the structure, functioning, and services provided by ecosystems, allowing EIA to go beyond linear impact identification and to consider the interrelationships among these impacts. Thus, EBM can be adopted to systematically assess cumulative impacts, providing a more comprehensive analysis of medium to long-term impacts (Andrade & Turra, 2021).

In the ecosystem approach to EIA, climate change is fundamental, as it both influences and is influenced by the dynamics of socio-ecological systems and their adaptive capacity (Xavier et al., 2022; Laurino et al., 2025). Therefore, it is essential to incorporate the climate change dimension into the EBM-EIA interface (Brownlie; Treweek, 2018) to improve the understanding of impacts, vulnerabilities, and cumulative impacts, as well as the definition of appropriate mitigation and adaptation measures in contexts of climate uncertainty and environmental transformations (Fernandino et al., 2018; Munroe et al., 2015).

The implementation of an offshore wind farm project has traditionally interfered with navigation, led to the establishment of exclusion zones, and impacted marine wildlife (see Chapter 5). EBM strengthens EIA by enhancing the analysis of ecological interactions (see Chapter 5); the consideration and application of ecosystem services (Chapters 5, 7, 8, and 9); the assessment of cumulative impacts (Chapter 10); the effectiveness of social participation processes (Chapter 3) and integrated understanding in the context of climate change.

1 Substantive effectiveness refers to the degree to which EIA contributes to improved outcomes, going beyond procedural compliance, indicating whether locational or technological alternatives selected were in fact less impactful, or point to adequate mitigation measures or the consideration of cumulative impacts, for example (Cashmore et al., 2004).

Among the proposals to operationalize the integration of EBM and EIA is the inclusion of an impact assessment of Ecosystem Services (ES) (Rosa and Sánchez, 2016; Landsberg et al., 2013). Ecosystem services (MEA, 2005) are the benefits that people obtain from ecosystems, classified into supporting services - photosynthesis and nutrient cycling; regulating services - climate regulation, flood regulation/control; provisioning services - food, water, wood, and fiber; and cultural services- such as spiritual or recreational benefits. Thus, ES encompasses both the processes and functions of ecosystems (intermediate and final services) as well as the material and non-material benefits resulting from them. Figure 1.1 presents a conceptual model for coastal and marine ecosystem services.



ECOSYSTEM SERVICES

REGULATING	PROVISIONING	SUPPORTING	CULTURAL
Climate regulation	Coastal and marine biota	Primary production	Marine spaces and landscapes
Clean water	Food – harvesting	Supply of larvae and gametes	Tourism and recreation
High-quality sediments	Food – aquaculture	Nutrient cycling	Nature observation
Biological control	Food for fish	Water cycling	Spiritual well-being
Waste decomposition	Fertilizers	Habitat formation	Cultural well-being
Neutralization of contaminants	Biofuels	Physical barriers	Aesthetic benefits
Carbon sequestration	Ornamental species	Marine landscapes	Education and research
Regulation and protection against extreme events	Pharmaceuticals		Health benefits
Pleasant climate	Biotechnology		
Coastal erosion prevention			
Coastal protection			
Waste removal			

Figure 1.1. Conceptual model for coastal and marine ecosystem services. (Turner, 2015).

In a socio-ecological system, ES are the linking elements between the ecological and social components of the system. The concept has been applied across various decision-making contexts, facilitating the understanding of complex processes and providing a common language that enhances understanding of socio-ecological interactions among diverse audiences.

The integration of EBM into EIA enables a more accurate assessment of these services, informing decision-making and supporting a more comprehensive understanding of how the benefits provided by ecosystems may be affected directly or indirectly by projects (Baulaz et al., 2023). This evaluation, together with the identification of the ES, contributes to planning and management by enabling the early identification of changes and non-linear impacts and by serving as a basis for more detailed analyses. The figure below illustrates when and how the ES can be applied to the EIA process.

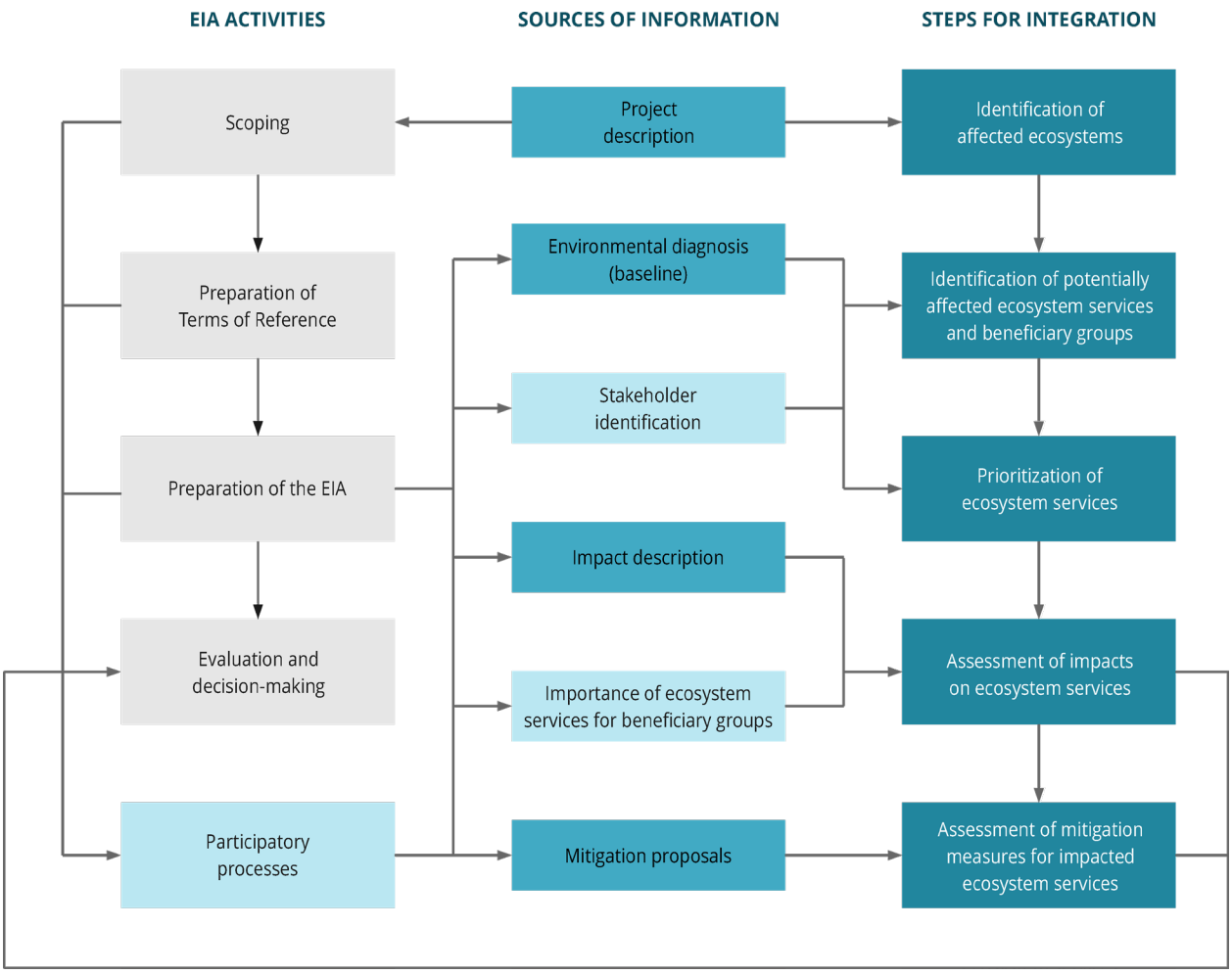


Figure 1.2. Proposal for identification and consideration of Ecosystem Services in Environmental Impact Assessment (based on Rosa and Sánchez, 2016; Landsberg et al., 2013).

It considers the ES in EIA to have the potential to: (i) promote a better characterization of socio-ecological systems; (ii) improve the integration of information for a better definition of the scope, delimitation of the study area, identification of impacts and mitigation measures; and (iii) facilitate communication processes between the groups involved in the decision-making process (Baker et al., 2013, Rosa; Sánchez, 2016). Thus, incorporating the ES approach can enhance EIA, contributing to more informed and sustainable decisions, and it is recommended that it be undertaken as part of EIA, rather than a separate analysis (Baker et al., 2013). To ensure the effectiveness of this integration, it is recommended to adopt good practices, including guidelines and strategies, across the different stages of EIA (**Box 1.3**).

Box 1.3. Best Practices Principles for Considering Ecosystem Services in Environmental Impact Assessment

1. Use EIA to maintain and enhance biodiversity, with a goal of no net loss (NNL) outcomes as a minimum and an aspiration for net gain (NG).
2. Integrate biodiversity and ecosystem services in development planning and EIA from the earliest possible stages.
3. Take an ecosystem perspective to framing of EIA, allowing the significance of ecological changes to be assessed at appropriate spatial and temporal scales.
4. Address the rights, values, dependencies, and benefits that people derive from biodiversity and ecosystems in EIA, taking a participatory and transparent approach throughout.
5. Design EIA baseline surveys and assessments to generate the information and understanding needed to support evidence-based approaches to assessment of impacts on biodiversity and ecosystems.
6. Ensure that implications for biodiversity and ecosystem services are fully addressed using transparent, evidence-based approaches and appropriate expertise.
7. Apply the MH, with emphasis on preventive measures and including offsets for residual impacts on biodiversity, ecosystems and the services they provide.
8. Use precautionary approaches where the consequences of development for biodiversity and ecosystem services are unclear and there is insufficient information to exclude the possibility of unacceptable, irreversible, or non-offsetable impacts.
9. Establish robust adaptive management systems to ensure that EIA commitments will be met, mitigation measures will be implemented and that no net loss/net gain (NNL/NG) outcomes can be demonstrated through monitoring, auditing and reporting.

(Source: Brownlie et al., 2018)

1.4 Challenges, opportunities, and recommendations

The integration of EBM into EIA is strategic for strengthening decision-making in marine and coastal management, especially amid the expansion of large-scale infrastructure projects at sea, including offshore wind farms.

In addition to EBM, international initiatives aimed at advancing ocean sustainability engage with EIA in different ways and can contribute principles and reference frameworks that enhance EIA practice. Examples include:

- **The 2030 Agenda for Sustainable Development:** EBM-EIA integration supports the implementation of SDG 14 by incorporating systemic, cumulative, and multi-scale analysis of impacts on biodiversity and ecosystem services. It strengthens the mitigation hierarchy and integrates conservation, sustainable use, and restoration, contributing to goals such as pollution reduction (14.1), ecosystem protection (14.2), and expansion of scientific knowledge (14.a).

- **Ocean Decade:** EBM–EIA integration supports the 10 challenges of the Decade by incorporating robust scientific data, adaptive monitoring, and social participation. By adopting an ecosystem-based and strategic approach, it strengthens efforts to address pollution, biodiversity loss, and climate risks, promoting evidence-based decision-making, interoperable data, and nature-based solutions.

- **Ocean Panel for Transformations to a Sustainable Ocean Economy - the High Level Panel for Sustainable Ocean Economy:** The application of EBM in EIA contributes to the goal of 100% sustainable management of areas under national jurisdiction by internalizing natural capital, ecological risks, and socio-environmental justice in decisions on ocean-based production and infrastructure, aligning environmental conservation, economic prosperity, and responsible governance.

The tables below provide an operational roadmap to guide the identification of challenges and opportunities, with recommendations that support aligning EBM-EIA integration with the global ocean agenda. Table 1.1 presents the challenges and opportunities for integrating EBM and EIA.

Table 1.1. Challenges and opportunities to integrate Ecosystem-Based Management with Environmental Impact Assessment.

	At the project level	At a strategic level
Challenges	• Limited availability of robust environmental data for marine environments. • Limited technical capacity to assess impacts in dynamic and hard-to-access environments. • Sectors continue to operate in a fragmented manner (e.g., transportation, fishing, tourism, oil and gas, offshore wind).	• Lack of legal frameworks requiring impact assessment instruments in coastal and marine planning. • Sectoral and institutional fragmentation and a lack of integrated governance. • Challenges in articulating across local, regional, national, and international scales.
Opportunities	• Growing use of remote monitoring technologies as well as spatial and ecosystem modeling. • Data integration promoted by the Ocean Decade can improve the quality of analysis. • Strengthening environmental policies through the use of international frameworks such as the High-Level Panel for a Sustainable Ocean Economy (Ocean Panel, 2023).	• The Ocean Decade provides momentum for investments in transdisciplinary science aligned with management objectives. • EIA, within the context of the 2030 Agenda, fosters international cooperation for the conservation of areas beyond national jurisdiction. • The integration of strategic planning instruments, such as Marine Spatial Planning and Strategic Environmental Assessment (see Chapter 2), enables impacts to be avoided before they occur — thereby increasing the effectiveness and legitimacy of decisions.

Table 1.2 provides practical recommendations at the project and strategic levels (i.e., sectoral and/or territorial planning). The incorporation of EBM principles into the EIA depends on institutional coordination and regulatory support, as well as on data availability, and ongoing technical capacity-building.

Table 1.2. Recommendations for integrating Ecosystem-Based Management into Environmental Impact Assessment.

At the project level	At a strategic level
1. Incorporate EBM principles • Consider ecological boundaries and socio-ecological connectivity between marine and coastal habitats. • Assess impacts on ecosystem structures (components), functions, and associated ecosystem services linked to the maintenance of ecosystem integrity and human well-being. **2. Align with SDG 14 (2030 Agenda)** • Evaluate projects for the risk of degradation and loss of essential habitats (mangroves, reefs, seagrass beds), adopting stringent acceptability criteria for their protection. • Monitor indicators linked to SDG 14 targets (e.g., marine pollution, overfishing, protected areas). **3. Consider the challenges highlighted by the Ocean Decade and High-Level Panel** • Integrate oceanographic, climatic, and ecological data produced by national and international scientific programs. • Value the local and traditional knowledge of indigenous peoples and local communities regarding coastal and marine ecosystems. **4. Implement Cumulative Impact Assessment (CIA; see Chapter 10)** • Include analyses of cumulative impacts with other projects or pressures in the same coastal and marine region or river basin. • Evaluate the contribution of projects to advancing the objectives of the Global Ocean Agenda.	**1. Implement and develop integrated assessments (other assessment tools) in coastal and marine areas** • Strengthen participatory governance across multiple scales (plans, programs, and policies), ensuring transparency, inclusion, equity, and institutional integration. • Incorporate climate change and coastal adaptation scenarios. • Integrate the ecological, social, and economic dimensions within an ecosystem-based and intersectoral perspective. • Align local practices with global commitments and guidelines for ocean sustainability, with feedback across local, regional, and global levels. **2. Incorporate the strategic vision of the Ocean Panel and Ocean Decade** • Prioritize policies that promote a sustainable ocean economy. • Identify synergies between sectors (e.g., low-impact tourism and marine conservation). • Develop capacities for institutions and technical teams to use integrated, ecosystem-based tools. **3. Strengthen regional Cumulative Impact Assessment (CIA) and sectoral and territorial planning (see Chapter 2)** • Develop regional databases that inventory environmental pressures. • Use spatial and temporal modeling tools to predict cumulative impacts.

1.5. Perspectives

Implementing EBM principles is challenging, given the complexity of the systems to which it applies, especially in coastal and marine socio-ecological systems. Nevertheless, it is an incremental and adaptive practice, allowing implementation to begin with concrete measures focused on selected principles and to progressively improve EIA practices.

Integrating EBM and EIA is a fundamental step to improve **project quality, strengthening coastal and marine governance, and increasing the effectiveness of environmental management instruments with social participation,** contributing to maintaining ecosystem integrity and the well-being of communities that depend on the ocean.

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Chapter 2

TIERING ENVIRONMENTAL IMPACT ASSESSMENT WITH OTHER PLANNING INSTRUMENTS

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The marine space with potential for wind energy installations is used for various purposes, such as fishing, navigation, tourism, extraction of mineral and oil and gas resources, and environmental conservation. To reconcile various current and potential uses of marine and coastal spaces, many governments adopt instruments to plan the use of resources. This chapter shows the importance of considering the planning framework in impact assessment and the key linkages among the instruments.

THIS CHAPTER:

1. Planning instruments: why and what to consider?
2. Key linkages: how to integrate relevant information?

2.1 Planning instruments: why and what to consider?

To assess the impacts of a project, it is necessary to take into account the guidelines established by more comprehensive planning instruments, usually formalized in public policies (Moura, 2016), related to the sector (e.g., aimed at the strategic planning of the energy sector) or to the area where a given project intends to be implemented (e.g., aimed at the integrated planning of marine space). These instruments, such as Policies, Plans, and Programs (PPPs), often establish obligations or restrictions that must be observed in project planning and, consequently, in their impact assessments. In addition, these PPPs can also be informed by strategic assessments, such as the Strategic Environmental Assessment (SEA) or the Cumulative Impact Assessment (CIA) at the regional level.

Considering that there is a hierarchy between the levels of planning (vertical hierarchy of the policy, for the plan, program, and project; and horizontal hierarchy between the different sectors), information needs to be transferred across these levels of planning and the impact assessment instruments applied at each level. This flow, or transfer of information, between the levels of planning and impact assessment (also called tiering in the literature), must happen in an organized manner (Therivel; González, 2021). The importance of tiering has been highlighted by Environmental Impact Assessment (EIA) literature, emphasizing, for example, its benefits in terms of better defining the *terms of reference* for Environmental Impact Studies (EIS), supporting the process of including or excluding what should be the object of project EIA (González; Therivel, 2022). In some countries, EIA regulations require project EIA to consider relevant planning instruments (Box 2.1).

Box 2.1. Examples of national regulations requiring the flow of information between planning instruments and Environmental Impact Assessment

In **Brazil**, Conama Resolution No. 01/1986, establishes as a guideline for the Environmental Impact Study "to consider the government plans and programs, proposed and being implemented in the area of influence of the project, and their compatibility" (BRASIL, 1986, Art. 5).

In the **United States**, the National Environmental Policy (NEPA, 40 CFR § 1501.11) establishes that when there is an Impact Assessment (whether of a strategic or project nature) that is relevant to a new EIA process, tiering should be promoted to avoid duplication of efforts and allow the focus on appropriate issues and alternatives for decision-making.

In **Colombia**, the methodology for preparing environmental studies, as recommended by Decree 1076/2015, states that integrating environmental studies entails, among other things, identifying the relationships that cause multiple impacts, so that they can be managed simultaneously. It indicates that the environmental impact assessment requires analysis of plans, programs, and zoning that allow for reducing the significant environmental impacts of a given project in a specific territory.

The expansion of offshore wind energy requires an approach that considers its coexistence with other uses of marine space. Therefore, knowing and considering the planning and impact assessment instruments of sectors related to offshore wind activities is essential for the EIA at project level to align with the decisions that precede it and the context in which it is subscribed. It aims to ensure the environmental, social, and economic viability of the project.

2.1.1 Planning instruments

Planning and management processes, in a simplified sense, can be understood as the paths by which strategic objectives are pursued, including, for example, defining objectives, goals, and measures to be implemented and followed-up over time. Sector planning deals with the definition and implementation of the paths adopted by a given sector (e.g., Energy), ranging from its strategic and long-term objectives (such as the reduction of greenhouse gas emissions by the energy sector) to the measures adopted (such as the definition of investments for the expansion of energy generation from renewable sources) (Katsanevakis et al., 2011; Brazil, 2024).

The infrastructure associated with the development of offshore wind projects interferes with both the marine environment (associated with the installation of wind towers), and the coastal areas (where substations, transmission lines, and logistics support areas are located). Thus, for the EIA applied to offshore wind projects, it is important to consider the PPPs of the offshore wind sector itself, as well as the coastal and marine space where the project is located, and the other sectors that use these spaces. A comprehensive overview of existing planning instruments makes it possible to assess the perspectives of different sectors operating in the offshore wind project area and to identify potential conflicts and synergies. Key sectors include tourism, ports, navigation, fishing and aquaculture, nature conservation, and coastal and marine management.

In the EIA of offshore wind projects, it is important to consider the planning of the entire energy sector, including both PPPs linked to renewable energies and oil and gas. They can point out, for example, prospects for expanding the exploration of different energy sources, allowing the identification of potential conflicts (such as oil and gas exploration in the same region as the offshore wind project) and positive interactions (such as the production of green hydrogen in the region where the wind project is located), as well as prospects for expansion of demand and transmission network.

There is no single model for the governance of coastal and marine areas. Each country establishes its regulatory framework, but some management models and instruments have been widely adopted and promoted worldwide. Strategies related to Integrated Coastal Management (ICM) and Marine Spatial Planning (MSP) are applied to guide the use and occupation of these spaces. With an integrative character and a focus on coastal and marine areas, rather than specific sectors, these instruments can form the initial basis of the planning framework that should be considered for the implementation of offshore wind projects.

The ICM has emerged as a comprehensive, multisectoral, participatory, and adaptive approach that seeks to recognize the complex challenges in coastal regions and to combine human, physical, and biological aspects within a single management instrument (Campuzano et al., 2013; GESAMP, 1996). The instruments related to the ICM include guidelines for the protection, conservation, and recovery of natural resources, zoning with typologies of permitted uses and activities, and regional development plans.

> **What is Integrated Coastal Management?**
> "[...] it is a process that unites government and the community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal ecosystems and resources. The overall goal of the ICM is to improve the quality of life of human communities that depend on coastal resources while maintaining the biological diversity and productivity of coastal ecosystems" (GESAMP, 1996, p. 2).

Protected Areas, or Marine Protected Areas (MPAs), are instruments of environmental policy and have been incorporated into coastal and marine management. In addition to promoting the conservation and protection of biodiversity, they are also strategic for disciplining other uses of marine ecosystems resources, for example, fishing and mineral exploration (Stori, Shinoda and Turra, 2019). The management of these areas relies on specific instruments, such as management plans and zoning schemes, which establish relevant guidance for offshore wind activities, for example, regarding restricted areas or guidelines for environmental quality monitoring.

> **What are Protected Areas?**
> "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (Dudley; Stolton, 2008, p. 9).

With a focus on the marine space beyond the coastal zone, Marine Spatial Planning (MSP) has been consolidated as a key instrument to harmonize the multiple uses of this space.

> **What is Marine Spatial Planning?**
> "[...] it is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process." (Ehler; Douvere, 2009, p. 18).

Based on the paradigm of Ecosystem-Based Management (EBM) (**Chapter 1**), the MSP should be an inclusive, multisectoral process (addressing the interrelationships and cumulative impacts), participatory and adaptive, seeking to meet demands within environmental limits and establishing spatial and temporal measures to guide the different uses of marine areas or resources (Ehler and Douvere, 2009; UNESCO-IOC, 2021). Its main products are usually a marine spatial management plan that defines objectives, goals, and a vision for the future, as well as zoning, which spatially translates the plan's guidelines.

Maintaining the logic of integration, in many countries, the MSP seeks to complement existing coastal and marine management instruments - such as the ICM, environmental zoning, or Protected Area management plans - and inform coordinated sectoral planning that is compatible with the current and intended uses of marine space.

Learn more

To learn about Marine Spatial Planning guidelines and experiences, we suggest:

MSPGlobal, which is an initiative of the Intergovernmental Oceanographic Commission of UNESCO (UNESCO-IOC) - https://www.mspglobal2030.org/

MSP4BIO, which approaches the MSP from the perspective of promoting the protection and restoration of biodiversity in the context of the European Union - https://msp4bio.eu

PEM Brazil - CIRM - Interministerial Commission for Sea Resources, on MSP projects in Brazil - https://www.marinha.mil.br/secirm/pt-br/psrm/pem

It is also worth mentioning that international guidelines have been developed to support offshore wind energy planning in different contexts. The World Bank, for example, has proposed the *Integrated Environmental and Social Sensitivity Mapping: Guidance for Early Offshore Wind Spatial Planning* (SenMap) (World Bank Group, 2024), which guides the mapping of environmental and social sensitivity in the early planning phase of these projects, helping to minimize negative impacts and optimize the choice of areas. This type of study can be developed in cases where MSP is not yet consolidated in a country, or when it already exists, but without guidelines for the expansion of offshore wind farms, and can be integrated into existing instruments. Brazil, which is developing MSP, will carry out studies using this methodology to select areas for offshore wind development (MME, 2025).

Respecting diversity and recognizing the need for a shared vision and strategy to promote ocean sustainability, in 2020, the High-Level Panel for a Sustainable Ocean Economy (**Chapter 1**) and, more recently, UNESCO, proposed the adoption of Sustainable Ocean Plans (SOPs). These plans seek to integrate national governance elements, such as the instruments mentioned above, at the political-strategic level, where priorities, institutional responsibilities, and investment needs are made explicit. Its ultimate goal is to promote the sustainable management of 100% of marine areas under national jurisdiction, guiding public and private decisions with a focus on long-term economic and social development, in line with the protection of natural ecosystems and global agreements and goals.

Learn more

To learn about initiatives and guidelines for the preparation of SOPs, we suggest:

100% Sustainable Ocean Management - an introductory guide from the High-Level Panel for a Sustainable Ocean Economy that provides guidance for implementing SOPs - https://oceanpanel.org/wp-content/uploads/2022/06/21_REP_Ocean-SOP_v10-9.pdf

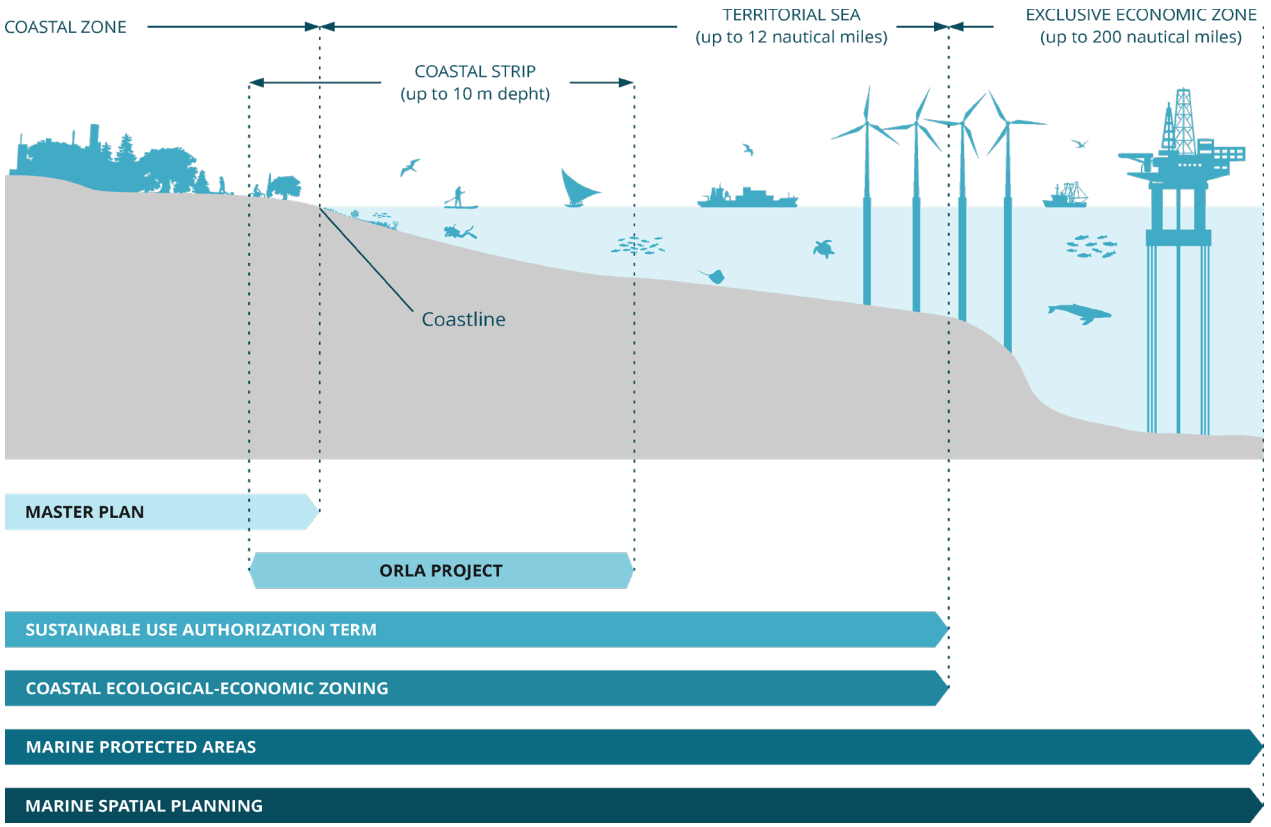
Handbook on Sustainable Ocean Plans: A practitioners' guide - a practical guide to help countries design and implement SOPs - https://oceanpanel.org/publication/SOPhandbook/

SOP Programme - an Ocean Decade program that seeks to disseminate tools and knowledge for the implementation of SOPs - https://oceandecade.org/actions/ocean-decade-programme-on-sustainable-ocean-planning/

Planning instruments can be binding — that is, compliance with their guidelines is legally mandatory — or indicative (non-binding), in which case decisions made at the planning level are less likely to be effectively implemented at the project level. In both cases, however, the EIA benefits from observing existing instruments.

Box 2.2 exemplifies the diversity and overlap of planning instruments that apply to the State of São Paulo, on the southeastern coast of Brazil.

Box 2.2. Planning Instruments - the case of Southeastern Brazil



Master Plan: A municipal urban planning instrument in Brazil, mandatory for cities with more than 20,000 inhabitants (see the City Statute – Law No. 10,257/2001).

ORLA Project: An Integrated Coastal Zone Management Plan, consisting of an integrated planning methodology aimed at rationalizing and coordinating public policies across the three levels of government (see Decree No. 5,300/2004).

Sustainable Use Authorization Term: An authorization that must be requested from the Secretariat for Federal Property Management (SPU) to ensure the rational and sustainable use of natural resources available in coastal and riverine areas, supporting the livelihoods of traditional communities through fishing activities (see Law No. 9,636/1998; Ordinance No. 89/2010; Law No. 13,465/2017).

Coastal Ecological-Economic Zoning: A planning instrument intended to guide the territorial management process required to achieve sustainable development conditions in the coastal zone (see Law No. 7,661/1988; Decree No. 4,297/2002; Decree No. 5,300/2004).

Marine Protected Areas: Designated areas within coastal and marine zones established to conserve biodiversity and natural resources (see Law No. 9,985/2000 – National System of Conservation Units – SNUC).

Marine Spatial Planning: A public process for planning the spatial and temporal distribution of human activities in marine areas, aimed at promoting sustainable uses and preventing conflicts among users and uses (see Decree No. 12,363/2025)

Tips for identifying planning instruments

For the sectors already mentioned (such as energy, fisheries, maritime, and environment), as well as any others relevant to your context, identify the responsible institutions and, for each of them, examine the PPPs that have been developed and that may influence your project and the areas where it is intended to be implemented.

2.1.2 Impact Assessment Instruments

Impact Assessment is a broad term that encompasses a set of environmental policy instruments used to identify, predict, and assess the impacts of a proposed action (policies, plans, programs, and projects). Within this broad concept, there is the EIA applied to projects, the Strategic Environmental Assessment (SEA), applied to the strategic levels before the individual projects, the Cumulative Impact Assessment (CIA), which can be applied both to projects (see Chapter 10) and at the strategic level. In addition, there are other specific types of impact assessment, such as the Social Impact Assessment and the Health Impact Assessment. In this chapter, we highlight SEA and CIA applied at the strategic level, due to their relevance to the context of coastal and marine planning.

Public participation in the SEA and regional CIA processes is fundamental and can contribute to avoid conflicts in the project level. See Chapter 3 to learn more about the subject.

Strategic Environmental Assessment

SEA is a tool for assessing the environmental and socio-economic risks and impacts of PPPs that subsequently give rise to individual development initiatives and projects (Dalal-Clayton and Scott-Brown, 2024). It aims to inform planners, decision-makers, and the public about the impacts and sustainability of PPPs, guiding the search for more appropriate alternatives and the consideration of environmental and social issues in decision-making (IAIA, 2002).

Impacts' assessment and follow-up through a systematic and strategic procedure, such as SEA, can inform project EIA with relevant information. It can, for example, identify areas that are more suitable or inappropriate for project implementation, anticipate and address relevant conflicts, provide recommendations for defining the scope of environmental impact studies, and support data collection and the development of databases to inform future projects.

Learn more

SEA is a widely used instrument, being formally required in more than 60 countries. In some contexts, its application is mandatory for certain plans and programs (for example, in the countries of the European Union, the United States, China, Chile). In others, SEA relies on more punctual and voluntary practices or is required by multilateral institutions and financing banks that may require it for certain investments, such as in Brazil, India, and Thailand (Fischer and González, 2021).

The methods and approaches for the preparation of an SEA vary according to the context in which it is applied; for example, one can follow an approach closer to a project EIA process when SEA is applied to a program or a set of projects, or adopt a more flexible approach, focused on engagement with the parties involved in decision-making (Partidário, 2021). Figure 2.1 presents the main contributions of the SEA.



Figure 2.1. Main contributions of the Strategic Environmental Assessment to improve decision-making. Source: Dalal-Clayton and Scott-Brown (2024, p. xix).

In the context of the energy transition, SEA is a highly relevant instrument, especially for countries without established protocols or guidelines to guide a sustainable and just transition. SEA can guide industry decisions, for example, by predicting and assessing possible negative impacts on marine ecosystems, conflicts with protected areas or areas of great ecological relevance, and changes in the ways of life of local communities (Dalal-Clayton and Scott-Brown, 2024).

SEA has also been frequently applied in the context of the MSP, as in the European Union, where it is mandatory for such plans. SEA applied to MSP can contribute in different ways, for example, by incorporating a wide range of environmental indicators and enabling extensive and legally structured participatory processes (Kusters et al. 2024), aligned with the principles of the EBM.

Learn more

Learn more about the application of SEA for the energy transition in the Guide "Improving Decision-Making for the Energy Transition: Guidelines for the Use of Strategic Environmental Assessment", published by the International Association for Impact Assessment (IAIA), available at https://seaguidance.iaia.org/

Cumulative Impact Assessment

CIA is one of the Impact Assessment instruments that can be applied both at the project level (see Chapter 10) and at the strategic level - integrated with SEA or regional assessments. In each of these approaches, the CIA provides different contributions (Figure 2.2). CIA is an essential instrument for assessing the implementation of PPP and understanding how certain environmental and social components will be affected in the future. In addition, CIA can contribute to defining acceptable limits of changes to be respected in the development of future projects, as well as to defining mitigation measures (Dalal-Clayton and Scott-Brown, 2024).

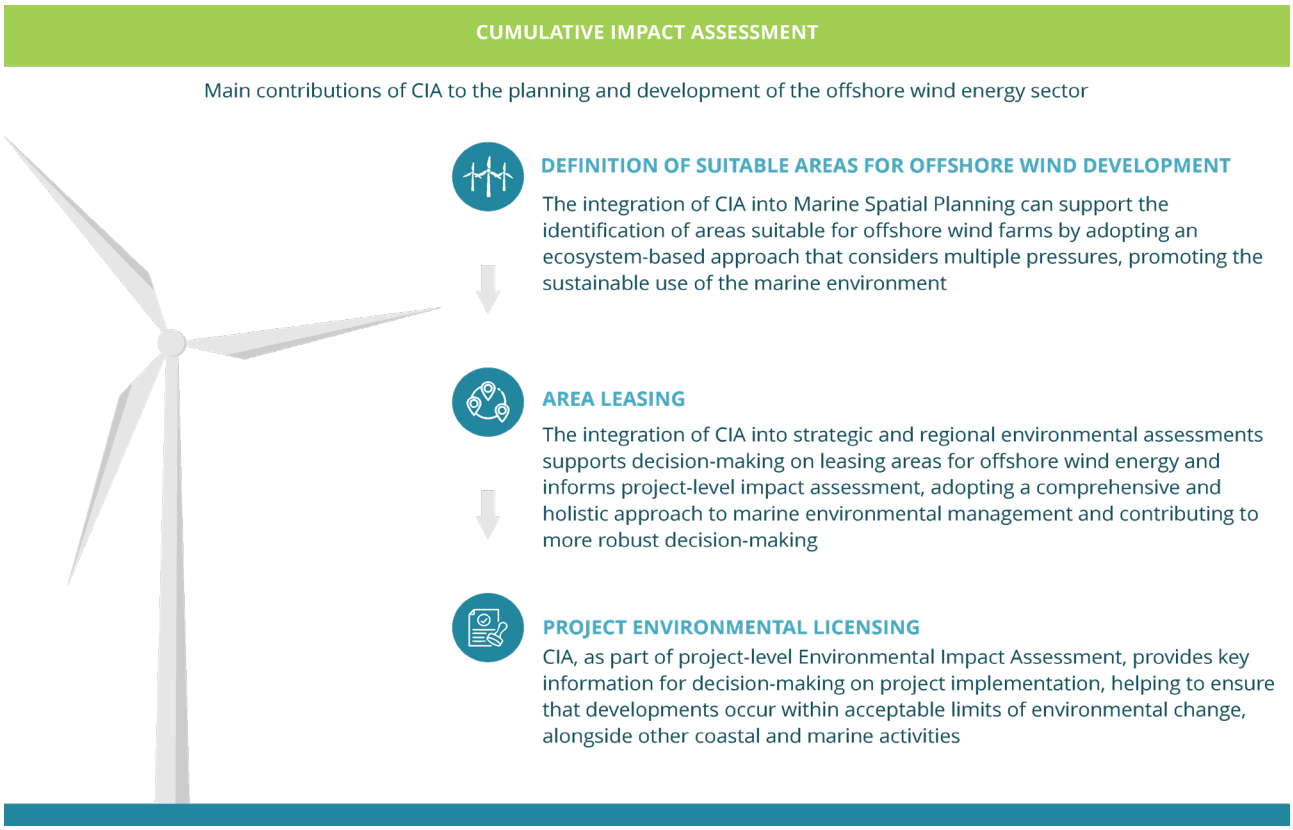


Figure 2.2. Main contributions of Cumulative Impact Assessment to the planning and development of the offshore wind energy sector. Source: Translated from Dibo et al. (2025).

CIA can also be conducted to understand the cumulative impacts of various activities in a region, assisting regional planning, influencing decisions about project development, and providing information on what is accepted regionally, based on defined standards or boundaries (Blakley and Noble, 2021). This is due to the expansion of spatial and temporal scales and the inclusion of multiple activities that affect environmental conditions (Willsteed et al., 2018). It is also important that there is collaborative governance with multiple interested parties (Chapter 3) so that everyone is engaged at the different stages of the assessment. As an example of the application of the regional CIA, the Cumulative Impact Assessment Project is presented in Box 2.3.

Box 2.3. Example of Cumulative Impact Assessment in the Brazilian marine area

The study "Cumulative Impact Assessment Project (Projeto de Avaliação de Impactos Cumulativos - PAIC)" was conducted by Petrobras, in Brazil, to fulfill the conditions for environmental authorization of oil and gas activities in the pre-salt cluster, covering Stages 1, 2, and 3 of oil and gas exploration in the region. The project was developed across five study areas in the states of São Paulo and Rio de Janeiro: Baixada Santista (region 1), North Coast (region 2), Sul Fluminense (region 3), and Guanabara Bay/Maricá (region 4), between 2017 and 2021. For each of these regions of interest, an integrated analysis of the impacts related to the main stressors was carried out, considering selected environmental and social factors, providing subsidies for the management of cumulative impacts. The project was developed in seven phases:

Phase 1 - Planning: definition of strategies for executing the activities to be developed, and surveying and characterizing actors/forums.

Phase 2 - Scoping: selection of environmental and social factors, temporal and spatial boundaries, and stressors.

Phase 3 - Data collection: determination of the baseline condition of the selected environmental and social factors.

Phase 4 - Assessment of cumulative impacts: assessment of the future state of the selected factors, considering the aggregate impacts of the various stressors.

Phase 5 - Assessment of the carrying capacity and significance of the predicted cumulative impacts: determination of the significance of the cumulative impacts considering limits of change.

Phase 6 - Analysis of the results and georeferenced database: discussion of the results and strategies to cope with the transformations in each region, in addition to the presentation of information on georeferenced maps with the respective database.

Phase 7 – Presentation of the final results: holding a meeting to discuss and validate the results with the actors of interest.

Cumulative impacts evaluated in the South Coast region of Rio de Janeiro

FACTOR	CUMULATIVE IMPACTS
TRADITIONAL COMMUNITIES	• Interference with traditional territories (terrestrial and marine) • Interference with traditional activities
HOUSING	• Increase in housing precariousness
BASIC SANITATION	• Mismatch in public sanitation service provision
COASTAL VEGETATION	• Vegetation removal • Degradation of vegetation and ecosystems
MARINE BIODIVERSITY	• Impacts on marine biodiversity
INLAND WATERS	• Increase in thermotolerant coliform concentrations • Reduced water availability for public supply
COASTAL WATER QUALITY	• Elevated levels of phytoplankton primary production • Remobilization of pollutants associated with dredging operations – increased turbidity and metal concentrations

A good practice observed is the inclusion of social participation, through workshops, when defining the selected factors and spatial and temporal limits (Phase 2) and the acceptable limits of change (Phase 5). The workshops included representatives of the government, civil society, and the business sector. One of the challenges was assessing the impacts on marine biodiversity due to insufficient data and monitoring, as well as the complexity of the marine environment.

Source: V&S, Nemus (2017); Témis, Nemus (2019).

Climate change

Climate change is a structuring and transversal element of sectoral and territorial planning (IPCC, 2023; IDB, 2023; Frazão Santos et al., 2020). In this context, targets, guidelines, and directives related to climate change mitigation and adaptation may be present in planning and impact assessment instruments related to offshore wind projects (World Bank, 2021; Fischer and González, 2021; Byer et al., 2018; Munroe et al., 2015).

It is recommended that the Environmental Impact Assessment verify the consistency of the project in relation to these instruments, considering, whenever applicable:

- Targets for reducing greenhouse gas emissions and aligning the project with national and international climate commitments;
- Cumulative impacts with respect to atmospheric emissions and effects on ecosystem services linked to climate regulation;
- Environmental vulnerabilities and risks associated with climate change;
- Guidelines and strategies for mitigation, adaptation and monitoring of impacts associated with climate change.

2.2 Key linkages: how to integrate relevant information?

The planning and Impact Assessment instruments mentioned above can provide a range of potentially relevant information for offshore wind projects EIA (Figure 2.3). Therefore, identifying and considering this information favors project-level EIA, avoiding duplication of efforts and keeping the focus on issues appropriate to their scale and the object of analysis.

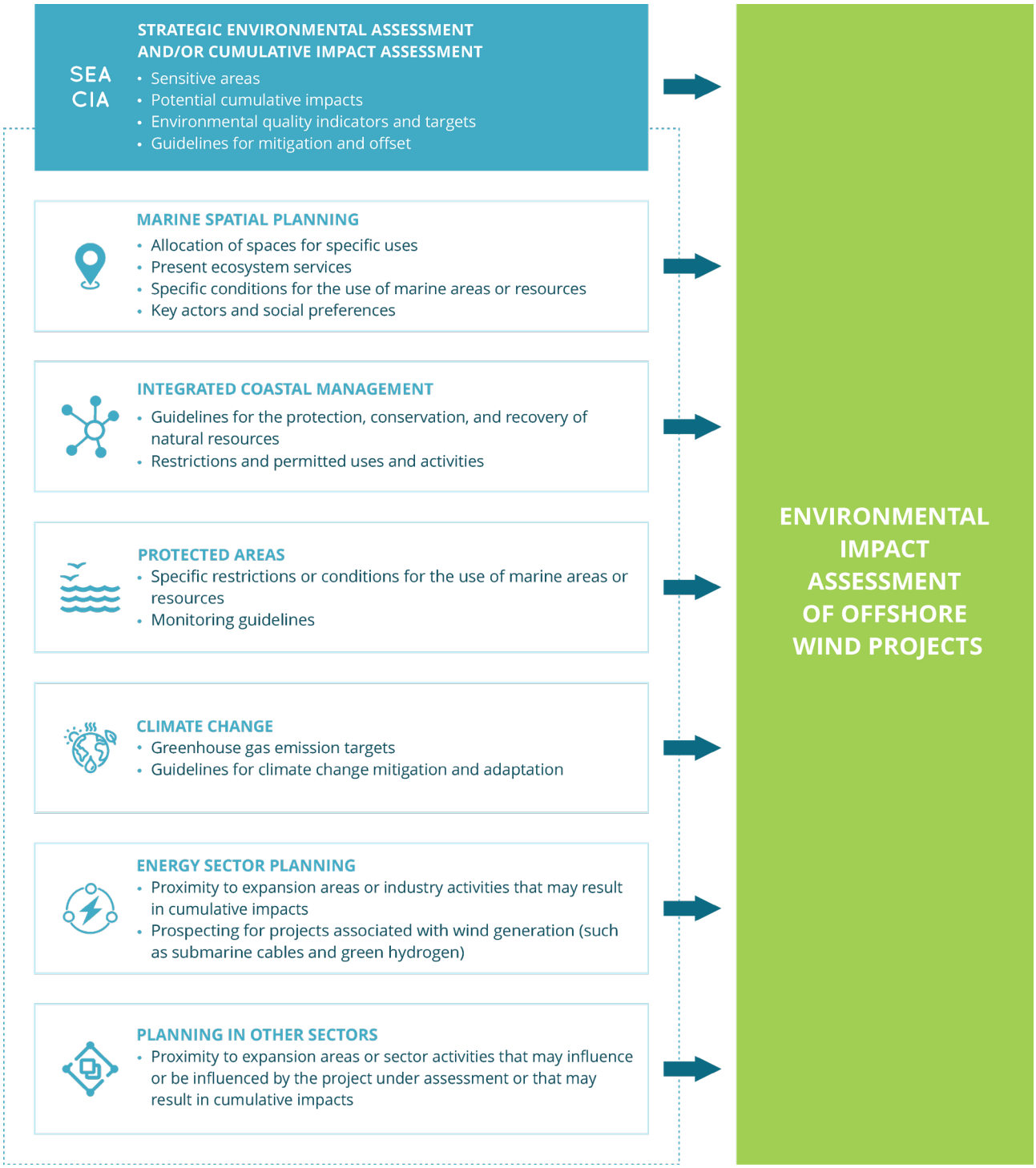


Figure 2.3. Planning instruments and potentially relevant information for the Environmental Impact Assessment of offshore wind projects. Source: prepared by the authors.

However, there are some challenges to be faced. One of these challenges concerns the scale of the data, since the baseline of project EIA requires more refined and specific data at a smaller scale than the data generally used at the strategic level. Therefore, information at the strategic level will generally help in defining the scope of the environmental study at the project level, but should not necessarily replace it.

Another challenge concerns the synchronicity between planning level and project EIA, since, in many situations, projects can be proposed before the MSP or ICM is completed. Despite this, it is important that the project EIA is attentive to the planning context to prevent conflicts between the project and the guidelines under discussion at the strategic level. To exemplify how tiering can happen in the practice of the offshore wind energy sector, Figure 2.4 illustrates the types of information that can be present in planning instruments and inform each stage of project EIA. Box 2.4 provides an example of how this information can be tiered across EIA steps.

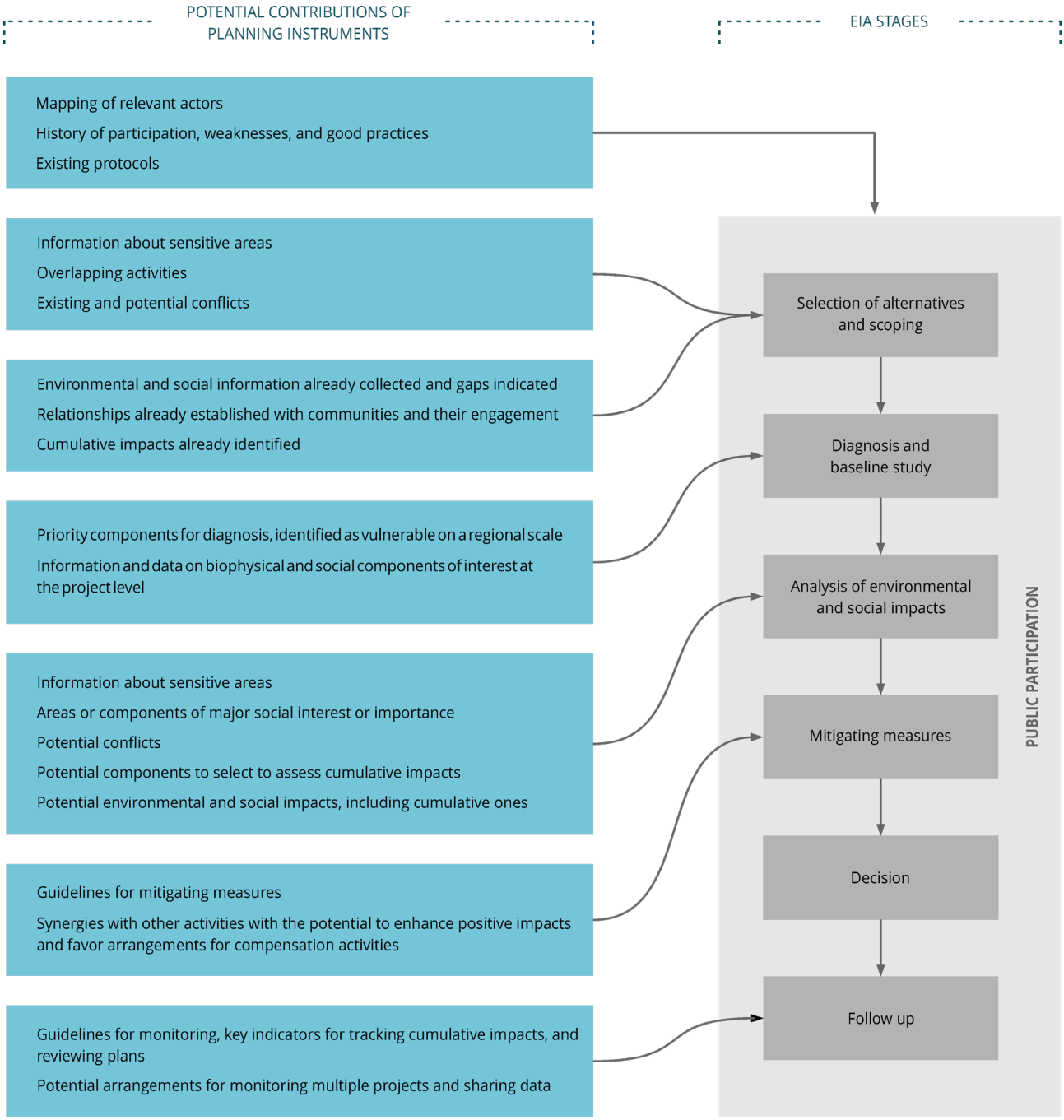


Figure 2.4. Potential contributions of planning instruments, Strategic Environmental Assessment and Regional Cumulative Impact Assessment to each step of project Environmental Impact Assessment. Source: prepared by the authors.

Box 2.4. Linkage between strategic and project levels: the case of the United States of America

In the United States, the flow of information between EIA instruments applied at different levels is a regulatory requirement (NEPA 40 CFR § 1501.11). In the case of offshore wind development, the *Programmatic Environmental Impact Statement* (PEIS) stands out, carried out before the assessment of individual projects, to identify mitigating and monitoring measures that must be observed by the project and by the EIA of projects.

To guide information flow across stages and avoid duplication of effort, the PEIS presents "Tiering guidelines", organizing, for each topic addressed in the PEIS, information on the affected environment, analysis of the impacts, and mitigating and monitoring measures as addressed in the PEIS, and indicating what should be the focus of the EIA of the individual projects. The following table presents an example extracted from the PEIS regarding sea turtles.

PEIS Content Overview	Additional analysis to be done in the EIA of individual projects
Affected environment. Provides a regional overview of the sea turtles present in the geographic analysis area. The data is collected from publicly available sources, including the Marine Registry, the Northeast Ocean Data Portal, habitat-based density models, digital regional aerial baseline surveys of marine life, BOEM documents, environmental studies, scientific papers, and other offshore wind projects.	**Affected environment.** Project EIA may incorporate by reference the regional characterization of the environment affected by sea turtles in the PEIS. However, the project-specific analysis will need to characterize the occurrence of sea turtles in the lease area and along offshore export cable routes, including implementing surveys consistent with BOEM's Marine Mammal and Sea Turtle Information Guidelines. These surveys may include seasonal, ship-based, and aerial surveys to determine the temporal and spatial distribution and abundance of sea turtle species. Surveys of specific habitats and species would enable accurate identification of any nesting sea turtles suspected to occur along offshore export cable routes and at landing sites.
Impact analysis. It provides a qualitative analysis of the impacts on sea turtles resulting from generating factors such as noise, structures, and traffic, based on the hypothetical design model.	**Impact analysis.** EIA needs to include a quantitative and qualitative impact analysis that includes the specific characterization of the intensity, geographic extent, frequency, and likelihood of impacts on sea turtles associated with each of the offshore activities associated with the relevant impact-generating factors (e.g., noise, presence of structures, and traffic), including results of underwater acoustic modeling of the proposed activities (e.g., pile driving) and the use of BOEM's Risk Assessment to model the encounter rates between large whales and sea turtles and the traffic of offshore wind vessels in the Atlantic Ocean.
Mitigating and monitoring measures. It includes the submission and approval of pile driving monitoring plans; protected species requirements; measures to minimize vessel noise; measures to limit the temporal and spatial extent of noise exposure; real-time and near-real-time monitoring to inform adaptive mitigation measures; trainings; collection of baseline information used to anticipate potential impacts better and further mitigate the impacts on sea turtles in the future; seasonal vessel speed requirements; measures to reduce marine debris and impacts of entanglement, ingestion and pollutants; monitoring of post-storm events; and reports of potential catches of protected species.	**Mitigating and monitoring measures.** EIA needs to include the mitigating and monitoring measures recommended by the PEIS, specific to the factors causing the impact.

Source: adapted from BOEM (2024).

To promote this flow of information between your project's strategic planning instruments and EIA, you can follow the steps indicated in Figure 2.5.

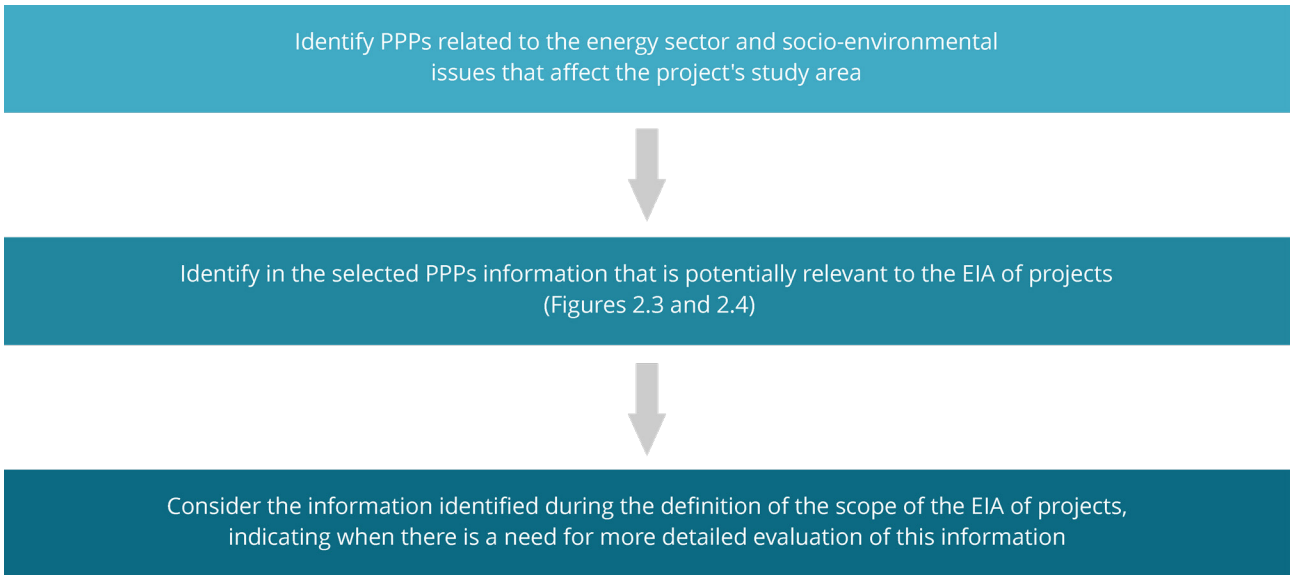


Figure 2.5. Practical guidelines for strengthening tiering between planning instruments and project-level Environmental Impact Assessment. Source: prepared by the authors.

Attention!

The Environmental Impact Study should make explicit how the information from other planning instruments (such as the MSP, SEA, Protected Area Management Plans) was considered throughout the Environmental Impact Assessment!

✓ **For the mapping of locational alternatives, we focused on the zones defined by the MSP as areas subject to exploitation of offshore wind potential, excluding the zones defined as priorities for conservation and the buffer zones of protected areas X and Y, as illustrated in map Z.**

✗ **For the mapping of locational alternatives, environmental zoning was considered.**

This guide features key planning and strategic-level impact assessment tools associated with offshore wind projects. In many places, however, these tools may be absent or only partially implemented. In certain contexts, their absence should not be impeditive of project EIAs to be carried out, but attention should be paid to potential conflicts and to cumulative impacts, so that they be fully considered in decision-making.

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Chapter 3

SOCIAL PARTICIPATION AND ENGAGEMENT

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Social participation in decision-making processes not only enhances legitimacy and gives voice and visibility to affected communities and stakeholders, but also helps mitigate investment risks and create spaces for dialogue that extend throughout the project's operational phase. Drawing on concepts, best practices, and examples, this chapter shows how different forms of participation can contribute to more equitable, inclusive, and effective processes across the various stages of the environmental impact assessment.

THIS CHAPTER:

1. Social participation and meaningful engagement: what is the difference?
2. How to plan social participation to promote meaningful engagement?
3. What comes next? Participation and engagement as strategic processes

3.1 Social participation and meaningful engagement: what is the difference?

Although some sources consider participation and engagement to be synonymous, in this chapter we use "social participation" as a broad term encompassing different forms and levels of involvement, whereas "meaningful engagement" is reserved for practices that seek greater depth, effectiveness, and inclusion, especially from the perspective of the most affected groups. Thus, all meaningful engagement is a form of participation, but not all participation meets the criteria for meaningful engagement.

Social participation can be broadly defined as the involvement of people (individually), organizations, social groups, and government institutions – collectively understood as stakeholders – in discussion and decision-making processes regarding projects, programs, plans, or public policies. Such processes may represent initiatives and actions that positively or negatively affect stakeholders, as well as those in which they have economic, social, cultural, environmental, or territorial interests, responsibilities, and roles (André et al., 2006).

In many countries, participation is partially governed by legislation, for example, with mandatory public consultations. However, practical experience shows that limiting participation to legal requirements is often insufficient to ensure that its outcomes are considered in decision-making processes. Beyond complying with the legal requirements of each jurisdiction, in order to build trust and relationships and promote inclusion and equity, the social participation process should be planned and conducted based on principles, such as those presented in **Box 3.1**.

Learn more

Regional and international instruments have contributed to strengthening social participation practices. The Escazú Agreement, in force since 2021, aims to guarantee access to information, public participation, and justice in environmental matters in Latin America and the Caribbean. It highlights the importance of robust participatory practices to ensure transparency, legitimacy, and fairness in environmental decision-making (Medici-Colombo and Ricarte, 2024).

Focused on the specific rights of indigenous and tribal peoples, ILO Convention 169 requires that these groups be consulted by public authorities before the implementation of any project, program, or policy that may interfere with their ways of life. The consultation process, following "Free, Prior, and Informed Consent" protocols developed by the groups themselves, aims to ensure that their perspectives are considered and respected in a timely manner (ILO, 1989).

Box 3.1. Basic principles of social participation in Environmental Impact Assessment

- **Adapted to the context –** Understanding and appreciating the social institutions, values, and culture of the communities in the project area; and respecting the historical, cultural, environmental, political, and social backgrounds of the communities that are affected by a proposal.
- **Informative and proactive –** Recognizing that the public has a right to be informed early and in a meaningful way in proposals that may affect their lives or livelihoods. Increased interest and motivation to participate occur by diffusing simple and understandable information to the affected and interested public.
- **Adaptive and communicative –** Recognizing that the public is heterogeneous according to their demographics, knowledge, power, values, and interests. The rules of effective communication among people, in the respect of all individuals and parties, should be followed.
- **Educative –** Contributing to a mutual respect and understanding of all IA stakeholders with respect to their values, interests, rights, and obligations. Inclusive and equitable – Ensuring that all interests, including those non-represented or underrepresented, are respected regarding the distribution of impacts, compensation, and benefits. The participation or defense of the interests of less represented groups, including Indigenous Peoples, women, children, elderly, and poor people, should be encouraged. Equity between present and future generations in a perspective of sustainability should be promoted.
- **Cooperative –** Promoting cooperation, convergence and consensus-building rather than confrontation. Engaging conflicting perspectives and values as well as trying to reach a general acceptance of the proposal toward a decision that promotes and supports sustainable development should be pursued.
- **Imputable –** Improving the proposal under study, taking into account the results of the public participation (PP) process; including reporting and feedback to stakeholders about the results of the PP process, especially how their inputs have contributed to decision-making.

Source: André et al., 2006.

Experiences in Environmental Impact Assessment (EIA) processes indicate that effective, transparent, and inclusive social participation generates benefits for both affected groups and project proponents (Figure 3.1), the one hand, participatory processes with these characteristics are more democratic, are inclusive of minority groups, recognize and seek to incorporate rights, values, and social interests, legitimize decisions, and foster social learning processes and social empowerment. On the other hand, they allow for the early identification of risks and conflicts, support their prevention and proactive management, improve the quality of information used in assessments, making them more robust and comprehensive, and enhance transparency and legitimacy, including the attainment of "social and cultural licenses to operate" in specific cases (OECD, 2017; Kvam, 2019).



Figure 3.1. Advantages of social participation.

Throughout social participation and engagement, multiple levels of involvement are possible. These levels vary according to the degree of influence attributed to stakeholders in decision-making (IAP2, 2018):

- **Inform:** To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities, and/or solutions.
- **Consult:** To obtain public feedback on analysis, alternatives, and/or decisions.
- **Engage:** To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.
- **Collaborate:** To partner with the public in each aspect of the decision, including the development of alternatives and the identification of the preferred solution.
- **Empower:** To place final decision making in the hands of the public.

Despite being presented as a continuous spectrum, participation levels can coexist in the same process. For example, different levels can be employed across the stages of EIA, depending on the specific objectives of each stage, the purpose of the participatory process, and the desired degree of involvement, influence, and power-sharing (Figure 3.2).

EIA STAGE	INFORM	CONSULT	ENGAGE	COLLABORATE	EMPOWER
SCREENING	Submission of the proposal for government approval; Disclosure of applicable criteria	Preliminary consultation on the type of license or the need for EIA	Discussion of expected initial impacts	Preliminary co-assessment of environmental risks	Participation in participatory bodies
SCOPING	Initiation of ToRs preparation; Disclosure of EIA requirements	Public consultation on the scope through hearings or written submissions	Participatory workshops to identify local concerns	Co-development of ToRs with civil society and experts	EIS scope approved by civil society
PREPARATION OF THE EIS	Disclosure of study progress; Access to preliminary technical documents	Open consultation on perceived impacts; Simplified participatory mapping	Participation in baseline studies and thematic workshops (e.g., land use, health)	Co-production of data with local groups; In-depth participatory research and mapping	Local groups co-leading studies or with veto power over non-representative sections
TECHNICAL ANALYSIS	Disclosure of the EIS and its non-technical summary in accessible language	Public hearings on EIS the content; Receipt of public comments and submissions	Workshops to interpret the EIS; Preparatory meetings for public hearings	Joint technical review committees involving experts and civil society	Deliberative voting by civil society in final statements
DECISION MAKING	Disclosure of the final decision and its technical justification; Clarification of how satkeholders inputs were applied	Consultation on the draft decision; Opportunities to comment on approval conditions	Feedback meetings with the community to explain the decision	Negotiation of conditions with local representatives; Formal agreements with stakeholders	Citizen participation with binding decision-making authority (e.g., environmental councils or citizen juries)
FOLLOW-UP	Periodic reports and reports published on institutional websites	Surveys and consultations on compliance with approval conditions	Open meetings to evaluate environmental performance; Accessible grievance mechanisms	Community monitoring committees; Participatory planning of compensation measures	Full social oversight through independent community audits

Figure 3.2. Examples of ways to foster social participation at different stages of the Environmental Impact Assessment (EIA) process. Acronyms: EIS - Environmental Impact Study. ToRs - Terms of Reference.

No single form of participation is intrinsically better than another. Higher levels of participation are not always necessary or appropriate in every context and should be adopted sensibly, as they require time and resources from both project proponents and stakeholders. The selection of appropriate engagement strategies should be guided by principles of proportionality and contextual appropriateness. This includes, among other factors, the level of project impact and associated risks, the degree of potential conflict or the presence of pre-existing conflicts, as well as the institutional capacity and social dynamics of the communities involved. It is also important to highlight that participation in EIA processes can play a capacity-building role, contributing to the strengthening of social capital and fostering progressively higher levels of engagement over time. Moreover, higher levels of involvement tend to move beyond consultation-only approaches, aiming instead to promote meaningful stakeholder engagement (Figure 3.3).

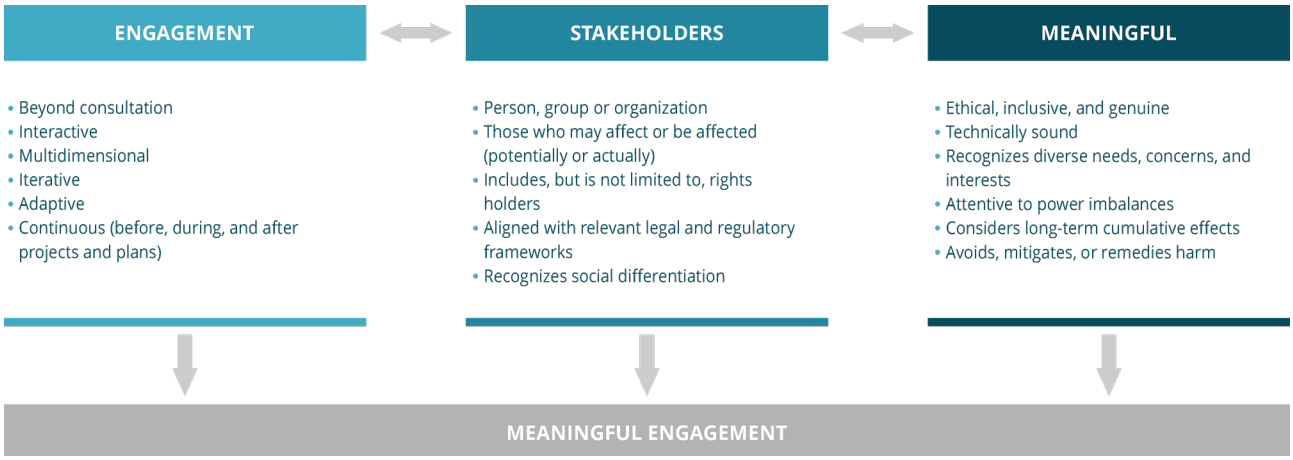


Figure 3.3. Characteristics of a meaningful stakeholder engagement process. (Adapted from Buhmann et al., 2024).

> **Meaningful engagement** refers to effective and inclusive forms of social participation that lead to processes and outcomes perceived as meaningful from the perspective of participants (Buhmann et al., 2024).

With higher levels of engagement and greater potential to drive transformation, meaningful engagement aims to promote processes and outcomes that are outcomes of genuine value to participants to participants while also helping to reduce risks for project proponents. The literature on the subject highlights the importance of the practice for negatively affected groups, distinguishing them from other stakeholders. The process should be grounded in the concerns and needs of these groups, creating conditions for their autonomous and informed participation in the decision-making processes that affect them (Buhmann et al., 2024). Among negatively affected groups, those with greater exposure to adverse impacts and more limited capacity to influence decision-making processes are particularly prominent. These groups are subject to power asymmetries and structural barriers to participation, which place them in situations of vulnerability or marginalization (OECD, 2017). They include, among others, local and traditional communities, Indigenous Peoples, women, and other groups whose social, economic, or institutional conditions heighten their exposure to negative impacts.

In the case of local communities, vulnerabilities are generally associated with their presence within the area of influence of interventions and their dependence on potentially affected economic activities and services. For traditional communities, vulnerabilities are also linked to direct dependence on natural resources, the continuity of their ways of life, and longstanding relationships with their territories. In both cases, these communities tend to experience the impacts of the interventions directly and immediately, whether through changes in employment and income generation or through transformations in the landscape and the use of natural resources, with repercussions for food security, health, and their ways of life. In this context, **community engagement** constitutes a **deliberate effort** to actively and inclusively involve the individuals and groups directly and indirectly affected by a project, with priority given to those most severely impacted.

In the community engagement process, the objective is **to ensure that the demands, expectations, and knowledge of the local population – both local and traditional communities – are considered on par with the project's technical and economic aspects**. Beyond simply hearing to or collecting isolated inputs, this type of participation presupposes the creation of spaces for active listening and continuous dialogue, in which local voices have the opportunity to effectively influence decisions, thereby fostering meaningful engagement. Properly planning participation and engagement, and identifying the most appropriate strategies for each context and group involved, is essential for the success of the process.

Box 3.2. Let us look at a practical example

A consulting firm was hired to plan and implement social participation in an offshore wind farm project.

Deficient social participation:

- Late and formal consultations: communities are only informed after strategic decisions have already been made, with no real opportunity to influence them.
- Limited access to information: extensive and complex technical reports are provided without accessible, adapted, or locally contextualized alternatives.
- Unrepresentative meetings: held in hard-to-access locations and during business hours, limiting the participation of local communities' representatives.
- Focus on more powerful actors: industry representatives, economically and politically influential groups, and government agencies dominate discussions, while local groups remain in situations of marginalization.
- Lack of feedback: contributions from less powerful groups are neither addressed nor incorporated into the project

Social participation with the potential to promote meaningful engagement:

- Proportionate and early planning: participation strategies and plans are established at the earliest stages, informed by the project's potential impacts, the level of conflict, and the characteristics of affected communities.
- Accessible and continuous communication: explanatory materials in plain language and multiple formats (audio, video, and visual) are provided to facilitate understanding.
- Adapted dialogue spaces: all meetings and hearings are scheduled at times and locations compatible with community routines, with interpreters or facilitators when necessary.
- Recognition of local knowledge: local ecological knowledge is integrated into baseline studies and impact assessment, enabling a more contextualized and accurate approach.
- Transparency and accountability: community inputs are documented, and clear feedback is provided on whether and how their recommendations — such as requests for supplementary studies, definition of measures and conditions — were considered in project decisions.
- Local capacity building: where necessary, the participatory process strengthens local stakeholders and fosters progressively higher levels of engagement over time.

3.2. How to plan social participation to promote meaningful engagement?

To foster meaningful engagement, the process is as important as the outcomes. It must be designed based on the objectives and contexts in which it will be carried out and should be timely, accessible, appropriate, and safe for participants. The strategies and tools employed must address diverse needs and remove barriers that hinder the participation of groups in situations of vulnerability or marginalization (OECD, 2017). Common steps for promoting meaningful engagement across different stages of EIA (Figure 3.1) include conceptualization, stakeholder analysis, planning, implementation, monitoring, and evaluation (Figure 3.4). The process should be **iterative, interactive, adaptive, and flexible**, open to learning and change in response to unforeseen situations.

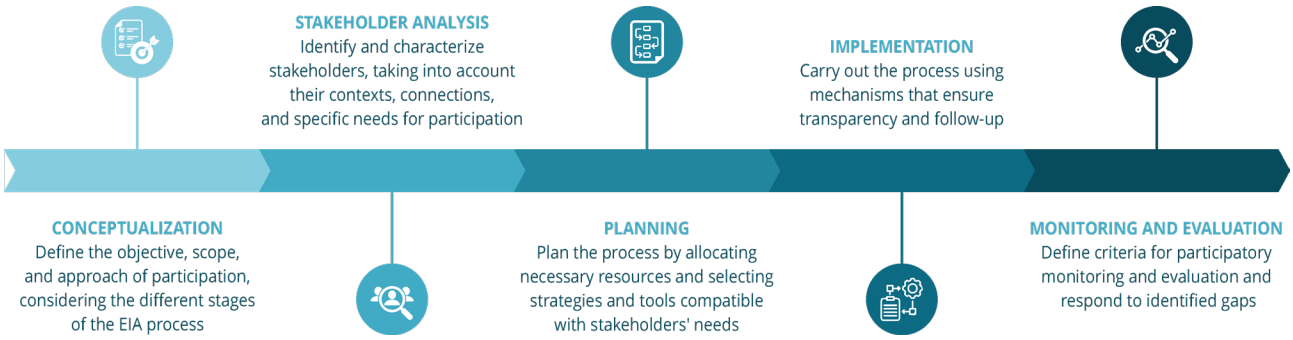


Figure 3.4. Steps in the process of planning participation and social engagement in the Environmental Impact Assessment (EIA).

3.2.1. Conceptualization

In the initial phase of conceptualizing an intervention, it is essential to define the objective, scope, and approach of the social participation process, considering the specific phase of the EIA process it is intended to support. The objective of participation is key to determining the appropriate level of involvement (Figure 3.1). This entails considering the context and applying proportionality criteria in relation to potential impacts, risks, conflict levels, and social capacities. The scope of the participation plan defines the boundaries and key themes of the participatory process, indicating the stages and aspects over which stakeholders may have influence. These boundaries may arise, for example, from institutional and legal requirements or constraints, as well as from operational and financial limitations and the characteristics and stage of the project under assessment. The approach outlines the principles, strategies, and methods to guide dialogue and decision-making.

Although stakeholder mapping is conducted at a later stage, it is advisable to initiate dialogue with key groups (such as local and traditional communities and local public authorities) at this stage, to engage them from the outset. Such early engagement helps align expectations, identify needs and values, prevent conflicts, and build trust.

3.2.2. Stakeholder Analysis

This stage involves identifying and characterizing stakeholders, considering their specific contexts, interests, and needs. The outcomes of social participation and engagement are influenced by internal and external factors, such as cultural and regulatory barriers, the adequacy of adopted strategies and tools, stakeholders' information needs, conflicts of interest, competition for resources, prior experiences, existing social relationships, and the maturity of ongoing processes, among others (Buhmann et al., 2024; OECD, 2017; O'Faircheallaigh, 2010; Vanclay & Esteves, 2024). Understanding these aspects is essential because, on the one hand, power asymmetries shape the degree of influence that different stakeholder groups can exert over a proposed intervention; on the other, both positive and negative impacts of the intervention are unequally distributed across groups.

In general, stakeholders can be classified into three categories: groups and individuals affected, either positively or negatively; groups directly responsible for decision-making; and other groups with an interest in and influence on the project (Figure 3.5).

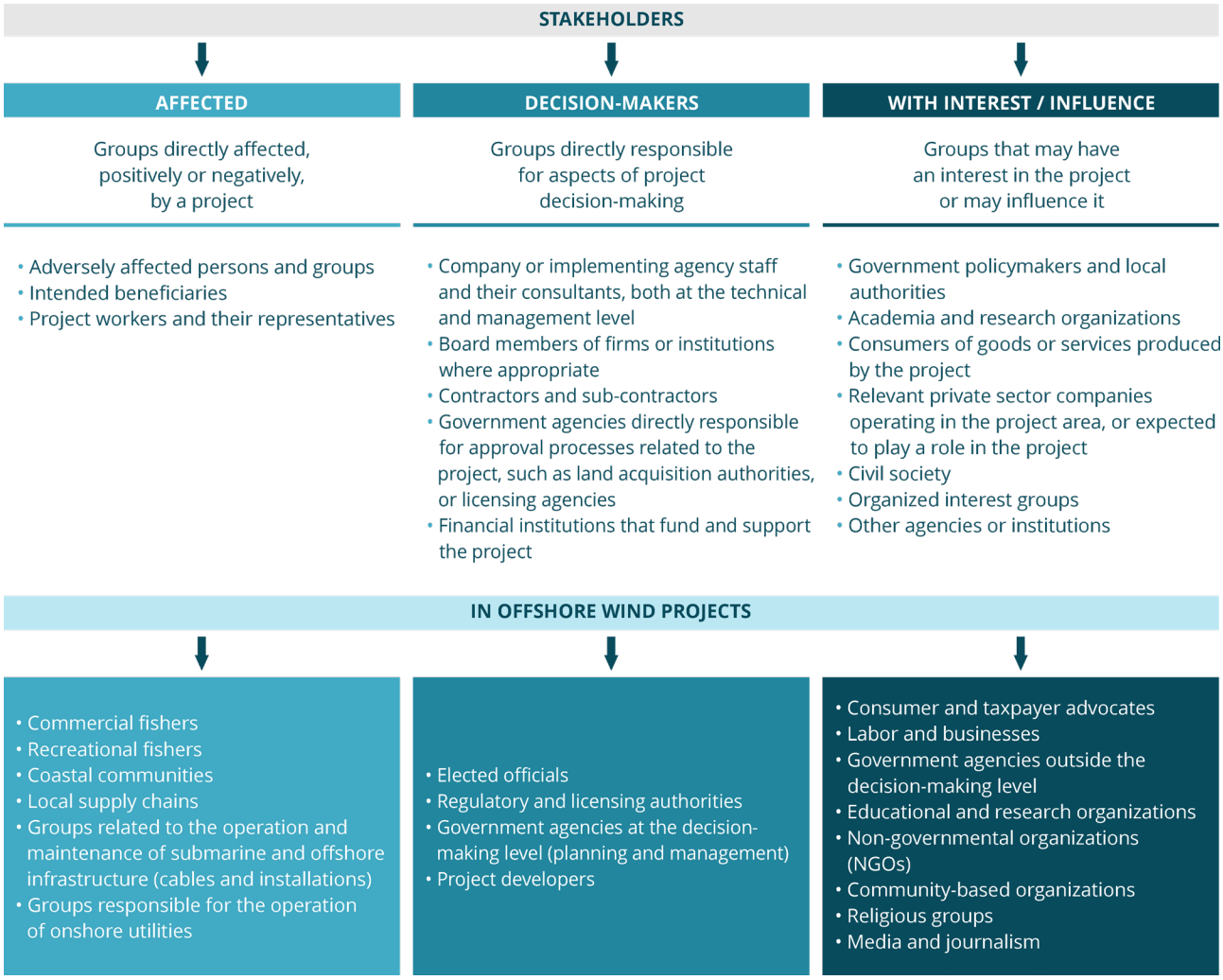
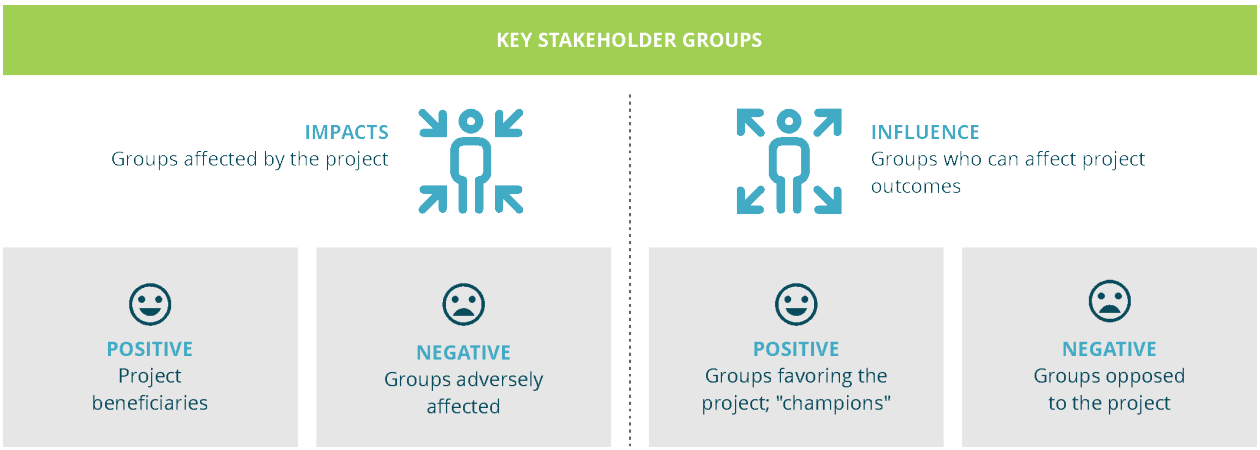


Figure 3.5. Representation of the three categories of stakeholders with examples of groups related to offshore projects development. (based on Kvam, 2019; Crowe, 2024).

Box 3.3. Understanding the stakeholders' relationship to the project

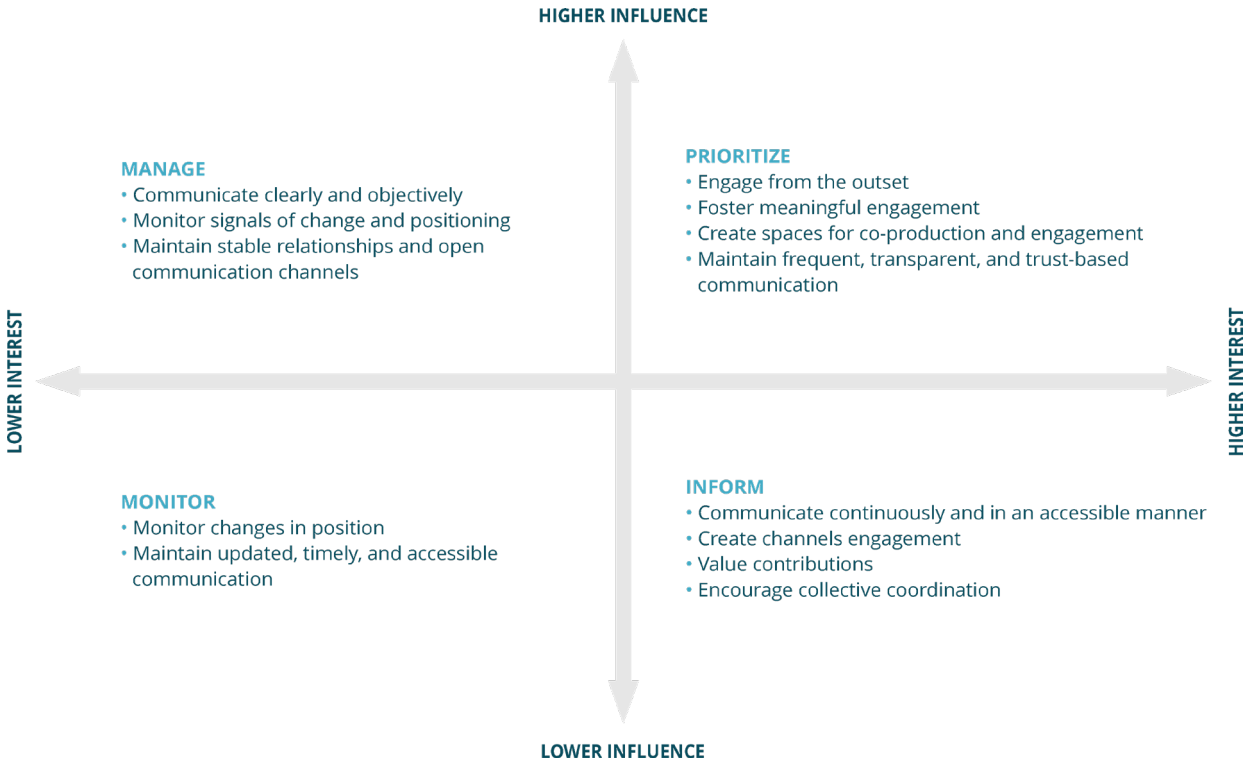
Several strategies can be applied to identify and characterize stakeholders and to guide the planning and implementation of social participation and engagement processes. Here we present two illustrative examples.

A simple way to classify stakeholders is to identify which groups are affected by the project and which exert influence over it. In both cases, interactions can be positive or negative, resulting in four distinct classes: project beneficiaries, groups adversely affected, groups favoring the project, and groups opposed to the project. It is important to note that the same group can be classified into different categories depending on the analysis criteria.



(Source: Adapted from Kvam (2019), published by the Inter-American Development Bank, under CC-IGO 3.0 BY-NC-SA license. The IDB is not responsible for this adaptation.).

The stakeholder matrix distinguishes levels of influence and interest among stakeholders to guide the definition of engagement strategies. Based on the degree of influence — whether exerted over the project or experienced as a result of it — and the level of interest, groups are classified into four strategies: monitor, inform, manage and prioritize.



At the stage of stakeholder analysis, it is critical to balance the quality of participation with the number of groups represented. Focusing on an excessive number of participants may compromise the representativeness of the process, favor certain groups, and create a false sense of legitimacy. This can lead to the exclusion of the most affected groups, thereby undermining the effectiveness and fairness of the process.

3.2.3. Planning

The planning stage of social participation consists of translating what was defined during the conceptualization phase and identified in the stakeholder analysis into a structured plan. This plan details the strategies, methods, and engagement tools, the schedule of activities, the allocation of human and financial resources, documentation procedures, and the mechanisms for transparency and process monitoring. Planning should focus on identifying and proactively responding to contextual factors identified in the stakeholder analysis, considering the appropriate timing for engagement and its alignment with EIA stages, thereby minimizing risks to effective engagement and the potential for legal disputes.

If participants do not recognize that their interests and values are reflected in the participation process, the process cannot be considered meaningful engagement.

The *Cape Breton Partnership* and *Net Zero Atlantic* surveyed 261 residents of *Unama'ki – Cape Breton* on social participation in offshore wind farm projects. The study included Indigenous communities and other populations located near areas of interest for project development, potentially affected in different ways. The results indicated a low level of recognition of participatory processes: only 1% of respondents felt that their voice was always recognized, 6% reported that this occurred very often, 25% felt that they were sometimes recognized, 15% said they were rarely recognized, 8% stated that they were never recognized, and 46% had never participated in participatory processes (Cape Breton, 2024).

The adoption of varied methods and tools for participation is essential to ensure the inclusion of diverse groups and promote meaningful engagement, particularly in fostering community engagement. It is important to emphasize that even within a single community, there is a diversity of interests, values, and relationships that must be considered in the engagement process. Integrating different perspectives into decision-making helps ensure more equitable and successful implementation, addressing the needs and expectations of all groups involved.

To meet different objectives and stakeholders, planning can combine traditional and innovative approaches, incorporating a range of interaction formats. In project EIA, **community meetings and open forums** are essential for direct engagement. Another important strategy is the use of **citizen panels and focus groups**, which bring together small representative groups to discuss the project's challenges and opportunities, ensuring more in-depth debate. To broaden participation, it is recommended to use **community surveys** and **questionnaires**, which allow a larger number of people to share their perceptions of the project's positive and negative impacts. In addition, **social and territorial mapping** is another important tool that helps identify the areas most affected by the project and supports the definition of appropriate compensation measures. Table 3.1 presents the definitions of the instruments listed above.

Table 3.1. Examples of methods and instruments for social participation and engagement.

Instruments	Definition
Community meetings	Large-group meetings for direct dialogue, aimed at identifying needs and gathering feedback from local stakeholders (World Bank, 2019).
Open forums	Open public sessions (hearings) to collect comments and inputs, often linked to regulatory requirements (World Bank, 2019).
Citizen panels	A group of individuals selected to learn, deliberate, and produce collective recommendations within a representative deliberative model (OECD, 2020).
Focus groups	A small group of participants guided by a facilitator around predefined topics to explore perceptions and perspectives (Kitzinger, 1995).
Community surveys and questionaries	Standardized questionnaires designed to capture the views of individuals and subgroups across broader segments of the community (World Bank, 2019).
Social and territorial mapping	Participatory mapping (social and spatial) to identify activities, infrastructures, services, and areas of use, among other topics, supporting the identification of more sensitive and affected areas, or areas with potential for specific actions, dependent on the scope (World Bank, 2019).

Aligning the methods and instruments described above with the use of **digital technologies** can enhance and expand the participatory process. **Interactive applications** can be used to gather community inputs and respond to questions in real time. **Social media and instant messaging groups** are also valuable tools for sharing information dynamically. **Public hearings, community meetings, and open forums** can also be held online, expanding access to discussions, especially for groups with travel constraints. However, it is important to consider the conditions related to accessibility, infrastructure, familiarity with technologies, and the availability of resources to enable access for interested and engaged parties (André et al., 2006; Lane & Hicks, 2017).

Learn more

To learn more about community engagement strategies, methods, and instruments, we recommend the following:

- **Planning for renewable energy:** Australia has developed guides to support the planning, implementation, and evaluation of community engagement activities in the field of renewable energy sector (https://www.planning.vic.gov.au/__data/assets/pdf_file/0025/621970/community-engagement-and-benefit-sharing-in-renewable-energy-development.pdf) and offshore wind (https://www.aeic.gov.au/sites/default/files/documents/2023-10/aeic-considerations-offshore-wind-industry-community-engagement.pdf)
- **Community meetings and open forums:** Middelgrunden (Denmark) engaged thousands of residents in public assemblies that reshaped the wind farm layout into an arc of 20 turbines. (https://www.middelgrunden.dk/wp-content/uploads/2021/03/mg-pjece_72dpi_rgb-2.pdf)
- **Citizen panels and focus groups:** Sectoral workshops at the Borssele wind farm (the Netherlands) brought stakeholders together to discuss coexistence with fisheries and navigation. (https://www.noordzeeloket.nl/publish/pages/232434/passive-fishing-in-borssele-owf.pdf)
- **Community surveys and questionnaires:** The Middelgrunden cooperative conducted pre-subscription surveys, confirming support for the operation of the offshore wind farm. (https://www.middelgrunden.dk/wp-content/uploads/2021/03/mg-pjece_72dpi_rgb-2.pdf)
- **Social and territorial mapping:** The "Value-Map" at Borssel identified coastal values and uses and informed offsets before construction. (https://www.noordzeeloket.nl/publish/pages/188385/handreiking-gebiedspaspoort-borssele.pdf)
- **Interactive apps:** The "Odor Explore" application (EPA, USA) enabled community members to report environmental impacts in real time, integrating citizen science into monitoring. (https://www.epa.gov/air-research/odor-explore-participatory-science-project-using-mobile-app-and-new-measurement)
- **Social media and messaging groups:** Westermost Rough (UK) used mailing lists and social media channels from fisheries organizations to communicate construction windows and monitoring activities. (https://www.seafish.org/safety-and-training/kingfisher-information-services/)
- **Digital Technologies and Online Public Hearings:** During the pandemic, several EIAs in the European Union shifted to virtual hearings, maintaining quorum and official records in line with best practices outlined by Aarhus Digital (https://www.aarhus-digital.com/online-public-hearings/)

While digital strategies can expand participation, they do not replace in-person approaches, as they are not equally accessible to all groups.

Box 3.4. An example of good practices: social participation in offshore project planning in the United States of America

The Bureau of Ocean Energy Management (BOEM), a government agency responsible for managing offshore activities, has an engagement policy that promotes social participation in different stages of the EIA. Even prior to environmental authorization or the final designation of project areas, the agency implements a structured set of mechanisms that make engagement not only desirable, but also mandatory, early, and integrated into project design. This institutional arrangement reflects a specific context, characterized by strong regulatory capacity, resource availability, and well-established regulatory requirements. Nevertheless, it offers relevant insights that can be proportionally adapted to other contexts. Among the strategies adopted, the following stand out as good practices:

Formal, early, and mandatory consultation processes

The agency structures public consultations using a range of methods, such as public hearings, formal comment periods, virtual seminars, workshops, open Q&A sessions, and technical forums with specific stakeholder groups. This approach is applied from the identification of areas for offshore wind leasing (informal public participation) through the scoping phase of the Environmental Impact Study (the first formal stage of public participation) to the receipt of comments on preliminary environmental analyses. In this initial phase, coastal communities, fishing communities, Indigenous Peoples, and local governments are invited to contribute relevant knowledge and information, including the identification of sensitive areas, navigation and fishing routes, cultural uses, and tribal traditions. Project siting is informed by a combination of local and scientific knowledge.

Requirement for Stakeholder Engagement Plans

The agency adopts the principle of early engagement, based on the premise that conflicts are more effectively addressed when considered from the outset and that decisions regarding location, project design, and mitigation should be grounded in local knowledge. Accordingly, fishing communities, tribal groups, and local communities must be consulted before key decisions are made. Engagement plans are required to include: 1) Initial stakeholder mapping; 2) Engagement strategies and timelines; 3) Dedicated teams (representatives of traditional and community groups and government focal points); 4) Mandatory documentation of interactions; 5) Preliminary social risk analysis (including potential conflicts, perceived impacts, and critical issues raised by communities).

Structured engagement with Indigenous Peoples

Specific consultation processes, referred to as "tribal" in the local context, are mandatory, documented, and monitored prior to area selection and the initiation of environmental studies. These processes include dedicated meetings with tribal leadership, adherence to traditional communication protocols, incorporation of traditional ecological knowledge, and assessment of cultural and visual impacts during the conceptual phase. The integration of traditional ecological knowledge into environmental studies is promoted. Many projects have been redesigned at this stage in response to cultural concerns raised by Indigenous Peoples (BOEM, 2019, 2021).

3.2.4. Implementation

This is the phase in which the participatory process is carried out, and the planned strategies, as well as transparency and monitoring mechanisms, are implemented. At this stage, it is essential to properly manage the process and resources to ensure the availability of human and financial capacity, as well as the efficient use of time, to avoid participation fatigue, characterized by a sense of overload and a consequent decline in willingness to participate (Durhan et al., 2014).

In contexts where the necessary conditions for effective participation are lacking — such as access to information, functional channels for dialogue, or organizational capacity — it is important to establish a support system. This system includes actions such as providing relevant information in accessible formats and languages, establishing appropriate consultation and response mechanisms, and offering capacity building and resources (OECD, 2017). These actions should be accounted for in the planning phase and be continuously monitored during implementation.

Box 3.5. Example of implementing a plan for community engagement in Australia

Ørsted's community engagement strategy for Gippsland 01 & 02 Offshore Wind Farms (Ørsted, 2025) established clear objectives, identified more than 40 stakeholder groups consulted, and included a grievance mechanism and a shared benefits program with annual evaluation metrics. Throughout the document, the project proponent highlighted the need to develop tailored strategies for communities, distinguishing them from other stakeholders.

Good practices adopted in the Gippsland Community Engagement Strategy 01 & 02:

- **Start early and remain engaged** – the strategy initiates engagement at the feasibility licensing stage and maintains a clear consultation timeline through post-EIA phases, helping to avoid participation fatigue and enabling community input to influence project design.
- **Co-creation with Traditional Owners** – the plan establishes a formal partnership with the Gunaikurnai Land and Waters Aboriginal Corporation, recognizing cultural rights, providing direct benefits, and aligning with the National First Nations Engagement guidelines.
- **Transparency, accountability, and multiple channels** – the approach commits to providing factual information, ensuring traceability of decisions, and offering multiple participation channels (in-person sessions, interactive maps, and social media), thereby promoting inclusion, particularly of groups in situations of vulnerability or marginalization.
- **Shared benefit co-directed by the community** – it was defined that part of the project's revenues are allocated to a benefits program co-designed in early stages, grounded in socio-economic legacy metrics and aligned with local expectations regarding employment, training, and infrastructure.
- **Adaptive monitoring and robust complaint mechanism** – the strategy includes periodic consultation reports, performance indicators (e.g., online reach, number of responses), a stakeholder database, and a grievance protocol with response times ranging from two hours to ten business days, ensuring continuous improvement and public trust.

3.2.5. Monitoring and evaluation

Although presented as the final stage, monitoring and evaluation of the process and its outcomes must be continuous activities. They should follow the specific strategies and criteria defined during the planning phase, considering each objective and activity undertaken. This approach helps ensure adaptability and flexibility to identify critical issues and adjust strategies whenever problems arise.

To this end, it is recommended to:

- **Develop indicators to assess engagement effectiveness:** establishing clear metrics enables the assessment of progress toward stated objectives and identifies areas for improvement;
- **Implement participatory monitoring and evaluation processes:** involving stakeholders in the ongoing evaluation of activities enables that diverse perspectives are considered, promoting necessary, context-specific adjustments, including transformations driven by the participatory process itself and reinforcing transparency;
- **Undertake independent evaluations:** evaluations of the participatory process (including during its implementation) and its outcomes conducted by external entities guarantee impartiality, identify possible internal biases, and strengthen the credibility of the process;
- **Address identified shortcomings:** acting proactively demonstrates a commitment to continuous improvement and responsiveness to participants' expectations;
- **Establish transparency mechanisms:** implement mechanisms that ensure appropriate access to information and provide stakeholders with clear feedback on how issues were addressed and what solutions were implemented.

During the process, documentation, accessible sharing of information, and expectation management are essential. Establishing communication channels, grievance mechanisms, and monitoring systems helps identify critical issues requiring adaptation. Engaging stakeholders in identifying solutions increases the likelihood of responses suited to the intended audience and helps prevent new problems.

Creating dedicated communication channels is essential to maintaining a continuous flow of information between project proponents and stakeholders. Channels such as telephone service, emails, and social media can be used to clarify questions and provide regular updates. In addition, periodic reports on the project's progress and on whether and how stakeholder inputs have been incorporated should be made available. This approach reinforces a commitment to transparency and respect for stakeholders.

Box 3.6. Communication tools with communities

Providing stakeholders with information through appropriate communication channels, using clear and accessible language, helps ensure that different audiences — such as local communities, traditional groups, public agencies, the private sector, and civil society — can understand the content presented and follow the process.

When information is predominantly presented in technical formats, differences in understanding may arise among audiences due to variations in background knowledge, education levels, familiarity with terminology, and access conditions. For this reason, organizing and translating content into multiple formats are important operational measures to expand the reach and intelligibility of information regarding impacts, proposed measures, and participation and monitoring mechanisms within the EIA process.

Good communication practices:

- **Accessible language** – avoid technical jargon and prioritize clear explanations, plain-language text, and visual aid (e.g., infographics and maps).
- **Use of digital platforms** – employ intuitive and modern tools to facilitate access to public meeting schedules and related materials.
- **Transparency in documents** – facilitate stakeholder access and ensure full disclosure of relevant documents.
- **Strategic public hearings and consultations** – promote broad participation through advance dissemination across multiple communication channels.
- **Institutional coordination** – involve relevant agencies from the outset, ensuring that.

3.3. What comes next? Participation and engagement as strategic processes

There is no single model for promoting social participation and engagement in offshore wind farm projects. Participatory processes must be properly planned and tailored to each phase of the project development and impact assessment. They must be adapted to the environmental and socio-cultural context of the territory, applying proportionality criteria relative to the project's level of impacts and risks, conflict dynamics, and existing social capacities, as well as opportunities for the progressive strengthening of participation over time. Inclusive strategies, accessible methodologies, and transparency and communication mechanisms are essential to ensure that groups in situations of vulnerability or marginalization have an active voice and influence decisions.

These processes depend on continuous investment by the organization responsible for their implementation. Accordingly, throughout the initiative, it is essential to ensure that participation and engagement are strategically positioned and aligned with the organization's management system. To this end, in addition to careful planning of the process itself, it is necessary to establish internal mechanisms to manage, monitor, and document the process, as well as to define clear objectives and guiding principles that inform subsequent engagement activities. Such institutional support is essential to ensure the continuity of participation, even in the absence of legal requirements.

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FOUNDATIONS FOR THE ENVIRONMENTAL IMPACT ASSESSMENT OF OFFSHORE WIND PROJECTS



Chapter 4

OFFSHORE WIND FARMS AND ASSOCIATED FACILITIES

Luis Enrique Sánchez
Juliana Siqueira-Gay

To identify and assess impacts of an offshore wind farm, it is necessary to describe and characterize the activities to be carried out, both offshore and onshore, including transportation of equipment and materials and building up power transmission facilities. The adequate characterization of the project's activities - and their alternatives - is the starting point for identifying the potential impacts to support EIA scoping and the preparation of the Environmental Impact Study.

THIS CHAPTER:

1. Main types of offshore wind projects and their associated facilities
2. Technology perspectives for Offshore wind projects and their associated facilities

To assess project impacts, it is necessary to know – and describe appropriately – the activities to be carried out in their planning, construction, operation, and decommissioning phases. These activities, such as transporting parts and equipment, driving piles, and laying submarine cables, are the sources of environmental and social impacts.

An Environmental Impact Study (EIS) must contain a description of the project to be assessed. It is important to communicate objectively key characteristics of the project to the EIS readers and to stakeholders. Such description usually includes information on location, size or capacity, construction schedule, labor requirements, and other details that help decision-makers, affected communities, and other stakeholders understand the project. The systematic and structured presentation of the project is also important to support the analysis of its impacts. For this purpose, all the activities to be carried out in each phase of the project should be described.

Hence, the starting point is to clearly establish the parts and boundaries of the project to be assessed. An offshore wind farm cannot be built or operate without a set of activities and support facilities, such as an electrical substation, electricity transmission lines, port facilities for shipping parts, equipment, and personnel, and land access routes to these facilities. This set is here called associated facilities, following the terminology adopted by the International Finance Corporation (IFC) in its Environmental and Social Sustainability Performance Standards, considered as best practice in the EIA context.

In the context of project financing, associated facilities are defined as "those that are not financed as part of the project, and that would not have been built or expanded if the project did not exist and without which the project would not be viable" (IFC, 2012, §8). For other impact assessment applications (i.e., not linked to project financing), *associated facilities* are those necessary for the construction, operation, or decommissioning of the project and that would not have been built or extended had the project not been built.

Without a transmission line, a wind farm cannot operate, so the line is an associated facility. Even if the line belongs to a different company and its EIA is conducted separately from the wind farm, its impacts are still associated with those of the wind farm. However, for impact assessment purposes, a practical boundary of an offshore wind project may be the onshore substation (**Figure 4.1**), while the impacts of other installations are assessed separately or as part of a Cumulative Impact Assessment (**Chapter 10**).

Hence, the description of a project, for the purpose of assessing its impacts, begins with the delimitation of what constitutes the project. If, for regulatory purposes (e.g., permitting), it is necessary to divide a project into parts, then the cumulative impacts of all parts must be assessed, either as part of individual Environmental Impact Studies or as a multi-project assessment (**Chapter 10**).

Consideration of alternatives is a good practice in impact assessment associated with engineering project planning. Among other functions, the development and analysis of technical and location alternatives are essential to avoid or minimize certain impacts, such as the loss of important habitats (Chapter 9).

The way alternatives are described and presented in an EIS varies. The range of alternatives can be featured with equivalent detail or only conceptually, with details furnished only for the project the proponent considers preferred. To mitigate impacts (Chapter 9), it is particularly important to consider location alternatives.

4.1 Main Types of Offshore Wind Projects and Their Associated Facilities

Offshore wind power generation has been evolving rapidly, particularly in terms of capacity and size (GWEC, 2025). If the first wind turbines installed in the ocean had a capacity of less than 1 MW, manufacturers are already testing 26 MW wind turbines, which require towers up to 200 m high.

The ways of attaching structures to the ocean floor have also evolved, with not only fixed structures, but also floating ones, anchored to the bottom and held together by steel cables. Figure 4.1 shows the main installations of an offshore wind farm in operation, and Figure 4.2 shows the forms of fixation currently employed.

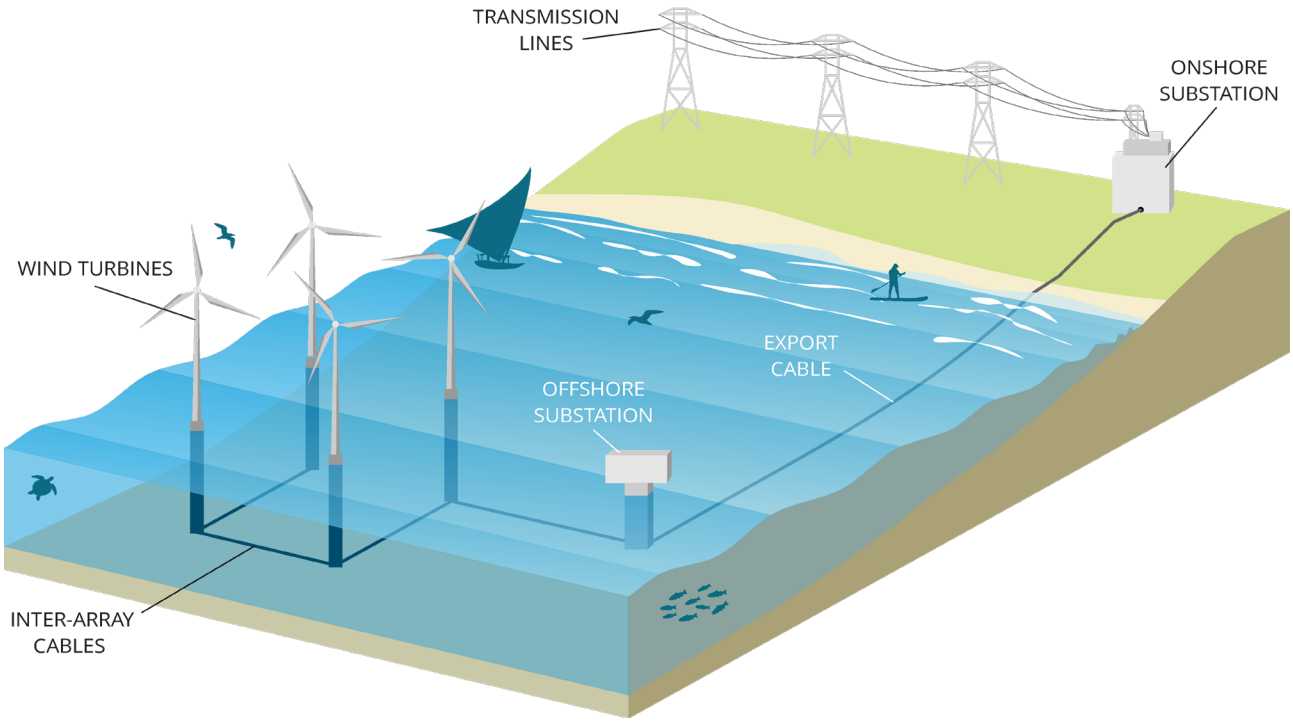


Figure 4.1. Main components of an offshore wind farm and associated facilities, including: (1) the towers and wind turbines, (2) the submarine cables, (3) the ocean substation, (4) the onshore connection cable, (5) the onshore substation, and (6) the transmission line (based on Bennun et al. (2021)).

Turbines can be divided into two main types: fixed and floating. Fixed turbines are the most common, currently installed at depths of up to 100 m, although most turbines installed by 2020 are at depths of less than 60 m (Tang and Kilpatrick, 2021). The deployment of floating turbines in deep waters requires anchoring and cabling, which today represent major technological challenges and pose challenges to their economic viability. There are differences in the construction activities of the two main types of structure, so that some environmental impacts also differ (**Chapter 5**).

Fixed structures require solid foundations (**Figure 4.2**) capable of resisting the forces of waves and wind on both the submerged and emerged structures (tower, nacelle, and blades). There are different ways to build foundations, for example, by driving piles. Floating structures, on the other hand, have several possible configurations that affect the anchoring and cabling system (**Figure 4.3**). The main difference from fixed ones is the way they are fixed to the seabed, using anchor cables. In both cases, the metal structures need to be transported – in parts – by ships, from a port, assembled, and fixed on site. For assembly, special ships are used.

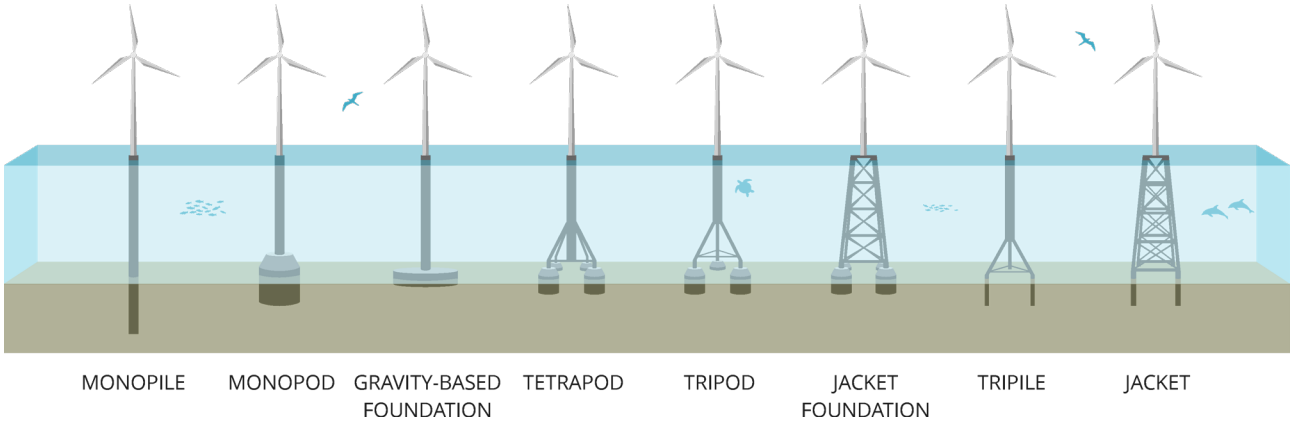


Figure 4.2. Main types of fixed structures of offshore wind farms.

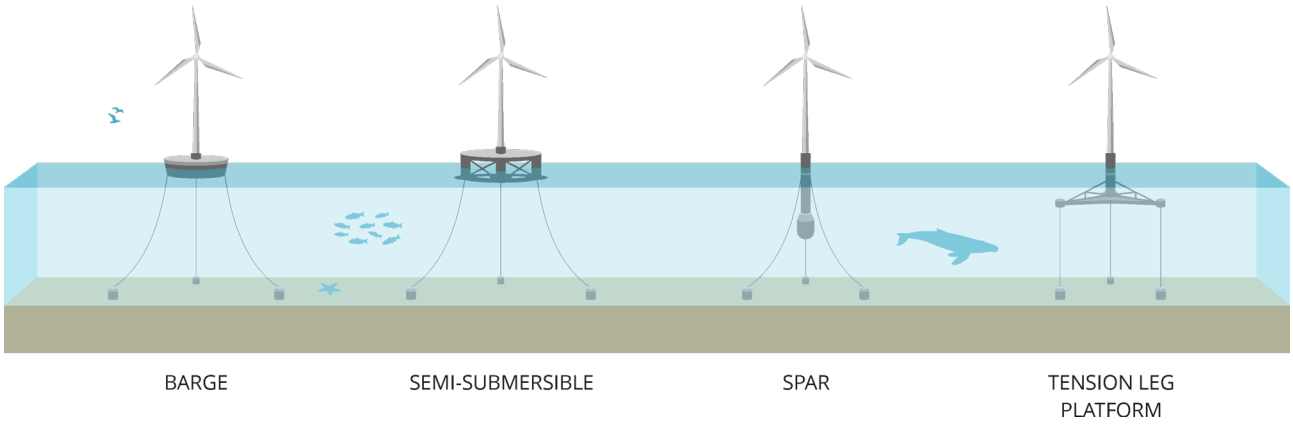


Figure 4.3. Main types of floating structures of offshore wind farms (Chen & Kim (2022)).

Among the other necessary installations, power cables transmit the electricity generated by each turbine to a substation and connect the turbines. Cables can be laid directly over the ocean floor or installed in trenches dug into the bottom. In the latter arrangement, they are protected from fishing gear, anchors, or other sources of damage. However, only fixed installations allow cable burial. In mobile installations, electrical cables must be suspended and long enough to accommodate foundation movement during turbine steel cable installation, as well as wave and tide movements (BVG Associates, 2024).

Generally, wind farms have an offshore substation installed in shallow waters on a monopile foundation (Figure 4.1). In the case of farms close to the coast, this substation can be onshore. The substation receives submarine cables from the wind turbines and has one or more output cables connecting to the onshore substation. The substations function to convert alternating current to direct current and to stabilize the voltage. Substations contain transformers, circuit breakers, emergency generators, and storage areas.

The installation of the electrical cables connecting the marine substation to the onshore substation (Figure 4.1) can be done on the surface or buried. Underground installations offer greater protection for cables. A project is needed for each locality, adapted to the geomorphological conditions of the coast and to any potential environmental or legal constraints. One possibility is drilling directional holes – a method widely used in installing underground pipes – thereby avoiding the need to open trenches (Figure 4.4).

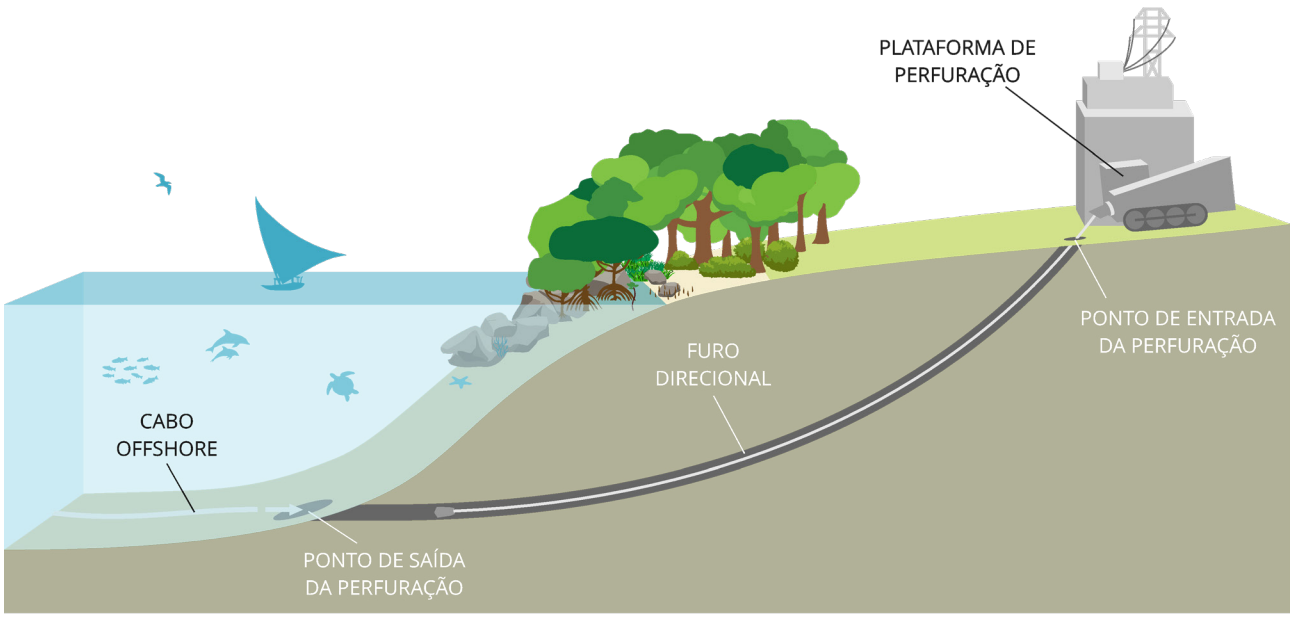


Figure 4.4. Installation of the electrical cables connecting the marine substation and the onshore substation.

4.2 Technological Perspectives for Offshore Wind Projects and Their Associated Facilities

Increasingly large offshore wind turbines have been developed and commercialized. A technological escalation of materials has accompanied the increase in capacity (Dodds et al., 2022; Huang et al., 2020). Design arrangements have also evolved, for example, in how turbines and other components are arranged, such as by connecting grid platforms to reduce contact between anchor lines and the seabed (Chen & Kim, 2022; Xu et al., 2024).

Recent research in several countries (Song et al., 2024) suggests ongoing technological development of offshore wind farms in areas such as materials and blade design, structures, aerodynamic effects, and other studies to optimize the performance of generating systems. From an environmental point of view, larger structures require larger foundations, larger amounts of construction materials, and, in general, larger construction equipment. Higher-capacity turbines are also taller and therefore visible at greater distances.

A relevant issue with limited experience so far is the decommissioning of offshore wind farms. This stage consists of the definitive shutdown of the turbines, removal of equipment, and dismantling of the facilities, activities that must be planned with the same care as construction and that also cause environmental and social impacts. In land parks, even though some have been in operation for several years, there is also little experience with decommissioning. Well-maintained farms can extend their useful life, and this is also true for offshore farms. When maintenance costs become too high, the alternative of repowering is generally considered, that is, equipping the park with more modern and more powerful turbines, taking advantage of the structure of the towers and the foundations.

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Chapter 5

IMPACTS AND CAUSAL RELATIONSHIPS

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The starting point for structuring an Environmental Impact Study (EIS) involves describing activities related to the planning, construction, operation, and decommissioning stages of projects and connecting them to their environmental and social impacts. The preliminary identification of potential impacts underpins the definition of the study scope and the planning of the surveys needed to establish the baseline for impact assessment.

THIS CHAPTER:

1. Causal relationships in project environmental impact assessment
2. Environmental impacts of offshore wind projects
3. Social impacts of offshore wind projects

5.1 Causal relationships in project environmental impact assessment

Explicitly demonstrating the causal relationship between the project's activities and their impacts helps to determine the information necessary to plan the EIS in the scope definition and preparation of Terms of Reference. The determination of the causal chain also supports impacts analysis and the development of mitigation measures.

A preliminary (interim) impact identification supports EIA scoping and planning baseline surveys

> **Causality** in impact assessment means explicitly relating the activities of a proposed project, the associated environmental aspects, and their respective potential impacts.

To promote the application of ecosystem-based management (Chapter 2), it is necessary to consider the dynamic nature of ecosystems (Long et al., 2015) and the components and processes that define them and that may be affected by a given project. To apply these principles to EIA practice, it is essential to explicitly communicate to decision-makers and stakeholders how ecosystems may be impacted and how these impacts interact, mapping the causal relationship between activities and impacts (Laurino et al., 2025).

Therefore, it is important to clearly represent the relationships among the project's activities, their environmental aspects, and their impacts, and to explain what environmental or social component is affected and how. Thus, the theoretical and practical understanding of the structure (components) and functioning (processes) supports hypotheses created about how the environment may be affected by the activities carried out during planning, construction, operation and decommissioning a project. These hypotheses allow the elaboration of narratives that represent, in accessible visual and written language, the causal chains.

Do not confuse the concepts of environmental aspects and impacts. Environmental aspects are elements of activities, products or services that interact or can interact with the environment (ISO 14001). Examples of environmental aspects are emissions of particulate matter or noise generation. Environmental impact, on the other hand, is the alteration of environmental quality that results from the modification of natural or social processes caused by human action. Examples of impacts are changes in air quality and changes in water quality.

Means to illustrate causality include impact matrices and causal diagrams (Perdicoulis and Glasson, 2009). A matrix describes the interactions between activities and components or between activities and impacts. Diagrams, on the other hand, graphically represent interactions using specific conventions. The diagrams can be of the action-to-result map type, which, in sequence, shows the main actions that lead to various impacts in a single direction (Perdicoúlis; Glasson, 2009).

In the following sections, the steps for structuring a causal chain of offshore wind energy projects are presented, starting from the characterization of the activities inherent to the project (Chapter 4) and providing the description of the environmental and social aspects associated with these activities and potentially related environmental and social impacts. Using the causal chain referenced by the competent federal EIA authority in Brazil, IBAMA, scientific literature, and sample environmental impact studies, causal relationships among various activities, aspects, and impacts are exemplified through causal diagrams.

Although the content presented here is quite comprehensive and can serve as a starting point for defining the scope of environmental studies, it does not intend to be exhaustive. The lists of activities, aspects and impacts can be completed by adding other activities, while other aspects and impacts can be identified and integrated, especially in case of technological advances and/or specificities of the locations in which offshore wind farms are intended to be implemented.

Learn more

As a reference for the environmental agency, some sectoral guides were prepared to support analysts in the preparation of the terms of reference and technical analysis of the studies. This content helps in a better understanding of the preliminary identification of the impacts that are characteristic of certain typologies.

As examples, Ibama's guides for transmission lines (2019) and for seismic research (2026) are published <https://www.gov.br/ibama/pt-br/assuntos/laf/publicacoes/laf-publicacoes>

5.1.1 Description of activities

The main impact-causing activities carried out in the planning, construction, operation, and decommissioning stages of offshore wind farms and their associated facilities are summarized in Table 5.1. Some activities can be broken down into other activities or sub-activities, providing a more detailed description that, in certain cases, can facilitate the identification of related aspects and impacts. To assess impacts, it is necessary to characterize each activity, i.e., describe how it will be executed, the resources and equipment needed, and obtain quantitative data to characterize the activity, such as the footprint, volume of concrete used, number of vessel trips, etc.

Table 5.1. Main activities in the planning, construction, operation, and decommissioning phases of an offshore wind farm.

Activities carried out in the marine environment	
1 Planning	**OF01** Characterization of oceanographic, meteorological, and other conditions
	OF02 Technical, economic, and environmental studies
2 Construction	**OF03** Maritime transport of supplies, equipment, and people between the port and the construction site
	OF04 Installation of anchoring systems (foundation preparation, cable, and anchor installation)
	OF05 Fastening and assembly of turbine structures
	OF06 Export cable installation (remote inspections, trenching, cable laying)
	OF07 Construction of the offshore substation
	OF08 Mechanical and Electrical Testing of Turbines
3 Operation	**OF09** Power Generation
	OF10 Submarine Power Transmission
	OF11 Substation Operation
	OF12 Inspection and maintenance of submerged and submerged installations
4 Decommissioning	**OF13** Removal of turbines and other parts
	OF14 Removal of submarine cables and auxiliary structures
	OF15 Transport of disassembled parts and structures
	OF16 Rehabilitation of the seabed and affected areas
Activities carried out in the terrestrial environment	
1 Planning	**ON01** Geotechnical, socio-environmental, and other characterization of the areas of interest
2 Construction	**ON02** Preparation of the site (suppression of vegetation, earthworks, construction of offices, workshops, and others)
	ON03 Construction and improvement of port and storage areas
	ON04 Receiving, storing, and shipping supplies and equipment
	ON05 Construction and assembly of structures
	ON06 Construction of Ground Substation and Transmission Lines
	ON07 Dismantling of the construction site (removal of materials and waste, recovery of degraded areas, and other activities)
	ON08 Inland transportation of goods and supplies
3 Operation	**ON09** Voltage Conversion and Electrical Power Transmission
	ON10 Maintenance
4 Decommissioning	**ON11** Demolition, removal of structures, transportation, recovery of degraded areas
Atividades gerais	
1 Planning	**GE01** Stakeholder Engagement
	GE02 Hiring of labor
	GE03 Acquisition of goods and services
	GE04 Electricity Trading

5.1.2 Environmental and social aspects and impacts

The second step, after identifying the activities, is to determine the related environmental and social aspects and impacts. Environmental and social aspects and impacts related to the activities illustrated above are listed in Table 5.2. It is important to notice that, for most projects, not all listed impacts will be significant (Chapter 9), and some impacts may not occur at all. Hence, the table should be used only as a reference for a preliminary impact identification, to be refined later on in the preparation of the EIS.

Table 5.2. Main activities, aspects, and environmental and social impacts of offshore wind farms.

Activities	Environmental and social aspects	Environmental and social impact
OF01 Characterization of oceanographic, meteorological, and other conditions (e.g., geophysical surveys, geotechnical tests, airborne surveys, biological sampling, buoys, visual observations of vessels or aircraft); maritime and air embarkation and disembarkation	**A01** Vessel traffic	**I01** Introduction and dispersal of exotic species
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
OF02 Technical, economic, and environmental studies	**A05** Collision with mammals and turtles	**I05** Injuries and death of mammals and chelonians
	A06 Accidental Oil Release	**I06** Deterioration of water quality
		I07 Disturbances in wild animals
OF03 Maritime transport of supplies, equipment, and people between the port and the construction site	**A01** Vessel traffic	**I01** Introduction and dispersal of exotic species
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
	A05 Collision with mammals and turtles	**I05** Injuries and death of mammals and chelonians
	A06 Accidental Oil Release	**I06** Deterioration of water quality
		I07 Disturbances in wild animals
OF04 Installation of anchoring systems (foundation preparation, cable, and anchor installation)	**A07** Seabed disturbances	**I08** Loss of habitats and benthic specimens
	A03 Noise Generation	**I03** Disturbances in wild animals
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
		I09 Hearing loss and death of noise-sensitive marine species (mammals, turtles, fish, and invertebrates)
		I10 Avoidance of site use by noise-sensitive marine species (mammals, turtles, fish, and invertebrates)
	A08 Sediment Plume Generation	**I06** Deterioration of water quality
		I11 Change in phytoplankton productivity and the trophic chain

Table 5.2. Main activities, aspects, and environmental and social impacts of offshore wind farms (continued).

Activities	Environmental and social aspects	Environmental and social impact
OF05 Fastening and assembly of turbine structures	**A03** Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
	A09 Landscape Changes	**I12** Visual impact
	A10 Bird and bat collision	**I13** Injuries and deaths of birds and bats
	A05 Collision with mammals and turtles	**I05** Injuries and death of mammals and chelonians
	A11 Restriction of use for fishing and other activities	**I14** Increase in conflicts related to the use of marine space
OF06 Export cable installation (remote inspections, trenching, cable laying)	**A07** Seabed disturbances	**I08** Loss of habitats and benthic specimens
	A08 Sediment Plume Generation	**I06** Deterioration of water quality
		I11 Changes in phytoplankton productivity and in the food chain
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
OF07 Construction of the offshore substation	**A07** Seabed disturbance	**I08** Loss of habitats and benthic specimens
OF08 Mechanical and Electrical Testing of Turbines	**A03** Noise Generation	**I03** Behavioral disorders in terrestrial fauna
OF09 Power Generation	**A12** Aerodynamic effects of leeward turbulence	**I15** Changes in water, sediment, and nutrient flows
		I11 Changes in phytoplankton productivity and in the food chain
	A13 Hydrodynamic effects (increased or reduced turbulence)	**I15** Changes in water, sediment, and nutrient flows
		I11 Changes in phytoplankton productivity and in the food chain
	A14 Barrier effect	**I16** Behavioral disorders in highly mobile species (birds, marine mammals, turtles, and fish)
		I17 Changes to routes (including migratory routes)
		I18 Changes in habitat use patterns of highly mobile species (birds, marine mammals, turtles, and fish)

Table 5.2. Main activities, aspects, and environmental and social impacts of offshore wind farms (continued).

Activities	Environmental and social aspects	Environmental and social impact
OF09 Power Generation (cont.)	**A07** Seabed disturbance	**I18** Creation of artificial habitats
		I08 Loss of habitats and benthic specimens
		I19 Changes in ecosystem functioning (organic enrichment of benthic environments; changes in nutrient flows and food webs
		I20 Changes in the composition of biodiversity (reef effect)
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
		I09 Hearing loss and death of noise-sensitive marine species (mammals, turtles, fish, and invertebrates)
		I10 Avoidance of site use by noise-sensitive marine species (mammals, turtles, fish, and invertebrates)
	A10 Bird and bat collision	**I13** Injuries and deaths of birds and bats
	A05 Collision with mammals and turtles	**I05** Injuries and death of mammals and chelonians
	A11 Restriction of use for fishing and other activities	**I21** Creation of refuges for fauna congregation, with changes in the composition of biodiversity and food webs (refuge effect)
	A09 Landscape Changes	**I12** Visual impact
OF10 Submarine Power Transmission	**A15** Generation of electromagnetic fields	**I22** Behavioral disturbances in electrosensitive marine species (mammals, chelonians, fish, and invertebrates)
OF11 Substation Operation	**A03** Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
OF12 Inspection and maintenance of submerged and submerged installations	**A01** Vessel traffic	**I01** Introduction and dispersal of exotic species
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)

Table 5.2. Main activities, aspects, and environmental and social impacts of offshore wind farms (continued).

Activities	Environmental and social aspects	Environmental and social impact
OF12 Inspection and maintenance of submerged and submerged installations (cont.)	**A05** Collision with mammals and turtles	**I05** Injuries and death of mammals and chelonians
	A06 Accidental Oil Release	**I06** Deterioration of water quality
		I07 Disturbances in wild animals
OF13 Removal of turbines and other parts	**A07** Seabed disturbances	**I08** Loss of habitats and benthic specimens
OF14 Removal of submarine cables and auxiliary structures		**I23** Loss of biological communities colonizing artificial structures
OF15 Transport of disassembled parts and structures	**A01** Vessel traffic	**I01** Introduction and dispersal of exotic species
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
OF16 Rehabilitation of the seabed and affected areas	**A01** Vessel traffic	**I01** Introduction and dispersal of exotic species
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A04 Underwater Noise Generation	**I04** Behavioral disturbances in noise-sensitive marine species (mammals, chelonians, fish, and invertebrates)
	A05 Collision with mammals and turtles	**I05** Injuries and death of mammals and chelonians
	A06 Accidental Oil Release	**I06** Deterioration of water quality
		I07 Disturbances in wild animals
ON01 Geotechnical, socio-environmental, and other characterization of the areas of interest	**A03** Noise Generation	**I03** Behavioral disorders in terrestrial fauna
ON02 Preparation of the site (suppression of vegetation, earthworks, construction of offices, workshops, and others)	**A16** Vehicle traffic	**I24** Loss of fauna due to roadkill
	A17 Loss of vegetation	**I07** Disturbances in wild animals
	A18 Intensification of erosion	**I25** Deterioration of soil quality

Table 5.2. Main activities, aspects, and environmental and social impacts of offshore wind farms (continued).

Activities	Environmental and social aspects	Environmental and social impact
ON03 Construction and improvement of port and storage areas	**A02** Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A16 Vehicle traffic	**I24** Loss of fauna due to roadkill
	A19 Land use change	**I26** Loss and fragmentation of natural habitats
	A20 Waste generation	**I25** Deterioration of soil quality
		I07 Disturbances in wild animals
		I27 Solid waste management infrastructure overload
	A21 Light Emissions	**I03** Behavioral disorders in terrestrial fauna
	A22 Water consumption	**I28** Reduction of water availability
ON04 Receiving, storing, and shipping supplies and equipment	**A19** Land use change	**I26** Loss and fragmentation of natural habitats
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
ON05 Construction and assembly of structures	**A02** Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A20 Waste generation	**I25** Deterioration of soil quality
		I07 Disturbances in wild animals
		I27 Solid waste management infrastructure overload
	A21 Light Emissions	**I03** Behavioral disorders in terrestrial fauna
ON06 Construction of Ground Substation and Transmission Lines	**A17** Vegetation losses	**I26** Loss and fragmentation of natural habitats
	A18 Intensification of erosion	**I25** Deterioration of soil quality
	A03 Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A19 Land use change	**I26** Loss and fragmentation of natural habitats
	A09 Landscape changes	**I12** Visual impact

Table 5.2. Main activities, aspects, and environmental and social impacts of offshore wind farms (continued).

Activities	Environmental and social aspects	Environmental and social impact
ON07 Dismantling of the construction site (removal of materials and waste, recovery of degraded areas, and other activities)	**A03** Noise Generation	**I03** Behavioral disorders in terrestrial fauna
	A20 Waste generation	**I25** Deterioration of soil quality
		I07 Disturbances in wild animals
		I27 Solid waste management infrastructure overload
ON08 Inland transportation of goods and supplies	**A02** Emission of air pollutants	**I02** Deterioration of air quality
	A16 Vehicle traffic	**I24** Loss of fauna due to roadkill
ON09 Voltage conversion and electric power transmission	**A15** Generation of electromagnetic fields	**I28** Behavioral disturbances in electrosensitive terrestrial species
ON10 Maintenance	**A20** Waste generation	**I25** Deterioration of soil quality
		I07 Behavioral disorders in wildlife
		I27 Solid waste management infrastructure overload
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A03 Noise generation	**I03** Behavioral disorders in terrestrial fauna
ON11 Demolition, removal of structures, transportation, recovery of degraded areas	**A20** Waste generation	**I25** Deterioration of soil quality
		I07 Disturbances in wild animals
		I27 Solid waste management infrastructure overload
	A03 Noise generation	**I03** Behavioral disorders in terrestrial fauna
	A02 Emission of air pollutants	**I02** Deterioration of air quality
	A19 Land use change	**I29** Habitat restoration
GE01 Stakeholder Engagement	**A23** Dissemination of information	**I30** Increasing scientific knowledge and local knowledge
GE02 Hiring of labor	**A24** Job creation	**I31** Boosting the local economy
	A25 Attraction of people/migration	**I32** Increased demand for services and infrastructure
GE03 Acquisition of goods and services	**A26** Tax Generation	**I33** Increase in tax collection
	A27 Increase in economic activities	**I31** Boosting the local economy
GE04 Electricity Trading	**A26** Tax Generation	**I33** Increase in tax collection

5.2 Environmental impacts of offshore wind projects

5.2.1 Impacts on the marine environment

The construction and operation of offshore wind farms affect various components of the marine environment, including the physical properties of the water column, planktonic communities, benthic systems, and nekton biodiversity. Different activities carried out during the construction phase of a project lead to direct seabed degradation, such as pile driving, sediment dredging, burying transmission cables, and installing artificial structures related to offshore turbines and substations. These activities promote the resuspension of sediments into the water column, which modifies its turbidity patterns and light penetrability, and consequently affects the planktonic community. Phytoplankton, the main source of primary production in the oceans, is affected by increased turbidity and reduced light penetration in the water column, thereby reducing biomass and cascading impacts on the entire trophic web, especially for zooplankton and benthic filter-feedings (Dannheim et al., 2020).

Benthic habitats and their associated invertebrates are also among the main components affected by the disturbances resulting from construction, especially due to the direct physical shock that leads to the mortality of sensitive organisms. Invertebrate species characterized by long life cycles and larger body size are most vulnerable to these direct disturbances and tend to decline in abundance in the affected area (Coates et al., 2015).

On the other hand, opportunistic invertebrates tend to benefit from disturbances and increase their dominance in the community. Because opportunistic species typically have smaller body sizes, construction activities are expected to reduce overall benthic biomass. Such negative impacts are aggravated by noise (mainly linked to pile driving and increased vessel traffic), which affects the behavior of sound-sensitive species and can cause direct injuries to invertebrates and benthic fish (Dannheim et al., 2020). Although these impacts on benthic communities are negative, previous experience indicates that they are temporary, and the sediment community tends to recover within a few years.

In addition to invertebrates and benthic fish, marine mammals also suffer impacts from these installation activities, especially during the period when turbines are staked on the seabed. Acoustic communication between individuals in the same group is crucial for socialization, navigation, feeding, and reproduction. Noise pollution and the potential hearing damage resulting from this activity hinder communication, leading to social isolation, difficulty forming social bonds, and reduced cooperation during hunting and reproduction, thereby impacting population dynamics (Wright et al., 2020). Moreover, some species may begin to avoid the directly affected area, leading to a reduction or alteration of their previously used home range for feeding, reproduction, or migration.

Started during construction phase and consolidated during the operation of the project, one of the main impacts on the marine environment is the creation of artificial consolidated habitats (turbine structures, cables, substations, etc.), which function as a substrate for the colonization of fouling invertebrates, replacing the previously present habitats and sedimentary species.

This habitat alteration affects the functioning of surrounding ecosystems, mainly by promoting local organic enrichment, as increased carbon flows to adjacent sediments from the fouling community's biodeposition of tailings (fecal pellets, shell remains, etc.). This benthic enrichment can increase local environmental complexity, primary productivity, and benthic community diversity. However, in some cases, excess organic matter leads to sediment anoxia (Dannheim et al., 2020), reducing habitat quality and species diversity and favoring the proliferation of opportunistic organisms.

Artificial structures introduced into the marine environment also alter local hydrodynamics, sediment flow, and the amount of organic matter in the water column (Wang et al., 2024). There are cases in which the presence of turbines increases the hydrodynamic energy of their surroundings, leading to substrate erosion and the resuspension of fine sediments, with negative consequences for the planktonic and benthic communities, similar to those observed during the installation phase.

However, in cases where resuspension of organic matter and nutrients, driven by hydrodynamic changes, favors local primary productivity and increases the abundance of zooplankton and benthic filter-feeding organisms, this contributes to the food supply for higher trophic levels. A third possible scenario is when the artificial structures act as hydrodynamic barriers, reducing the energy of the local water flow. In these cases, deposition of fine sediments and organic matter in their surroundings occurs, favoring benthic organic enrichment and increasing the risk of local oxygen depletion.

The introduction of new consolidated habitats also promotes the attraction of fish and epibenthic invertebrates characteristic of reef environments (called the reef effect), which use the project's structures for feeding and shelter. The attraction of fish and epibenthic invertebrates is also enhanced by the prohibition of fishing in the project area, which creates refuges for commercial species that are vulnerable to, for example, trawling (called the *refuge effect*).

Although reef and refuge effects are positive for biodiversity, the creation of new consolidated habitats may favor the introduction and dispersal of exotic species, intensified by the increase in local vessel traffic, and may reduce the abundance of non-reef species that previously occupied the replaced sedimentary habitats (Griffin et al., 2016; Dannheim et al., 2020).

Many nektonic organisms depend on benthic organisms as a food source, establishing a strong ecological relationship between them. The reef effect may favor increases in local benthic biodiversity, thereby increasing food availability in the nekton and influencing trophic relationships (Degraer et al., 2020). As a consequence, nektonic organisms are also attracted to these areas during the operation phase.

Thus, it is common to observe a significant increase in the biomass of pelagic fish, also attracted by the reef and refuge effects. This increase in prey availability, in turn, attracts top predators such as marine mammals, pelagic birds, and sharks, thereby enriching the food chain in the region (Nogues et al., 2023). However, the greater presence of these organisms can also increase the risk of being run over by vessels used in the installation and operation/maintenance of wind farms, representing an impact to be monitored.

The reef effect, followed by the increased frequency of pelagic bird visitation in the region, also increases the risk of collision with turbines and propellers during flight, which tends to increase the mortality of these animals.

On the other hand, some bird species, as well as certain marine mammals, begin to avoid these areas, leading to a reduction in their home range and loss of habitat for reproduction, breeding, feeding, and resting, as well as suffering deviations from migratory routes. This alteration of home range can force birds to occupy suboptimal sites and increase energy expenditure by avoiding them, compromising the survival and reproductive success of individuals, and the productivity of the population (Croll et al., 2022).

Another relevant aspect to consider during the operation of offshore wind farms is the generation of electromagnetic fields by underwater power transmission cables. Sea turtles, sharks, and rays use geomagnetic cues to aid navigation during migration and may experience behavioral disturbances from these electromagnetic fields (Gill et al., 2020). While most of the impacts mentioned are mainly associated with wind farms with fixed turbines, these impacts related to transmission cables extend to wind farms with floating turbines. In addition, when considering floating wind farms, moorings and mooring systems consisting of chains and heavy cables are necessary to keep their substructures stationary, which increases the risk of entanglement of turtles and other nektonic organisms in these structures.

Figure 5.1 illustrates some of these causal relationships associated with the activities, aspects, components, and impacts of offshore wind farms on the marine environment.

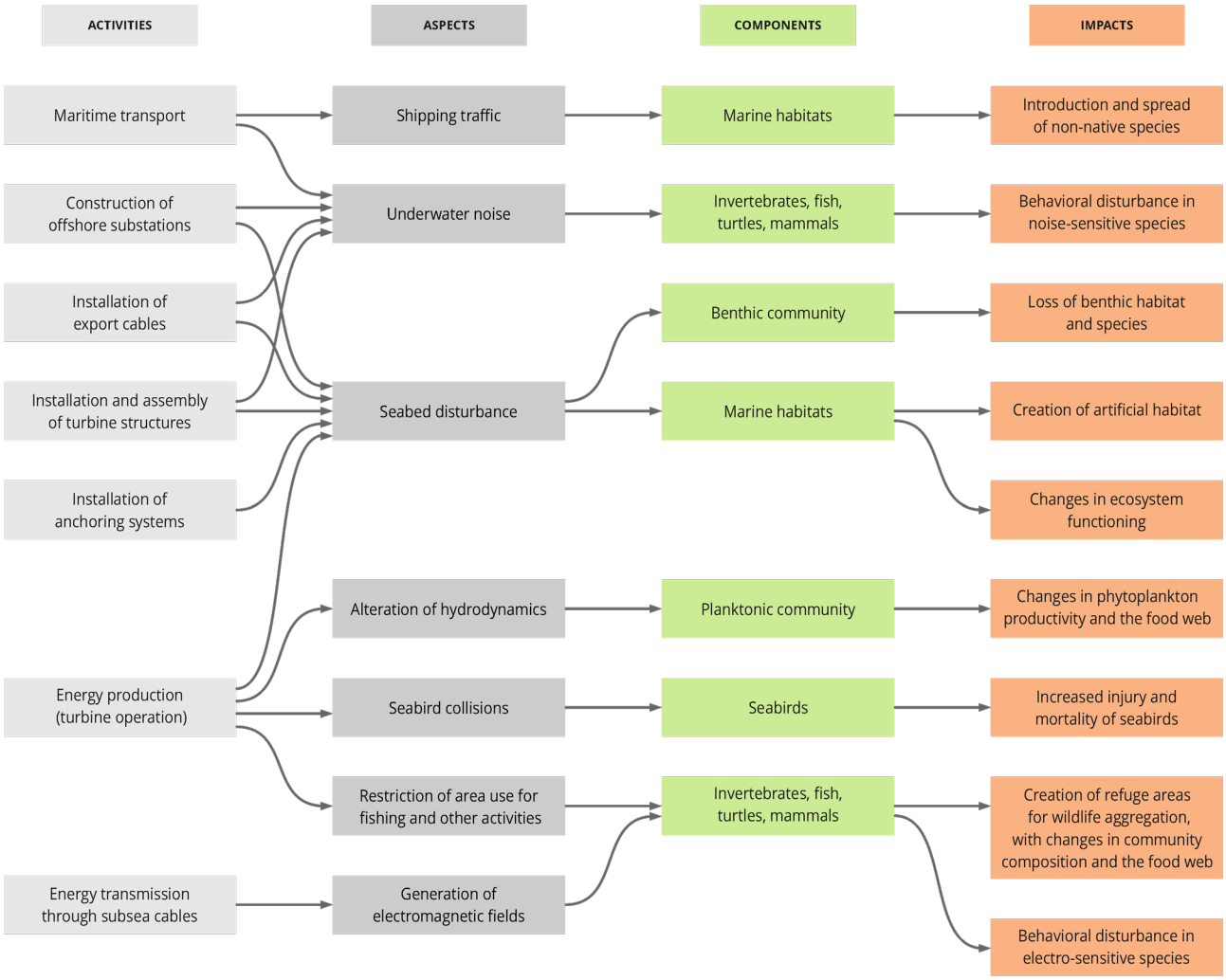


Figure 5.1. Example of a causal chain highlighting the main activities, aspects, components, and impacts on the marine environment related to the installation and operation of offshore wind farms.

5.2.2 Impacts on the coastal and terrestrial environment

The construction and operation of offshore wind farms can also result in direct and indirect impacts on coastal and terrestrial habitats, as well as their associated biodiversity. Such impacts are particularly associated with the installation phase of the associated infrastructure, such as onshore substations and transmission lines. Those activities can affect habitats and various biological groups, including flora, coastal invertebrates, terrestrial mammals, herpetofauna (reptiles and amphibians), avifauna, and chiropterofauna (bats).

The suppression of vegetation and the modification of habitats for the construction of substations and the installation of transmission lines result in direct loss and fragmentation of flora components. For associated fauna, this disturbance reduces and degrades habitats and triggers indirect impacts, such as changes in resource availability. The generation of pollutants such as solid waste and effluents is also expected, with potential impacts on coastal and terrestrial ecosystems and their associated biodiversity.

Among the main coastal ecosystems along tropical coasts, dunes, sandbanks, beaches, rocky shores, coral reefs, estuaries, and mangroves stand out. In the construction phase, parts of these environments are subject to the suppression of local vegetation for the installation of transmission cables from offshore wind turbines and onshore power substations, as well as to the loss of coastal benthic habitats due to the placement of cables on the seabed. All activities involved in installing onshore structures also generate noise pollution and increase local road traffic, with risks of being run over and behavioral disturbances for terrestrial fauna.

In the operation phase, expected impacts include changes in the behavior of coastal species due to the obstacles posed by the cables and the electromagnetic fields generated by high-voltage transmission. The installed artificial structures can also generate points of higher erosion or sedimentation rates in coastal ecosystems, altering sediment granulometry, especially on beaches and in mangroves. The increase in noise pollution from the operation of offshore turbines can also impact coastal species, such as estuarine crustaceans, depending on the distance of the project from the coast (Pine et al, 2012).

Most impacts of installing and operating onshore structures are similar to those observed in other coastal zone projects and constructions, whose impacts are already relatively well documented. However, the impacts of offshore wind farms on coastal birds (continental, waders, and marine birds linked to coastal environments) and bats extend throughout their operation and exhibit particularities relative to other types of projects in the coastal zone. Shorebirds and bats often use marine areas during seasonal migrations or daily commutes, including foraging trips. The presence and operation of offshore wind farms pose significant risks to these groups, both by direct mortality and behavioral impacts.

One of the main risks is collision with wind turbines, especially for species that fly at altitudes compatible with the blades' heights. This impact is compounded in low-visibility conditions, such as fog or nighttime periods, when many bats and migratory birds are on the move. In addition to direct mortality, turbines can cause behavioral disturbances (Furness et al., 2013). The response to this disturbance can vary between species. Still, it can generate the *barrier effect* – an obstacle that alters flight paths and increases energy costs by displacing affected individuals to areas far from the wind farm. Depending on the intensity of this response, the consequence is the effective loss of home range, potentially reducing the availability of essential resources for the affected species.

In coastal areas, in addition to impacts from the installation of onshore wind farm infrastructure, there are additional risks related to transmission lines. These structures can cause fatal collisions for birds, especially in stretches close to feeding or resting areas. In addition, towers and cables can serve as landing and shelter sites, increasing the risk of electric shock.

These factors reinforce the need for mitigation measures that account for the coastal zone, the specific vulnerability of each associated biological group, and the ecological connectivity among terrestrial, coastal, and marine environments. Figure 5.2 illustrates some of these causal relationships associated with the activities, aspects, components, and impacts of offshore wind farms on the coastal and onshore environment.

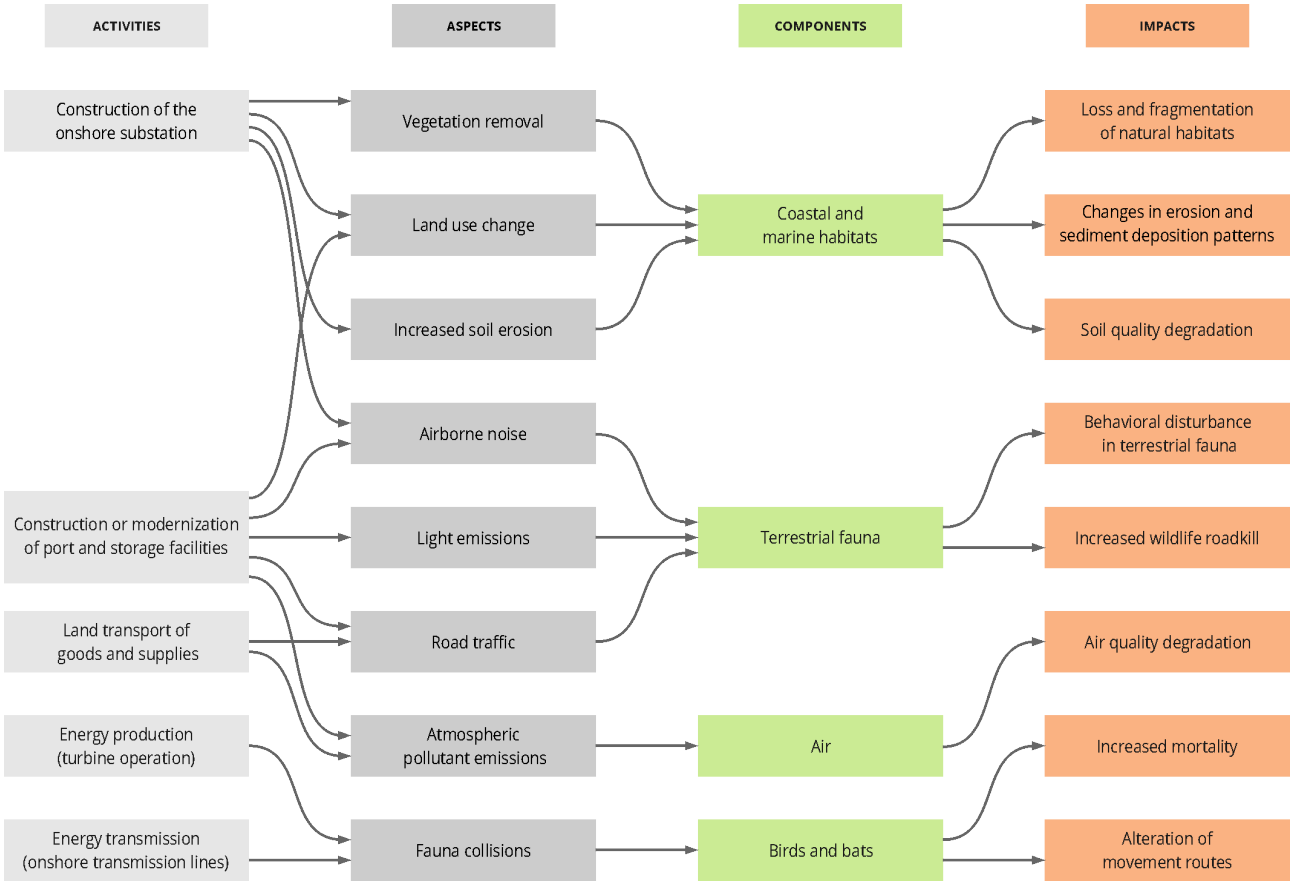


Figure 5.2. Example of a causal chain highlighting the main activities, aspects, components, and environmental impacts on the coastal and terrestrial environment related to the installation and operation of offshore wind farms.

5.3 Social impacts of offshore wind projects

Offshore wind farms affect the marine and coastal environment, generating a complex range of direct and indirect impacts not only on ecosystems but also on the economic, socio-cultural, and infrastructure components of the communities located within the area of influence of these projects. Construction and operation activities generate social impacts, such as jobs. They can boost the local economy, but they can also overload public services due to the influx of people to communities near the projects, as well as possible losses in fishing areas and in the tourist potential of these areas.

Fishing areas, in particular, tend to be directly affected by changes in the marine environment, including restrictions on the use of marine space, which can lead to conflicts over the right to use it and intensify the impacts on the local economy. These impacts highlight the need for great attention to social factors, neglected in the context of some EIS.

Considering employment and labor market components, the need to mobilize the labor force and meet demand for goods and services in the implementation of offshore wind farms has the potential to maximize the absorption of local labor and boost local economies by generating direct, indirect, and induced jobs. Previous studies indicate a range of 0.2 to 1.5 jobs per MW installed during the construction phase, considering the multiplier impacts on the local production chain. In contrast, the operation phase, lasting 20 to 25 years, maintains approximately 0.15 to 0.2 jobs per MW annually (Glasson et al., 2022).

It is important to note that, regarding the demand for jobs that require high training capacity and skills, there may be community resistance to external professionals occupying these roles. At the same time, the local population is relegated to lower-paid positions, creating a context of distributive injustice (Jørgensen et al., 2020).

On the other hand, local economic benefits correlate directly with the degree of national and regional content of the project: UK analyses show that only 30% of capital investments (CAPEX) remain in the domestic economy during construction, due to dependence on imports of turbines and specialized equipment, contrasting with 75% of national content in the operation phase (Glasson et al., 2022). This dynamic underscore the importance of policies that support the development of local production chains to maximize regional economic multipliers. However, it should be noted that such actions are beyond the scope of project-level EIA.

The mobilization of the workforce can also generate negative impacts by affecting demography and population dynamics, especially by attracting people, reproducing impacts typical of large projects in regions with low population density. The temporary influx of workers during construction can put pressure on the local real estate market, raising living costs and overloading infrastructure and services, such as health, education, security, and emergency services, as already observed in other types of offshore projects (such as oil and gas).

In addition, some studies warn of the risk of spreading prostitution, with cases of children being born locally called "children of the winds", in addition to the spread of drug use in onshore wind projects (Brannstrom et al., 2018; Brannstrom et al., 2022; Gorayeb et al., 2018). This phenomenon, comparable to the "boomtown effect", requires cross-sectoral planning to mitigate negative impacts and maximize positive ones, such as port improvements and professional training of the local population (Glasson et al., 2022).

Particularly, the impacts on tourism and fisheries have distinct characteristics that require careful analysis. The aesthetic changes in coastal and marine landscapes during wind turbine operations can result in visual impacts.

Behavioral studies reveal that tourists' reactions vary by individual environmental value profiles, with environmentally oriented people showing greater acceptance or neutrality toward the presence of offshore wind turbines.

In the literature, there are records of modest impacts on visitation decisions at a given location, especially when the turbines are positioned beyond the immediate visual horizon of the beaches (Oh et al., 2023; Glasson et al., 2022). Additionally, the development of educational and ecological tourism niches centered on visiting wind farms is observed, indicating the potential for a positive re-signification of these projects within the local tourism context (Machado & de Andrés, 2023).

However, in tropical environments, this relationship demands particular attention, because in these regions, coastal tourism is usually strongly associated with landscape attributes and sensory experiences linked to the naturalness of the landscape. In these contexts, the aesthetic and symbolic perception of the landscape plays a central role in tourist attractiveness, and any visual alteration can negatively impact the visitor experience and, in some cases, the destination's market positioning. In addition, in many tropical regions, tourism is one of the main local economic activities; this means that possible changes in the landscape, even if technically classified as low impact, can have significant impacts on the income and socioeconomic stability of communities operating in this sector (De Carvalho Filho et al., 2022; Forastiero, 2024).

It is also important to consider that sensitivity to visual change can vary across groups of national and international tourists, influenced by cultural expectations, levels of information about the energy transition, and familiarity with renewable generation technologies (Devine-Wright, 2004; Ladenburg, 2010).

Thus, the installation of offshore wind turbines can be perceived as more intrusive than in higher-latitude scenarios, where climatic and aesthetic conditions differ, and tourism has a more diverse profile.

For the local fishing economy, especially for traditional communities that practice artisanal fishing, the impacts are complex. During the fixing and operation of the turbines, the restriction of areas for fishing can generate positive ecological impacts on the marine fauna component, however, this same restriction imposes access limits that influence the local economy, as it results in the loss of fishing territories, which can increase conflicts related to the use of marine space, in addition to directly affecting the livelihoods of these communities and impacting local income.

During the installation phase, vessels are temporarily excluded from the work areas. Also in this phase, the activities of moving vessels and installing offshore substations disturb sound-sensitive species. In the operation phase, restrictions on navigation and fishing in certain areas constitute a permanent loss of fishing space, which can be partially offset by the artificial reef effect of the foundations, thereby increasing the abundance of local marine fauna (Stelzenmüller et al., 2021).

In addition, fishing activity can damage submarine cables (Liao, 2023), which underscores the need for co-location strategies, including the development of fishing corridors, mariculture programs associated with project structures, and financial compensation mechanisms for affected fishing communities.

The impacts associated with the socio-cultural component, although less tangible, are of fundamental relevance to the sustainability of the projects. Community cohesion can be affected by polarization of opinions about the project. In contrast, transparent and participatory engagement of the local population tends to mitigate negative psychosocial impacts and reduce anxiety about the community's future (Mabon et al., 2017).

The concept of topophilia - emotional attachment to place (Tuan, 1980) - is of particular importance in coastal communities with a strong historical and cultural connection to the marine environment. During the operation of the wind turbines, the aesthetic changes in the seascape can affect local identity and sense of place, reduce perceived well-being, and require mitigation strategies that respect pre-existing cultural values and promote a positive re-signification of the project within the community context. In this sense, the consolidation of the "social license to operate" depends fundamentally on the proper management of these intangible aspects, including respect for local culture, minimization of intrusions into culturally sensitive sites, and provision of broad social benefits that contribute to collective well-being (Boutilier, 2017; Glasson et al., 2022).

The analysis of the social impacts of offshore wind farms requires specific methodological instruments, including the identification of affected groups, the quantification of distributive benefits and losses, and the continuous monitoring of socioeconomic and sociocultural indicators.

The implementation of strategies to maximize local benefits, mitigate negative impacts, and provide adequate compensation is essential to ensure that offshore energy development occurs in a socially responsible manner, contributing not only to renewable energy generation but also to strengthening the economic vitality and social resilience of affected communities. Neglect of social aspects can compromise project sustainability by exacerbating inequalities and community resistance, underscoring the need for integrated approaches that simultaneously consider the technical, environmental, and social dimensions of these highly complex projects.

Figure 5.3 illustrates some of these causal relationships associated with the activities, aspects, components, and impacts of offshore wind farms on the socio-economic environment.

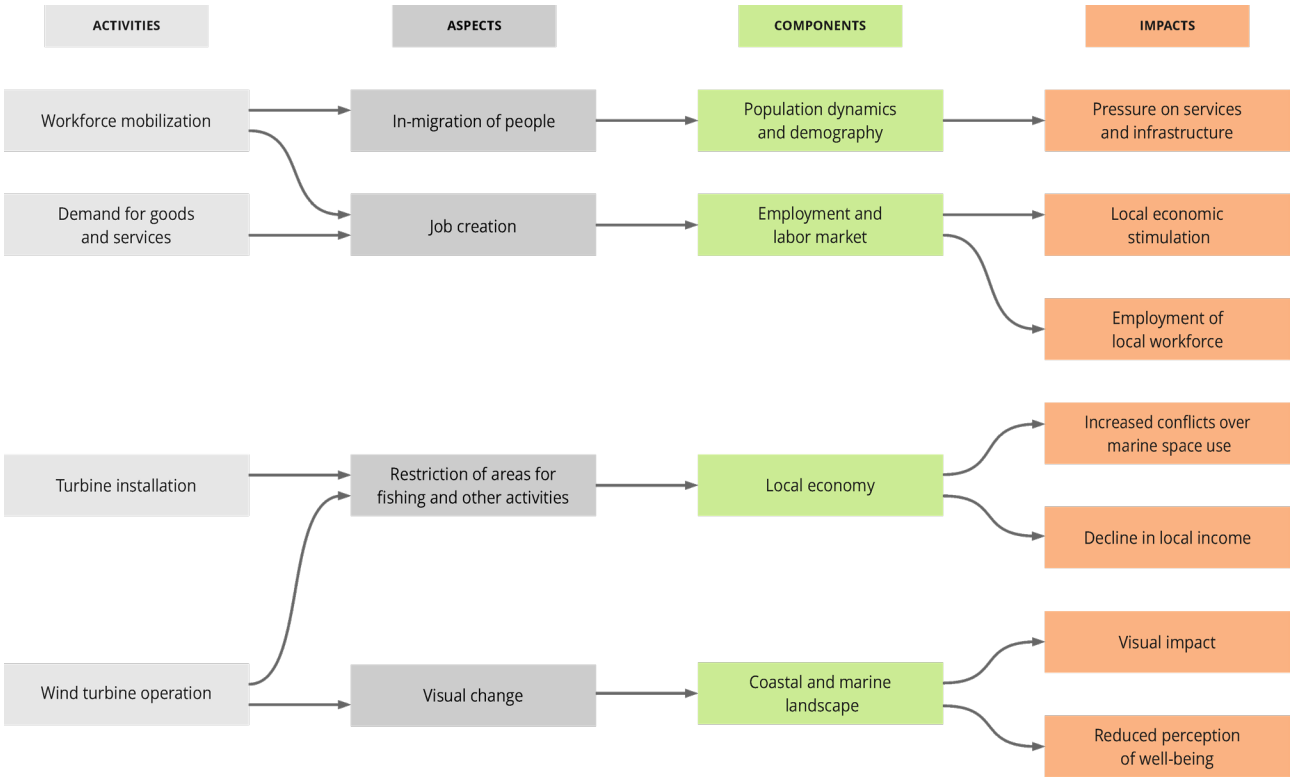


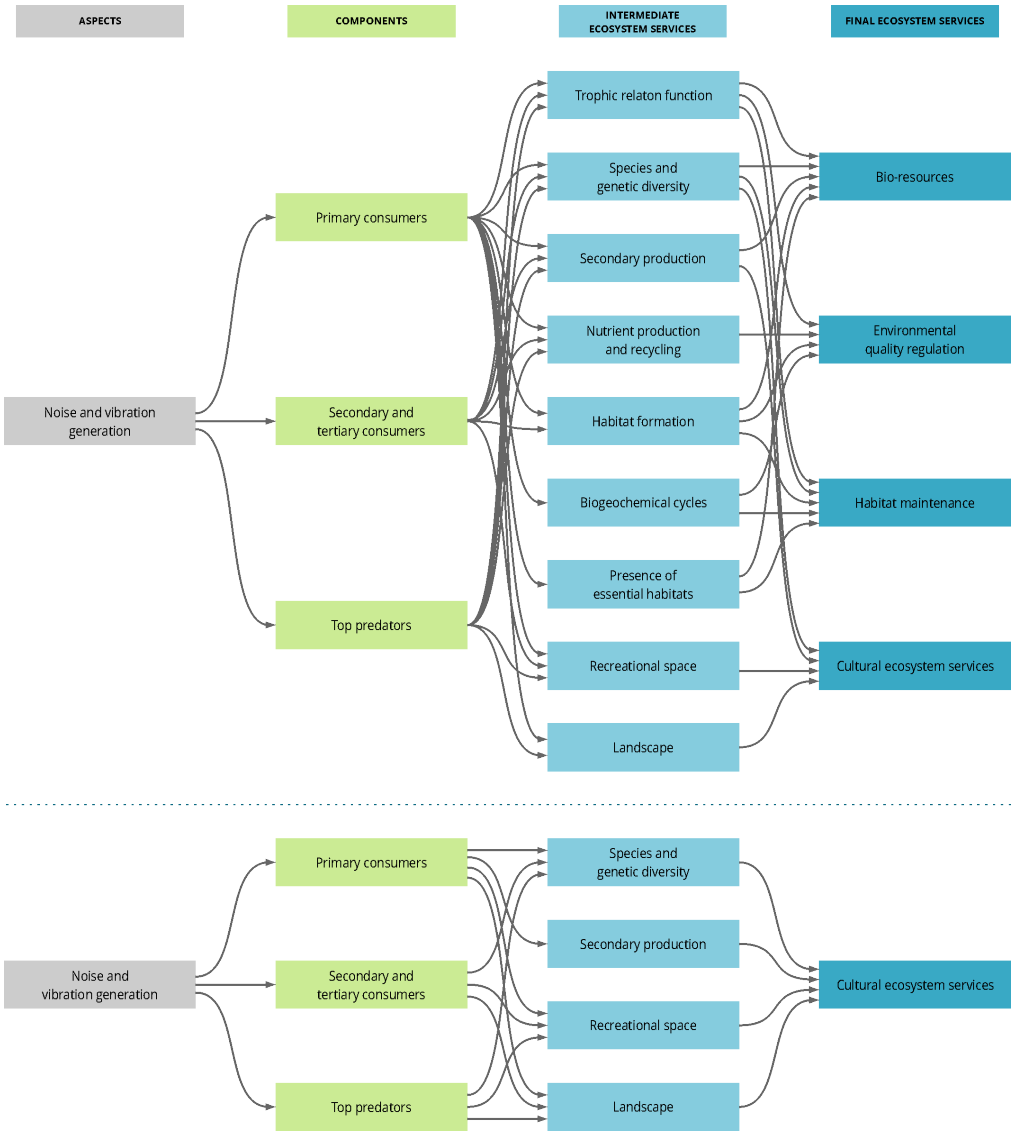
Figure 5.3. Example of a partial causal chain highlighting the main activities, aspects, components, and social impacts related to the installation and operation of offshore wind farms.

In the context of Ecosystem-Based Management, understanding social impacts arising from the causalities of human activities highlights the interdependence of socio-ecological systems. The actions, interests, and visions of different groups guide the management of natural resources. Still, they can also compromise ecosystems' capacity and, consequently, the meeting of communities' needs in coastal environments. Box 5.1 discusses and illustrates this causal relationship between ecosystem services and the generation of noise and vibration from offshore wind project activities.

Box 5.1. Causal relationships of Ecosystem Services

Understanding the causal relationships between offshore wind energy activities and Ecosystem Services (ES - see Box 1.1) is an additional step in integrating EBM into EIS. Accordingly, recent approaches have focused on incorporating the ES concept into key elements of EIS. In one such proposal, Baulaz et al. (2023) integrate causal chains with the ecosystem services cascade (Haines-Young, Potschin, 2018) to illustrate how impacts on specific system components (trophic compartments) affect functions (i.e., essential ecological processes) and, consequently, ES. With a focus on biodiversity, the approach provides a practical tool for more integrated environmental impact assessments that link biodiversity, ecological functioning, and human well-being, with strong potential to inform decision-making.

Below is an example of a causal chain for the ES related to noise and vibration generated during the construction phase of an offshore wind farm. It begins with (1) the identification of relevant aspects, based on activities previously examined in the causal chains presented in this chapter, and (2) the affected trophic components, illustrating (3) the interactions between these components and ecosystem functions and, consequently, (4) local ecosystem services. Even when focusing on a single aspect, the network of interactions highlights the complexity that such analysis can incorporate into EIA, including the consideration of cumulative impacts (Chapter 10).



Example of a partial causal chain highlighting functions (intermediate ecosystem services) and final ecosystem services affected by noise and vibration generated by various installation and operational activities of offshore wind farms, as described in previous chains. In the upper causal chain, arrows indicate possible interactions; in the lower chain, interactions are presented in a more linear manner, focusing on a single service category.

Adapted from Baulaz et al., 2023.

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RECOMMENDATIONS FOR ENVIRONMENTAL IMPACT ASSESSMENT OF OFFSHORE WIND PROJECTS



Chapter 6

SCOPING

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The preparation of an Environmental Impact Study (EIS) is preceded by a planning stage known as scoping, during which the boundaries and focus of the study are established. At this stage, the relevant information to be collected and analysed is identified, along with the main questions the EIS is expected to address. Careful scoping is essential to ensure an EIA focused on the issues most relevant to decision-making.

THIS CHAPTER:

1. What is Environmental Impact Assessment scoping?
2. Stakeholder engagement during scoping
3. Recommendations for defining the minimum content of an environmental impact study

6.1 What is Environmental Impact Assessment scoping?

Scoping is one of the strategic stages of EIA. Its main functions are to (1) direct the studies towards the relevant issues; (2) establish the boundaries and content of the studies to be carried out; (3) plan the baseline studies, including the surveys and data collection required; and (4) define the project alternatives to be assessed (Sánchez, 2020).

Accordingly, this stage addresses questions such as: What are the main potential impacts to be considered? What information is needed to characterize and assess these impacts? Are there any specific standards, guidelines, or procedures that should be taken into account? Which technological and/or locational alternatives should be considered? Who should participate in the EIA process, and how should that participation take place?

To answer these questions, it is necessary to consider the principle of proportionality, which establishes that EIA processes and outputs should involve the right level of effort, detail, data, and communication: neither less than what is necessary to support a well-informed decision and comply with legal requirements, nor more, to the point of becoming a lengthy, costly, difficult-to-understand document, that is more vulnerable to inconsistencies (IEMA, 2025). It is during scoping that many decisions are made about what is, or should be, necessary and sufficient in an EIA.

Box 6.1. Proportionality in project impact assessment

A few critical factors influence the appropriate application of the proportionality principle. Firstly, it is necessary to consider how advanced is regional, territorial, marine, environmental, and sectoral planning for the area of interest, as well as sectoral planning. In cases were strategic assessments, zoning, environmental sensitivity maps, public databases and monitoring systems already identify critical areas, existing or potential conflicts, priority environmental components or knowledge gaps, EIA scoping can be directed to those issues still in need of deeper analysis to inform decision-making. In such contexts, many resource-consuming and/or redundant surveys may be scoped out. However, when such a planning apparatus is absent, experience shows that EIA process at project-level tends to become broader and more detailed. Hence, the planning context (**Chapter 2**) should influence project EIA scoping, with more advanced and consolidated planning reducing the need for primary data collection and extensive analysis.

The second key factor is the accumulated experience in a certain sector or project type. As more projects of the same type are assessed, built, and monitored, it is easier to determine which impacts require detailed review, which can be managed by known mitigation measures, and which can be scoped out, where there is sufficient technical justification.

A 2025 review of 79 cases of EIA of offshore wind projects in the UK showed that experiential learning can support more focused scoping, clearer and more concise environmental impact statements and more consistent assessments. The study also highlights other elements that could ensure proportionality while maintaining technical quality, such as standard terms of reference, consistent use of terms, integration between assessment and follow-up and the use of digital tools and shared evidence bases. It should be noted, however, the experience gained in the UK practice is not available for most tropical marine environments.

Reference: OWEKH (2025). OWEKH Evidence Review Note: Environmental Impact Assessment. Available at: https://cms.owekh.com/media/Evidence%20Review%20Notes/2025%20OWEKH%20Evidence%20Review%20Note_Environmental%20Impact%20Assessment.pdf

Scoping may be supported by Terms of Reference (ToR) issued by the EIA authority. In other cases, it may be based on a document prepared by the project proponent, drawing on pre-established guidance and subject to review and validation by the EIA authority.

Practical experience shows that, even given the complexity of coastal and marine environments, public debate on large-scale projects such as offshore wind energy tends to concentrate on a limited number of key issues. These concerns often relate to impacts on sensitive marine biodiversity, such as coral reefs, kelp beds, and breeding areas for endangered species, as well as impacts on birds and artisanal fisheries, the latter often supporting traditional and vulnerable communities.

Scoping should therefore guide the preparation of studies capable of organising the collection and analysis of information that is relevant for decision-making, while recognising risks, local values, and conservation priorities. This also means recognising that not all potential impacts have the same importance (see **Chapter 5**), and that available technical and institutional resources should be directed towards issues of greater environmental, social, or economic significance.

Scoping is a strategic stage, as it identifies the key questions to be addressed in the studies and sets the level of detail needed to properly understand potential impacts.

In this sense, rather than simply listing a long set of studies to be carried out and indicators to be collected, scoping must ensure that appropriate evidence is generated to answer the key questions. In other words, effective scoping should lead to the preparation of an EIS that supports the determination of impact significance. The focus should be on answering key questions, rather than on presenting fragmented and merely descriptive results from individual studies. To achieve this, both the design of studies and the interpretation of impacts should consider causal links (**Chapter 5**) and the direct and indirect impacts arising from project activities, incorporating an understanding of the components and processes of the socio-ecological system and recognising the role of science in decision-making. In addition, scoping should require that uncertainties and knowledge gaps related to key issues are properly identified and communicated.

The clearer and more precisely defined the key issues are, the stronger the impact assessment will be. These questions may address environmental impacts (e.g. what reduction is expected in the abundance of individuals within a given bird population? What increase in organic enrichment is expected in the sediment, and over what area?) or social impacts (e.g. what reduction in income is expected in the fishing and tourism sectors?). Alternatively, they may integrate different types of impact and focus on the loss of ecosystem services (e.g. to what extent may food insecurity increase among fishing communities? What is the magnitude and spatial and temporal extent of any reduction in carbon capture and storage?).

To support this, it is essential to consider causal links and develop a representation of the socio-ecological system that enables the application of qualitative and quantitative predictive models, together with their associated uncertainties. This is a central aspect of incorporating Ecosystem-Based Management into EIA. Although the difficulties involved in applying such an approach are recognised, only real-world application will enable impact assessment professionals working for consulting firms, public authorities, and project proponents to learn in ways that strengthen and improve EIA practice.

Previous EIAs in the same sector, together with studies of the proposed project area, can play an important role in scoping by identifying potential impacts that warrant investigation and by highlighting the key questions to be addressed. Public policies and socio-environmental plans applicable to the affected area also provide important sources of information, including biodiversity conservation strategies (e.g. protected area management plans and regional plans for endangered species), as well as marine spatial planning and coastal management instruments (see **Chapter 2**). Technical guidance prepared by the EIA authority provides a further useful reference for scoping (**Box 6.2**).

Box 6.2. The importance of technical guidance documents

Even when scoping documents are detailed, they do not fully capture all the guidance needed to support the impact assessment process. EIA involves multiple disciplines, methods, and technical decisions, and many requirements depend on how studies are designed and carried out, as well as on the parameters adopted. For this reason, technical guides prepared by the EIA authority can play an essential role in clarifying objectives, methods, and expectations, thereby reducing ambiguity and increasing consistency and comparability across studies.

A well-known international example comes from Western Australia (Wood, 2003). In this system, EIA is structured around environmental factors defined in state legislation, and technical guides are issued for each factor. These guides provide definitions, explain relevant interrelationships between factors, identify the key questions that the EIS is expected to address, indicate how significance should be interpreted, and specify the technical information that the authority considers sufficient.

These guides are available at:
<www.epa.wa.gov.au/policy-and-guideline-type/environmental-factor-guideline>

In several jurisdictions, EIA authorities have expanded the production of technical guidance, publications, and regulations to support scoping and other stages of EIA.

Another example is Brazil:
<www.gov.br/ibama/pt-br/assuntos/laf/orientacoes-tecnicas/orientacoes-tecnicas>.

Indications of good practice for scoping, drawn from the technical and scientific literature, are presented in Table 6.1 and discussed in the following sections.

Table 6.1. Good practices for Environmental Impact Assessment scoping, organised according to its main purposes (categories).

Category	Good Practices
Provision of initial information	1. Summary of project aims, alternatives, and key technical characteristics
	2. Outline of the environmental and social context
	3. Identification of relevant government policies and legal requirements
	4. Identification of affected communities, relevant government agencies, and other stakeholders
Scoping determination	5. Review of alternatives
	6. Broad identification of key issues and potential impacts
	7. Preliminary assessment of the significance of potential impacts
	8. Narrowing of issues and impacts
	9. Definition of study boundaries (study areas, timelines, project components, and associated facilities)
Stakeholder involvement	10. Involvement of affected communities and the interested public
	11. Involvement of government agencies
Process management	12. Documentation of decisions concerning the scope definition
	13. Information sharing among stakeholders
	14. Monitoring and review of the scoping process
	15. Capacity building
	16. Preparation of guidance documents

Source: Borioni et al. (2017).

6.2 Stakeholder engagement and scoping

Public participation is essential for the effective incorporation of EBM into EIA (Chapter 3), as it helps shape the scope of the assessment and brings different perspectives and values into the process from the outset. Incorporating the concerns and priorities of potentially affected communities and other relevant stakeholders into the scope of environmental studies broadens understanding of the issues that matter to those affected and helps identify potentially important impacts that a purely technical approach might overlook.

By recognising the coexistence of different forms of knowledge and rationalities, both scientific and social, scoping becomes more legitimate and effective. It helps connect technical concerns with local values, while strengthening the quality, relevance, and acceptability of environmental studies. In this sense, it is widely recommended that the document defining the scope should be informed by the views of interested groups, made available for consultation, and revised to incorporate relevant contributions. This process can help reduce conflict and, consequently, shorten decision-making time (Veronez and Montaño, 2024).

Accordingly, principles and procedures that promote the engagement and participation of diverse interest groups may be included among the requirements for preparing environmental studies. These may include participatory workshops, targeted meetings, public hearings, and questionnaires, as discussed in Chapter 3.

Scoping may also include recommendations and requirements for the preparation of the non-technical summary, which is often submitted for public consultation during the technical review stage of the EIA. Guidance may be provided on the expected language and on alternative formats for communicating key EIS information. Examples include videos, interactive websites, social media, and virtual reality simulation tools.

6.3 Recommendations for defining the minimum content of an Environmental Impact Study

Environmental Impact Studies usually contain four main parts: (1) description of the project and its alternatives, (2) description of baseline conditions in the potentially affected environment, (3) impact analysis, and (4) measures required to avoid, reduce, or compensate for adverse impacts and to enhance positive ones. EIA must, of course, comply with the applicable legal requirements in each jurisdiction. This Guide focuses on technical content, which is not entirely determined by specific legal frameworks.

Guidance on cumulative impact assessment should also be provided (see Chapter 10). It is necessary to decide whether cumulative impacts will be addressed in a dedicated chapter of the EIS, integrated into the broader impact analysis, or dealt with through a regional-scale assessment; in the latter case, it may fall outside the scope of project-level EIA.

6.3.1 Description of the project and its alternatives

The description of an offshore wind project should include information such as installed capacity, number of wind turbines, total area, and location. It should also describe the planned phases, main activities, and implementation schedule. All associated facilities (Chapter 4), even if they are not constructed, operated, or owned by the project proponent, should be described.

It is also important to place the project within its sectoral and spatial planning context, in order to demonstrate its consistency with territorial and environmental planning instruments. It is recommended that the project's compatibility with plans, zoning instruments, standards, and strategic guidance be examined across different levels of government, from national to local. Scoping should require this analysis, as important information and relevant linkages may be identified (Chapter 2), and these may also be relevant to the assessment of cumulative impacts associated with the project under review (Chapter 10).

Comparative assessment of location and technology alternatives should also be required, using technical, environmental, and socioeconomic criteria. For example, alternatives may be examined in relation to turbine height, blade size, and especially spacing between turbines and between the wind farm and the coast. Alternative routes for the power transmission system and alternative locations for substations may also be considered. Timing alternatives may be relevant as well, for example to avoid breeding periods of sensitive species or periods that are culturally or economically important to traditional communities and local activities such as tourism.

It is considered good practice to require a comparison between implementation alternatives and the no-development scenario. This contributes to informed decision-making by reinforcing the importance of location, chosen technology, and consistency with existing planning as central elements of environmental analysis.

6.3.2 Description of baseline conditions in the potentially affected environment

With regard to data collection and baseline description, it is necessary to establish criteria that allow potentially significant impacts to be identified in advance, so that the themes, or key issues, to be addressed in the EIA can be defined, together with the appropriate level of detail. Three complementary approaches have proved useful in identifying relevant issues in EIA (Sánchez, 2020):

- **Importance of an environmental component or vulnerability of potentially affected communities.** Legal requirements are a fundamental criterion for selecting relevant issues, as they reflect social values recognized in national legal instruments and international treaties. Common examples include the protection of endangered species, sensitive ecosystems such as mangroves and coral reefs, cultural and archaeological assets, and restrictions on the use of terrestrial and marine areas located within protected areas. International conventions, such as the Ramsar Convention, the Convention on Biological Diversity, and the World Heritage Convention, reinforce these commitments.

- **Public opinion and local knowledge.** The views, concerns, and knowledge of affected communities should be considered through appropriate methods such as meetings, questionnaires, or written consultation, even where there is no legal requirement to do so. These contributions need to be interpreted and incorporated systematically by the technical team responsible for the study. In addition to providing insights, local knowledge, including knowledge of the environment, natural resources, and temporal dynamics, can substantially enrich scoping and support more contextualized and effective assessment.

- **Prior knowledge, including analysts' professional experience.** Documents produced by intergovernmental, non-governmental, or institutional organizations may provide useful guidance, such as the IUCN Red List of Threatened Species and the World Bank Group's Environmental, Health and Safety Guidelines. Scientific knowledge and civil society initiatives often help bring emerging themes to attention, such as the importance of carbon-storing ecosystems (e.g., peatlands and mangroves), whose protection is relevant to climate change mitigation. Climate change has also increasingly been addressed in studies, both in relation to greenhouse gas emissions generated by projects and in relation to impacts on carbon sinks and project vulnerability to climate change. It is also important to consider the knowledge generated through learning within EIA itself (Sánchez and Mitchell, 2017). In this sense, the experience of analysts, consultants, and communities can help define the scope of new projects on the basis of prior cases.

During scoping, decisions are made about the themes to be included in the EIA and the level of detail required for each of them. During implementation of the studies, however, it may become clear that the knowledge generated through data collection, baseline description, and impact prediction still involves important uncertainties. In such cases, certain actions should already have been anticipated during scoping (Box 6.3).

Box 6.3. Scoping in understudied regions: how to deal with knowledge gaps and uncertainties

- Require studies to be transparent about knowledge limitations and uncertainties associated with the information presented in the EIA, clarifying whether they result from methodological choices or from limitations in their application, and whether they are related to the quantity or quality of the available information.
- In cases where the occurrence of impacts is uncertain, it is recommended to require more robust baseline studies, while already calling for the development of more comprehensive monitoring measures in line with the recommendations of adaptive management (Moretto et al., 2021). These include studies designed to confirm, during project construction and operation, whether the impacts identified in the EIA are in fact occurring and whether the proposed measures are sufficient (see Chapter 11).
- Where knowledge gaps represent relevant scientific challenges, it may be recommended that the project proponent establish partnerships with research institutions or research funding agencies, with a view to promoting calls for applied research aligned with EIA needs in the region.

When compliance with these recommendations is later assessed in the studies submitted for the technical review stage of the EIA, the EIA authority will have a stronger basis for deciding whether additional studies should be requested. Based on the precautionary principle, uncertainties concerning significant adverse and irreversible impacts should be treated with particular attention, in order to assess whether the proposed adaptive management measures are compatible with the predicted residual impacts, and whether those impacts are acceptable.

Once potentially significant impacts and key issues have been defined, the scoping document should clearly indicate which environmental and social components need to be characterized and assessed in the EIS, as well as the expected level of detail, recommended methods, the spatial and temporal scales of analysis, and the rationale for the choice of methods.

The scoping document may also require that the criteria for including and excluding impacts from the analysis be made explicit and that impacts be presented through a causal chain (Chapter 5) clearly linked to the activities and aspects inherent to the project. In some cases, specific guidance is available on the impact statements to be adopted and on the structure of the causal chain model, as in some sectors in Brazil (IBAMA, 2026) and Colombia (ANLA, 2026), where efforts have advanced towards greater standardization.

6.3.3 Impact analysis

The scoping document should guide how the description of baseline conditions and the impact analysis are to be linked, making clear that baseline information must be sufficient to support the prediction and determination of impact significance (Duarte and Sánchez, 2020), particularly for residual impacts, and to answer the key questions identified during scoping. Further discussion of this topic is provided in Chapter 8 of this Guide.

6.3.4 Measures needed to avoid, reduce or compensate for adverse impacts and enhance positive impacts

With regard to the measures to be presented, scoping may set minimum expectations for their content. Good practice recommends making explicit how the mitigation hierarchy will be applied (Chapter 10) and specifying the minimum content of social and environmental management plans, based on models and standard requirements already used by the EIA authority. The set of measures and programmes defined should be sufficient to address the key questions associated with the significant impacts identified. Their design should also make explicit the parameters that will guide follow-up, as well as the contextual factors and assumptions adopted.

6.3.5 Conclusion of the Environmental Impact Study

The scoping document may require the EIS to include a concluding section that provides a clear synthesis of the project's environmental feasibility, prepared in light of the objectives of the study. Based on the description of baseline conditions and impact prediction, including cumulative impacts and the expected results of the proposed mitigation and compensation measures, the conclusion should explain the key elements for decision-making, making clear whether the analysis seeks only to determine the acceptability of residual impacts or to demonstrate an overall positive outcome. Feasibility should be presented as a reasoned judgement on the acceptability of residual impacts in light of the proposed benefits and measures. This reasoned judgement should include the uncertainties involved and be presented for consideration by the EIA authority, affected communities, other stakeholders, and decision-makers.

Learn more

For further guidance on scoping, see Borioni et al. (2017), IEMA (2025), and Sánchez (2020).

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Chapter 7

BASELINE

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The impacts of a project are evaluated in relation to a reference condition, generally understood as a description of the current conditions of the social and environmental components and processes that may be affected by the activities and aspects related to a project. This chapter explains the objective and importance of constructing a baseline – a reference condition for assessing impacts – as well as the main components to be addressed and the indicators to be generated at this stage for subsequent identification, prediction, evaluation, mitigation, and monitoring of impacts.

THIS CHAPTER:

1 Why develop a baseline?
2 How to select the components and indicators for the baseline?
3 How to define the spatio-temporal scale for the baseline?
4 Marine environment baseline
5 Coastal and terrestrial environments baseline
6 Social baseline

7.1 Why develop a baseline?

One of the central objectives of establishing a baseline is to characterize the study area, which may be directly or indirectly affected by the project, considering environmental and social components vulnerable to the potential impacts of offshore wind projects. It includes understanding which ecosystems, habitats, species, human communities, and socioeconomic and cultural activities may be affected by a new project, providing relevant information about the sensitivity of these components to the expected impacts.

The baseline is not limited to a description of the current state, but it should also provide an understanding of the dynamics and functioning of the socio-ecological systems that may be affected by the project, knowledge that expands the capacity to identify and analyze impacts from the Ecosystem-Based Management (EBM) perspective. Priority components can be identified and some of them selected for monitoring before and during the construction and operation phases of the project. Thus, the objective is creating a baseline for these components (Brooks et al., 2018; Laurino et al., 2025).

The **baseline** is the reference condition (before the start of the project's construction) for environmental and social aspects, which can later be used as indicators of impacts throughout the monitoring stage (Chapter 11). This reference condition is also fundamental for prognosis, i.e., predicting impacts, and for determining their significance (Chapter 8). In other words, the preparation of the baseline is a fundamental step that underpins the entire EIA process.

This central role underscores the importance of valuing a targeted approach, to avoid spending resources on baseline data collection that contribute little (or nothing) to the impact analysis and subsequent follow-up (Wilding et al., 2017). In this sense, under the EBM vision (Chapter 1), a focused baseline considers the effective survey of the reference condition of components and indicators, establishes clear cause-and-effect relationships with the project, and is dedicated to answering the key questions that the Environmental Impact Study must address. From this information, it is possible to record changes in the values measured at baseline during the follow-up stage and assess whether the impact assessment was accurate and whether the mitigation measures were appropriate (Laurino et al., 2025).

The baseline should not be an exhaustive collection of multiple compartmentalized information, but rather a characterization focused on components and indicators that have a recognized meaning within the project's causal chain.

7.2 How to select the components and indicators for the baseline?

As it is neither practical nor necessary to measure all parameters of all environmental and social components of a given target site in the baseline, criteria must be used to select priority components and indicators (Stephenson, 2021). To define criteria for selecting components, it is necessary to consider their ecological, social, or economic importance, as well as legal aspects, traditional knowledge, public opinion, and previous experiences (see Chapter 6).

> **What are components and indicators?**
> Environmental and social components in the baseline can be different physical attributes of the environment, biota groups, particular species, habitats, specific activities, fishing communities or any other socio-environmental attribute that will have parameters measured during the preparation of the baseline. The so-called indicators, on the other hand, are the specific parameters that will be measured and subsequently monitored for each component, such as, for example, the abundance of a target species, the extent of a habitat, or the frequency of occurrence of a cultural activity in the area (Laurino *et al.*, 2025).

However, in addition to considering these issues, the central basis for defining priorities should be the project's causal chain of impacts (Chapter 5), which should be built in the scoping phase (Chapter 6), before starting the collection of secondary information and the fieldwork for the collection of primary data. The engagement of local actors in this discussion of priority components and their perceptions of these components' vulnerability to the project are important steps in this process (Chapters 3 and 6). Obtaining and analyzing secondary data on the multiple socio-environmental attributes of the study area is also necessary to understand the main local components and their roles within the causal chain expected for the project. Fieldwork to obtain primary data on the different components is also essential, especially for those with severe local gaps (lack of secondary data) and/or high importance for predicting impacts and understanding causal processes.

The importance of the causal chain for defining baseline priorities is justified by its function as an ecosystem conceptual model that reflects the nexus between the activities and environmental aspects (i.e., pressures) of the project and the components affected. This approach brings data collection closer to the EBM perspective by considering the complexity of the socio-ecological system (Chapter 1). From it, it is possible to identify which socio-environmental attributes are receptors of the different expected impacts and, thus, should be selected or prioritized as components of the baseline. Likewise, the causal chain highlights which specific, measurable parameters of each component may vary due to project activities and aspects, signaling potential indicators for baseline and monitoring. Connections among components and parameters can also be identified within the causal chain, facilitating the selection of indicators that reflect cascading causal processes (Wang et al., 2024).

Such process-based causality indicators, in turn, are highly useful for describing the affected environment, as they enable a holistic and integrated understanding of the flow of change within the socio-ecological system in which the project is embedded. After understanding the different cause-and-effect processes, the relationships among components, and the socio-ecological significance of the indicators (adherence to key questions), future monitoring can focus on one or a few parameters that comprehensively represent each process. Figure 7.1 illustrates how the causal chain nexus can help identify such indicators in benthic components, which can be measured in the baseline and used for monitoring in the future. This holistic indicator approach is essential to bringing impact analysis closer to the principles of EBM (Chapter 1), as it considers key connections among multiple components and fosters interdisciplinarity in process evaluation (Laurino et al., 2025).

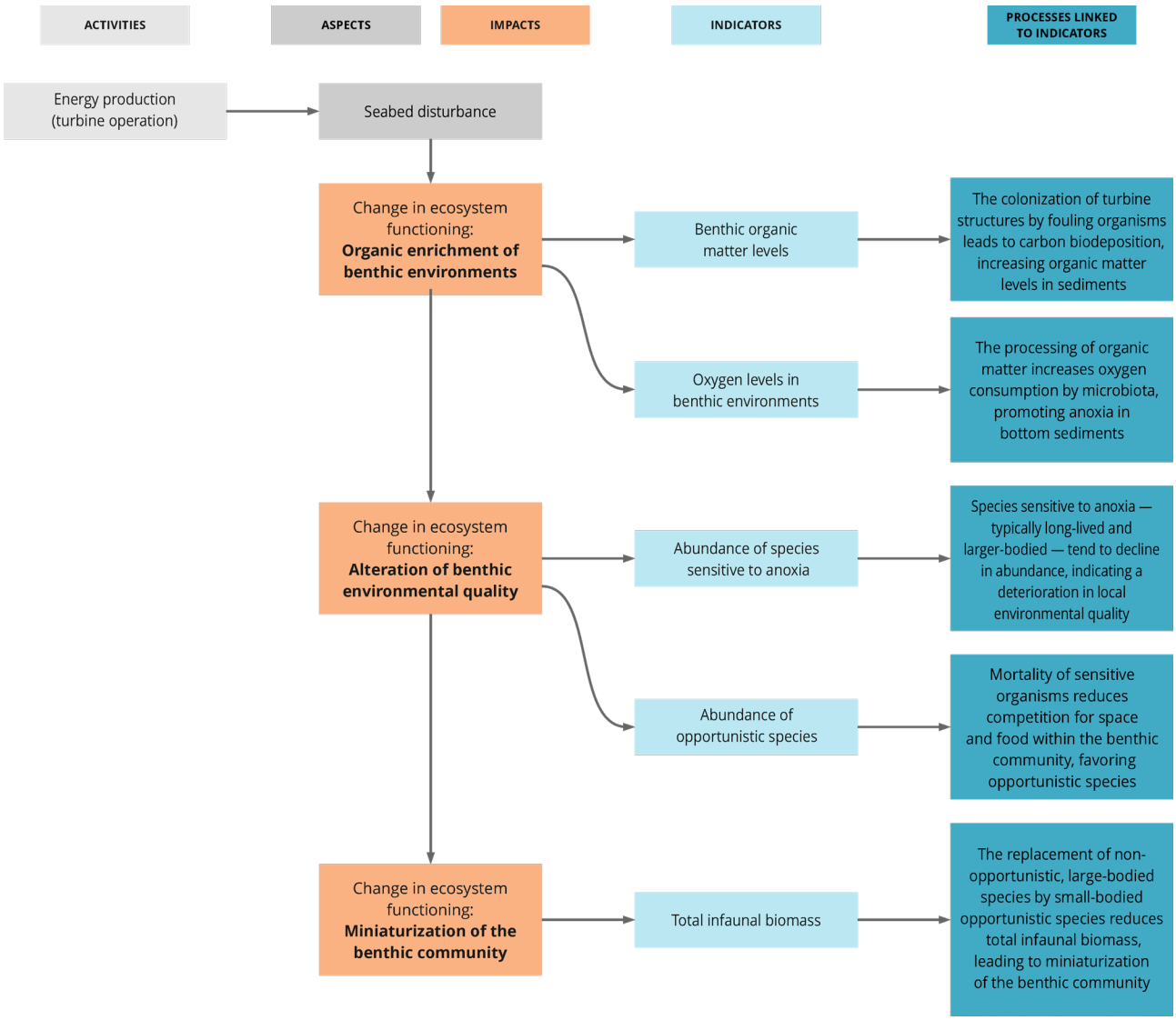


Figure 7.1. Scheme exemplifying how the causal chain evidences the main indicators to be produced in the baseline, seeking to prioritize parameters that are more appropriate for understanding the causal process. In this case, the figure illustrates the process of organic enrichment in the benthic environment and alteration of local environmental quality that can occur in the substrate around offshore wind turbines in operation (see Lu et al., 2020).

7.3 How to define the spatio-temporal scale for the baseline?

Simultaneously with the definition of priority components and indicators, it is necessary to define the spatial limits of the area to be considered for the collection of baseline data (spatial scale). Although the direct and indirect areas of influence of the project can only be definitively understood after the impact analysis, it is important to establish a study area that encompasses the spatial limits that reasonably anticipate the range of influence of the future wind farm. Such limits depend, in principle, on the characteristics and dimensions of the project, such as distance from the coast, the number of turbines and their model (fixed or floating), the length and quantity of transmission cables, and the characteristics of the offshore and onshore substations, among other issues. However, for certain components, the collection of information restricted to these potential areas of project influence may not provide an appropriate (representative) view of the baseline and, consequently, setting the basis for future monitoring (Stephenson, 2021).

For example, the presence of the project can trigger the "**barrier effect**" (Chapter 5) and modify the routes of organisms such as mammals, turtles, birds, and fish. Such modifications can only be fully understood if reference values for these complete routes are obtained during the baseline, which will often need to encompass locations considerably farther from the project.

Thus, understanding the scale of the socio-ecological processes in which the selected components are involved is fundamental for defining the study area, which includes the extent of the selected habitats, the potential home ranges of the prioritized organisms, and the distribution of the activities of target traditional communities. In addition, characterizing areas that may remain under low or no influence after the start of project construction is important for determining the reference areas (control areas) for future monitoring (see Chapter 11 for more details on control areas).

The study area for the baseline is usually larger than the area of influence of the project. It is important that data collection be conducted on a spatial scale commensurate with the scale of the socio-ecological processes under analysis, which usually extrapolates the project's area of influence. Also remember that, in order to create references for monitoring, it is important that the study area includes sites without the influence of the project, which in the future can be used as control areas (see Chapter 11).

In addition to spatial coverage, the duration of sampling should also be appropriately defined for a robust baseline. Socio-ecological processes are not static; few components and indicators can be effectively characterized in a single collection ("photographic sampling"). Most prioritized components require multiple observations to effectively characterize their dynamics. This is critical for future monitoring to differentiate current component variations, including natural variations and those caused by other existing pressures (such as climate change - see **Box 7.1**), from those that the project will cause.

For example, many species exhibit natural seasonal variations in abundance. If these species are sampled only in one season of the year that happens to be the season of low abundance, the baseline indicators will be underestimated. Likewise, species dynamics can vary from year to year, due to phenomena such as El Niño. Thus, the ideal is that the time scale encompasses more than one year of sampling, with collections across all seasons, to capture the current dynamics of the processes involving multiple components (Methratta, 2024). It should be noted, however, that the level of detail and the range of the scale, both temporal and spatial, must be conditioned by the level of uncertainty relevant to decision-making, avoiding unnecessary delays in the environmental licensing process.

If the baseline is being made for an analysis of cumulative impacts (see Chapter 10), the timescale should be expanded to multiple years in order to understand the changing condition of the selected components over the years, prior to the arrival of the new wind farm. Especially in these cases, it is essential to prepare a retrospective analysis of the components, evaluating the temporal dynamics of their relationships with the natural environment and with the pressures of the past and present in the study area

Different components exhibit different dynamics in space and time, implying the need for different sampling scales for each one. However, multiple connections among the components of a socio-ecological system mean that variation in one component can propagate and affect other components. In these cases, the spatio-temporal scales adopted for the different components must be as closely matched as possible to enable an integrated baseline (Stephenson, 2021).

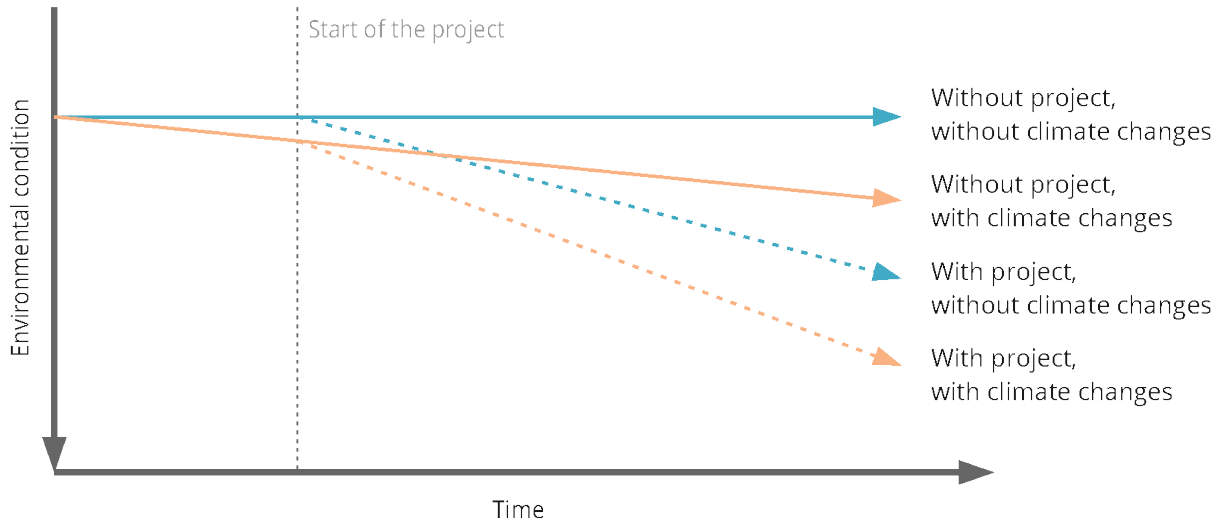
An alteration in the physical environment, for example, can lead to changes in the biota that generate socio-economic consequences. This cascade of events can only be observed if the physical, biotic, and socioeconomic indicators involved are measured on the same scales at baseline, as well as at impact prediction and follow-up. For example, it will be difficult to link impacts on fish to impacts on fishing if the indicators for these two components are measured in different locations and times. Therefore, the collection of information must be as integrated as possible in space and time to clarify existing connections.

Box 7.1. Climate change and baseline evolution

Climate change is one of the major drivers of pressure and impacts on biodiversity and other components of ecological and social systems (IPBES, 2019; IPCC, 2023). Therefore, a robust impact assessment should explicitly consider climate change as a driver of environmental change and account for its effects on environmental components that may also be affected by the proposed project (Byer et al., 2018; EU Directive 2014/52/EU; Sparling et al., 2017).

From an Ecosystem-Based Management perspective, climate change highlights the dynamic nature of the socio-ecological systems within which projects are developed. In other words, the environmental baseline should not be regarded as static; rather, its evolution under different climate scenarios needs to be understood (Byer et al., 2018; EC, 2013). The future baseline represents the expected environmental trends or conditions in the absence of the project. It describes how sensitive environmental components may evolve under different climate change scenarios, providing the reference against which project-related effects will accumulate (Figure) (Byer et al., 2009; Sparling et al., 2017; IEMA, 2020; EC, 2013; see also **Chapter 10** – Cumulative Impacts).

Retrospective analyses that incorporate climate change and other additional pressures are also recommended to improve understanding of ecosystem dynamics and support the prediction of cumulative impacts (Laurino et al., 2025). It is important that the uncertainties associated with climate projections and their potential effects are explicitly recognized within the EIA process, thereby supporting adaptive management in the face of the challenges and the need for continuous adjustments and refinements to decision-making and adaptation strategies (EC, 2013; Sparling et al., 2017).



Source: adapted from Byer; Lalani; Yeomans, 2009

7.4 Marine environment baseline

The selection of priority components for marine environment baseline primarily considers habitats and biological groups vulnerable to the construction and operation of offshore structures, such as turbines, transmission cables, and substations.

Thus, among the most important components for describing the marine environment (Figure 7.2), the water column, the planktonic community (plankton), the benthic community and habitats (benthos, including sediments and reefs), and the nektonic community (nekton) stand out.

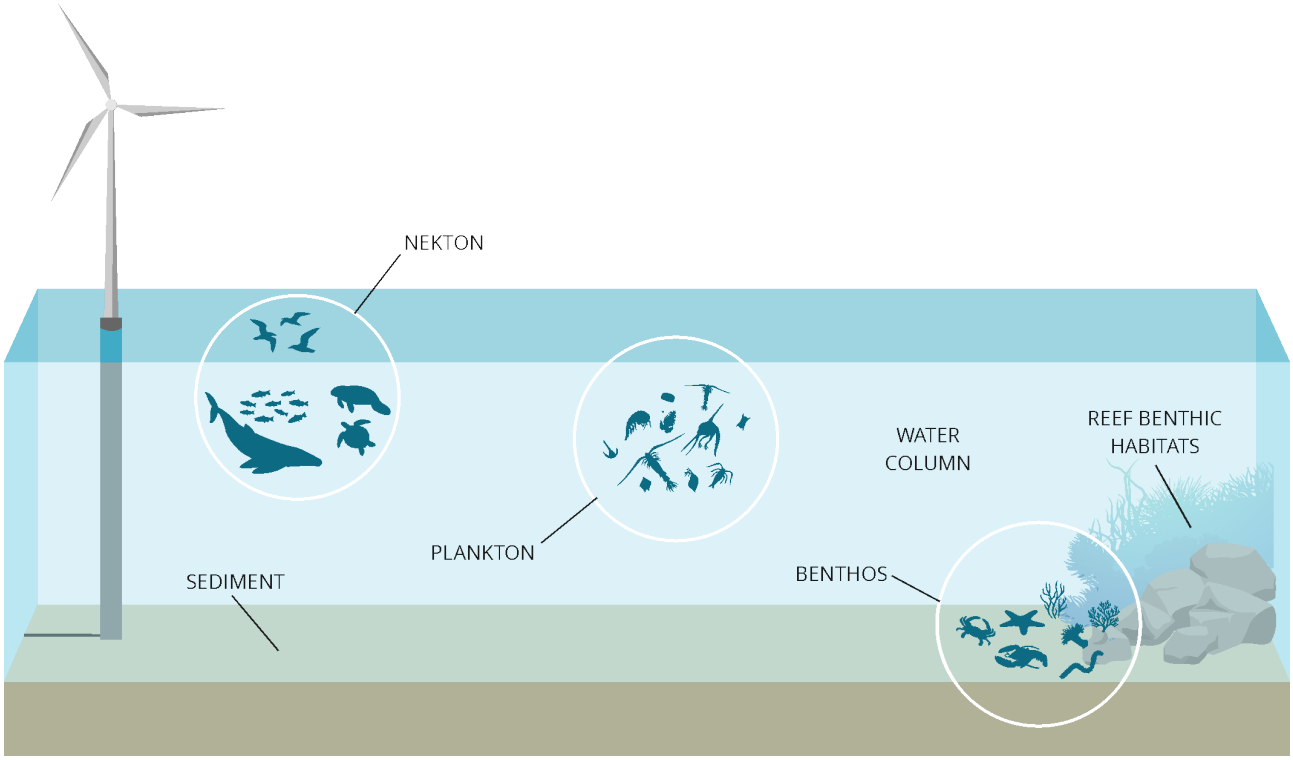


Figure 7.2. Main components of the marine environment that may be affected by offshore wind farms.

Table 7.1 synthesizes these components and recommends priority indicators, which will be discussed in the following subtopics. The table also provides preliminary predictions of the possible responses these indicators will exhibit to the impacts of an offshore wind farm, as shown in the causal chain (Chapter 5).

Table 7.1. Synthesis of the main components and indicators to be considered for the marine environment baseline, highlighting the expected responses (preliminary predictions) for each indicator to the impacts of offshore wind farms.

Priority components	Priority indicators	Preliminary predictions of the main expected responses
Water column	Water turbidity levels	Increase due to sediment resuspension
	Velocity of bottom currents or grain size of bottom sediment (particle size)	Increase or decrease depending on hydrodynamic changes in the operation phase
Planktonic community	Total biomass of phytoplankton	Decrease at installation due to increased turbidity. It can increase with nutrient resuspension and organic enrichment, especially in operation
	Total zooplankton biomass	Vary as a trophic consequence of changes in phytoplankton
Benthic habitats	Organic matter levels in the sediment	Increase due to benthic organic enrichment
	Oxygen levels on the seabed	Decrease due to benthic organic enrichment
Benthic community	Species richness	Increase due to the attraction of reef species, but can decrease if the loss of species from sedimentary environments and oxygen depletion is high
	Abundance of infaunal opportunists	Increase with the degradation of the seabed and the organic enrichment of sediments (when anoxia occurs)
	Abundance of infaunal non-opportunists	Decrease with the degradation of the seabed and the organic enrichment of sediments (when anoxia occurs)
	Total biomass of infauna	Decrease with the replacement of non-opportunistic species by opportunistic species
	Abundance of epibenthic invertebrates and fishes from unconsolidated substrates (sediments)	Decrease due to the replacement of sedimentary (unconsolidated) environments by artificial (consolidated) reef environments
	Abundance of epibenthic invertebrates and fishes from consolidated substrates (reefs)	Increase due to the replacement of sedimentary (unconsolidated) environments by artificial (consolidated) reef environments
	Ratio of non-native/native species in the surrounding habitats	Increase due to the potential colonization and dispersal of exotic species in the new artificial habitats
Nektonic community	Abundance of fish, turtles, mammals, and seabirds	Increase due to the reef effect and the refuge effect
	Fish biomass	Increase due to the reef effect and the refuge effect
	Species richness	Increase due to the reef effect and the refuge effect
	Habitat use	Vary (avoidance or attraction) with species-dependent responses
Nektonic and benthic community	Abundance of noise-sensitive species	Decrease due to the increase in underwater noise
	Behavior of noise-sensitive species	Vary with species-dependent responses
	Behavior of species sensitive to electromagnetic fields	Vary with species-dependent responses

7.4.1 Water column and plankton

The water column and the planktonic community (phytoplankton and zooplankton) are important components of the marine environment. Changes in the water column resulting from the resuspension of sediments during construction activities require characterizing water physical parameters, such as turbidity, which tends to increase. The increase in turbidity, in turn, tends to reduce the light penetrability of the water column, affecting phytoplankton and, consequently, local primary productivity.

An important parameter to be characterized, which will later serve as an indicator of this impact, is the local phytoplankton biomass. Understanding the reference values for this parameter before the start of installation is essential, as during follow-up monitoring, reduction in phytoplankton biomass can indicate high sediment resuspension, with impacts on light penetration and local primary production (Wang et al., 2024).

It is worth mentioning that the resuspension of sediments and the consequent increase in water turbidity are not exclusive impacts of the construction phase and may also occur during the project's operation, because the physical presence of the turbines alters local hydrodynamics, potentially increasing water - and sediment - transport rates in the water column. Thus, hydrodynamic indicators, such as local current velocity and bottom sediment granulometry, should be characterized in the baseline. Sediment granulometry, in particular, is a parameter that provides evidence of erosion (an increase in average grain size) and deposition (a decrease in average grain size) resulting from hydrodynamic changes.

The characterization of phytoplankton biomass is also an important indicator for the operation phase, since, in addition to hydrodynamic changes, benthic organic enrichment can affect primary productivity and local oxygen levels (Daewel et al., 2022). The increased nutrient flow due to sediment resuspension and fouling communities in turbines also tends to influence phytoplankton and primary productivity.

Given that phytoplankton is the base of the marine food web, impacts on these components are expected to be reflected at higher trophic levels. In this way, the biomass of zooplankton, the main primary consumers of the water column, is another important indicator, capable of detecting possible cascading effects along the trophic web (Wang et al., 2019).

7.4.2 Benthic organisms and habitats

Benthic organisms (invertebrates and demersal fishes) and their habitats are among the main components to be considered in offshore wind farm projects. A first objective of describing the benthic component is to map the different local habitats to identify those sensitive to the construction and operation of an offshore wind farm. This includes habitats such as coral reefs and rhodolith beds (Figure 7.3). Such mapping can inform decisions about the project's location, aiming to avoid overlapping areas or areas near these habitats. In addition, the baseline should capture reference conditions for the composition of the benthic community in the selected area, listing appropriate indicators to evidence the changes predicted to occur after the beginning of the project.

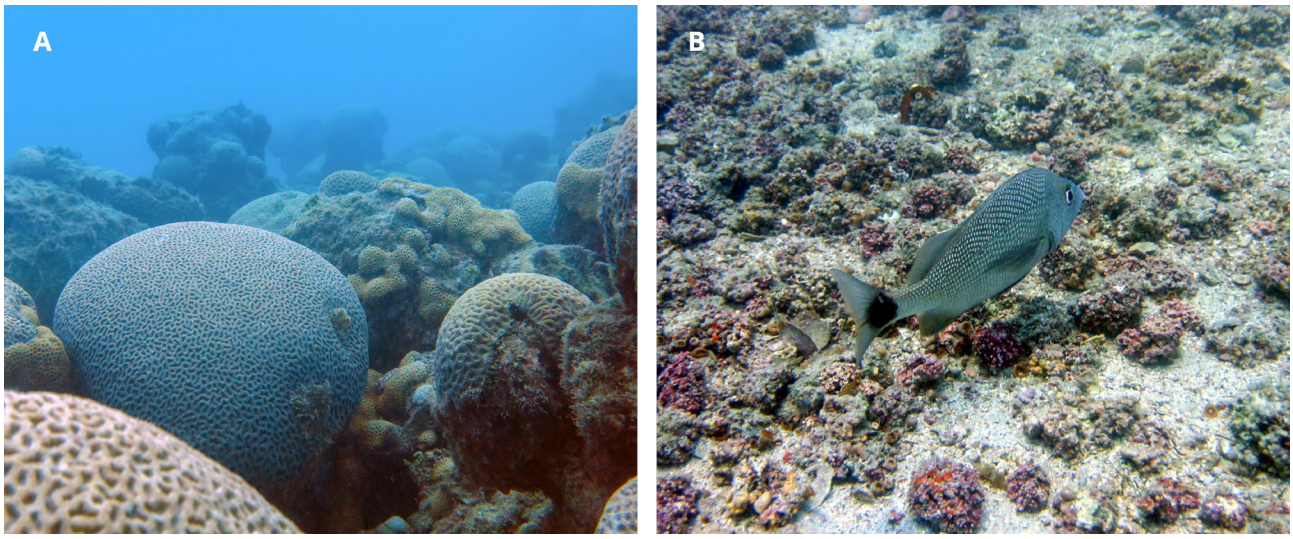


Figure 7.3. Examples of tropical benthic habitats, priority for establishing the baseline of the marine environment in offshore wind farm projects. A: coral reef, with emphasis on the brain coral, family Mussidae (source: Wikimedia Commons). B: Rhodolith bed (photo by Rosana Rocha)

It is known that the construction of offshore wind farms causes severe seabed disturbances, leading to habitat destruction and the mortality of organisms. The project also introduces artificial habitats into the environment that persist throughout the operational phase, which can significantly alter the functioning of the benthic system.

The colonization of fouling species in these artificial habitats alters the flow of local carbon and oxygen, enriches the surrounding sediments with organic matter, and attracts organisms with greater mobility, such as crustaceans and fish typical of reef environments (Griffin et al., 2016; Dannheim et al., 2020). As a result, the benthic community tends to change its composition. It may be dominated by infaunal invertebrates adapted to higher levels of organic matter in the sediment and reef epibenthic species.

In this context, the local richness of benthic species stands out as one of the main indicators to use, as it can inform whether, in general, there was a loss or gain in benthic biodiversity with the arrival of the project.

The abundance of organisms can also be a useful indicator; however, as some organisms tend to decrease in abundance while others tend to increase, assessing the total abundance of the community provides little information about the impacts. On the other hand, the abundance weighted by ecological groups related to the life history and functions of different species tends to be quite informative.

For example, the degradation of the seabed and the organic enrichment of sediments, especially when associated with local anoxia, favor the replacement of long-lived infaunal species with large body size by opportunistic infaunal species (small, short-lived organisms). In this sense, characterizing the total abundance of opportunists and non-opportunists at baseline is essential to evidence these changes in future monitoring.

Additionally, the community's total biomass stands out as an important indicator, as it can evidence a process of "miniaturization" (Lu et al., 2020) due to the replacement of large organisms (high biomass) with small ones (low biomass).

Similarly, epibenthic invertebrates and fishes from sedimentary environments (unconsolidated substrates) tend to be replaced by reef species (from consolidated substrates). This change can be evidenced by using the abundance of these distinct groups as indicators during baseline and, subsequently, in monitoring (Griffin et al., 2016). In addition, non-native species can proliferate due to vessel traffic and the creation of new habitats. The presence of such species in the area and their relative proportions among native species in the surrounding natural habitats should be identified in the baseline.

In tropical regions, such as the Brazilian coast, artificial structures have stood out as a determinant vector of proliferation of several non-native species, including the Sun Coral (see **Box 7.2**) and other representatives of groups such as bryozoans and sea squirts (Soares et al., 2022; Martinez et al., 2026). This demonstrates the crucial need to map such species in the vicinity of a future project, to generate predictions about the potential contribution of the artificial structures to be installed to the proliferation of non-native species in natural habitats.

The joint analysis of all these indicators can signal the reference condition for benthic community composition and the ecological quality of their habitats, especially when combined with measurements and predictions of changes in physico-chemical indicators, such as granulometry and the levels of organic matter and oxygen in the sediments. It is worth noting that many crustaceans, mollusks, and benthic fish are sensitive to noise pollution.

Hence, the presence and abundance of these groups (i.e., sensitive to noise) are also important indicators to be characterized in the baseline, together with the evaluation of noise levels. Various techniques for sampling the benthic environment can be useful for measuring such indicators, both for baseline and monitoring. These include the use of bottom sediment samplers (such as dredging and seabed filming), as well as scuba diving with trawls to collect fish and epibenthic invertebrates (see **Chapter 11** for more detail on sampling techniques).

Box 7.2. The proliferation of non-native species is a central concern in tropical and subtropical regions: the case of Sun Coral

Tropical marine ecosystems are usually a favorable environment for the proliferation of non-native species. In the Southwestern Atlantic, the invasion by Sun Coral (genus *Tubastraea*) has severely impacted natural reefs in the region. The introduction of offshore wind farm structures into the marine environment tends to create new artificial habitats, which can intensify the colonization and proliferation of this invasive coral.

The local increase in the flow of vessels during the installation and operation of wind farms will also contribute to this problem, considering that ships are the main vectors for the entry of these invasive species into a new area. As warm environments are conducive to the Sun Coral, it is feasible that, especially in Brazil, these invaders are among the main colonizers of the submerged portions of the wind turbines to be installed.



This situation may be aggravated by the current climate change scenario, with the increase in the intensity of heat waves in the region. These weather events promote bleaching and mortality of native corals, facilitating the invasion of reefs by Sun Coral. Understanding the potential for colonization and dispersion of this and other non-native species in the areas planned for the installation and operation of offshore wind farms is essential to prevent new projects from aggravating the problem.

Photo: Wikimedia Commons.

7.4.3 Nektonic organisms

Nektonic organisms play a crucial role in providing essential ecosystem services, such as food security and the economic stability of human populations, through fisheries resources. These organisms also contribute to nutrient cycling, which is fundamental for maintaining the health of marine ecosystems and climate regulation (Hooper et al., 2017).

Additionally, many of these species are of great importance for observation tourism, generating economic benefits and favoring the conservation of marine biodiversity. Thus, the inclusion of nektonic organisms as priority components of the baseline of offshore wind farm projects is essential, not only to maintain these ecosystem services but also for long-term conservation.

Different activities carried out during the construction and operation phases of offshore wind farms can affect nektonic organisms. The so-called reef effect promoted by the installed artificial structures tends to increase biodiversity in their surroundings, attracting a variety of nektonic organisms, such as fish, turtles, sea birds, and marine mammals (Figure 7.4). Fishing bans in the surrounding area lead to the creation of refuges and enhances this effect, but also increases the risk of being run over by maintenance vessels.



Figure 7.4. Examples of tropical nektonic organisms, priority for marine environment baseline in offshore wind farm projects. A) Green turtle (*Chelonia mydas*); B) Manatee (*Trichechus manatus*); C) Humpback whale (*Megaptera novaeangliae*); D) Spinner dolphin (*Stenella longirostris*); E) Atlantic yellow-billed albatross (*Thalassarche chlororhynchos*); F) Tuna (genus *Thunnus*). (Wikimedia Commons).

During the construction phase, underwater noise can disrupt the communication and behavior of marine mammals, leading to changes in home range, while electromagnetic fields from transmission cables, in the operational phase, can affect the orientation of turtles, sharks, and rays.

Anchoring systems, in turn, increase the risk of entanglement, and some pelagic birds, attracted by the food supply, face the risk of collision with the turbines. In addition, other species avoid the parks, moving to suboptimal habitats, which compromises their productivity and survival.

In view of these possible impacts, it is essential that the baseline include these nektonic organisms as priority components and be guided by key indicators to monitor the changes resulting from the project. This includes understanding the species' life history, habitat use, behavior patterns, and the levels of underwater noise to which they are exposed.

The life history of species and understanding of habitat use provide a deep understanding of the critical stages of development and reproduction, helping identify changes that may compromise survival.

Underwater noise, in turn, can directly affect feeding, reproduction, vocalization, and migration, impairing interactions between organisms and their environment (Wright et al., 2020).

For sea birds, flight height is a crucial indicator, as it can evidence the impacts of wind farms on their migratory routes and behaviors (Cleasby et al., 2015). The measurement of these indicators, both for baseline and monitoring, can be done via direct observation in the field or with advanced techniques such as satellite tracking, acoustic monitoring, and environmental DNA surveys of species (see **Chapter 11** for more detail on sampling techniques).

7.5. Coastal and terrestrial environments baseline

Offshore wind farms generate impacts that extend beyond the marine environment, also affecting coastal and terrestrial ecosystems. Thus, the selection of priority components should also include components related to these environments and their biodiversity, considering mainly the habitats and biological groups vulnerable to the construction and operation activities of onshore structures, such as transmission cables and power substations, as well as the impacts induced by construction activities and the increase in energy availability.

Among the most important components for coastal and terrestrial environments (Figure 7.5), coastal habitats, coastal flora, terrestrial vertebrates, and flying vertebrates stand out.

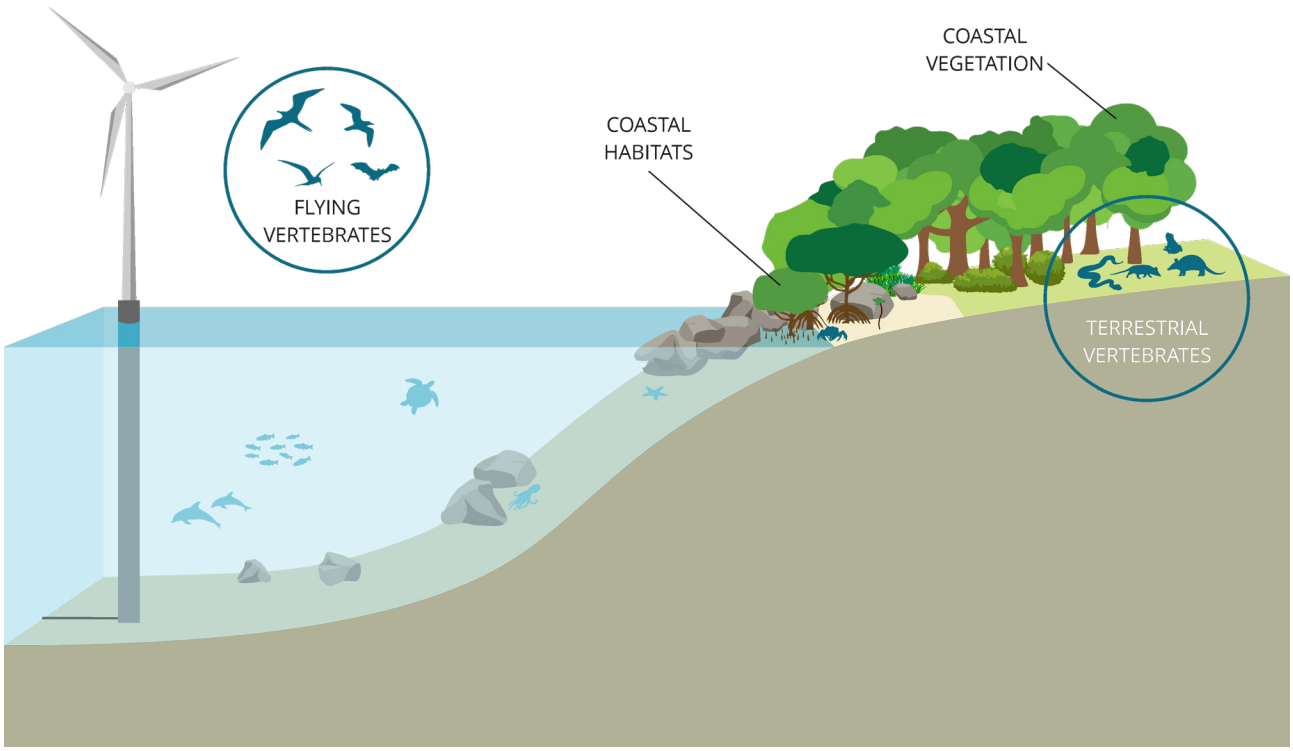


Figure 7.5. Main components of the coastal and terrestrial environment that may be affected by offshore wind farms.

Table 7.2 provides a synthesis of these components and their main indicators for consideration in the baseline, which will be discussed in the following subtopics. The table also provides preliminary predictions of the possible responses these indicators will exhibit to the project's impacts, identified during the elaboration of the causal chain (Chapter 5).

Table 7.2. Main components of the coastal and terrestrial environment that may be affected by offshore wind farms.

Componentes prioritários	Priority indicators	Preliminary predictions of the main expected responses
Coastal habitats	Grain size of sediments on sandy beaches	Increase (erosion) or decrease (deposition) due to the presence of onshore structures
	Slope of the beach profile	Increase (erosion) or decrease (deposition) due to the presence of onshore structures
	Diversity of benthic communities on beaches, rocky shores, and mangroves	Reduce due to the change in the ecosystem
Coastal flora	Total biomass	Reduce locally due to clearing
	Species richness	Reduce locally due to clearing
Terrestrial vertebrates	Abundance of mammals, reptiles, and amphibians	Decrease due to habitat loss and fragmentation
Terrestrial and flying vertebrates	Species richness	Decrease due to habitat loss, fragmentation, and disturbance associated with the operation
	Habitat use	Move to less disturbed, albeit suboptimal, habitats. Some flying species may be attracted to turbine structures
Flying vertebrates	Abundance of birds and bats	Decrease due to habitat loss, fragmentation, and disturbance associated with the operation
	Flight paths of birds and bats	Avoid transmission lines and turbines (for species that use the marine environment)
	Flight height of birds and bats	Potentially altered to avoid turbines and transmission lines. Species that do not respond in this way and fly at a height compatible with turbines and transmission lines are subject to the risk of collision
	Mortality rate	Increase due to the risk of fatal collision with structures
	Reproductive success	Reduce due to increased energy costs from avoiding the structures and the disturbance generated

7.5.1 Coastal habitats and biodiversity

Some tropical regions have coastal ecosystems and habitats that are highly sensitive to anthropogenic changes, such as sandy beaches, dunes, sandbanks, rocky shores, estuaries, mangroves, and coastal forests. Any local change, even if minimal, can generate an imbalance in these environments and the species that inhabit them, changing the local dynamics and how the fauna relates to the environment.

For example, mangroves play an extremely important role in the coastal zone, serving as a nursery for several marine species, a source of organic matter, and a carbon sink, and it is of paramount importance to evaluate and monitor the possible impacts caused in these ecosystems. Thus, mapping coastal habitats is fundamental to establish a baseline, and can inform project decisions, such as the location of substations and onshore transmission lines.

Beyond baseline-informed selecting the location of onshore structures, the project's influence on nearby habitats has to be considered. Thus, the baseline must consider a set of indicators that are sensitive to these impacts. In practical terms, it is not necessary to survey all coastal biodiversity in depth; rather, focus on the components most likely to be affected, using key indicators that really help measure these impacts, optimizing the EIA process, with greater capacity to detect biodiversity responses to the project.

On sandy beaches, for example, the presence of new fixed structures on the coast can alter coastal drift, generating points of accentuated erosion or deposition, different from what occurs without interventions. It tends to alter the morphodynamics of the beaches near the project, so the baseline should include indicators such as sediment granulometry and the slope and width of the beach profile to obtain reference values for future monitoring.

Establishing a baseline for the benthic communities of beaches, rocky shores, reefs, and mangroves is also recommended, especially regarding species diversity. The diversity of these organisms is a recognized indicator of physical changes in coastal dynamics and may point to potential project impacts during monitoring programs.

7.5.2 Terrestrial habitats and biodiversity

In cases where it is inevitable to occupy vegetated areas during the construction of transmission lines and onshore substations, clearing is necessary, causing habitat fragmentation, loss of local floristic diversity, and, consequently, impacts on the associated terrestrial fauna. Thus, in the areas surrounding these project-associated structures, it is essential to gather information on the floristic and faunal composition, including mastofauna, herpetofauna, avifauna, and chiropterofauna.

Data on the life history of species and habitat use, especially in relation to patterns of behavior, foraging, reproduction, and mortality, help us understand the critical phases of development and reproduction, thereby identifying changes that may compromise the survival of individuals and the maintenance of populations.

An especially important component of the coastal and terrestrial environment is flying vertebrates, which include birds (continental, wader, and marine linked to the coastal environment, many of which are migratory), and bats. These animals are subject to direct impacts during the project's operation. They can be fatally struck by transmission lines and wind turbines, especially species that use the marine environment for foraging, daily commuting, or migration. For species sensitive to disturbance caused by the wind farm (such as noise, lighting, and visual pollution), displacement into suboptimal habitats can, over time, compromise their reproductive success and survival.

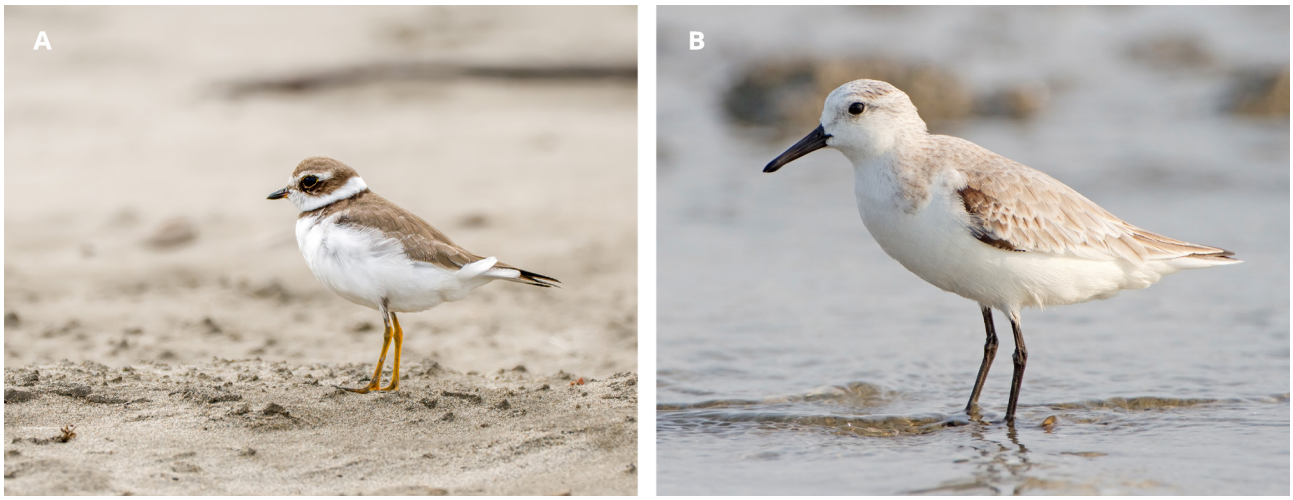


Figure 7.6. Examples of shorebirds that use tropical environments as migratory corridors, a priority for coastal and terrestrial environmental assessments in offshore wind farm projects. These birds use coastal stopping points for rest and food. A) Banded Batuíra (*Charadrius semipalmatus*); B) White Sandpiper (*Calidris alba*). (Wikimedia Commons).

Thus, for flying organisms, it is necessary to obtain information about flight and displacement patterns, including foraging, resting, and breeding sites, as well as migratory routes and flight height. This data is essential for assessing the risk of collisions to which bats and coastal birds are exposed during the project's operation. In addition, habitat use and flight paths are key parameters for detecting impacts such as barrier effect, displacement, and actual habitat loss.

Integrating this data with information on species' life history makes it possible not only to assess direct impacts, such as habitat loss, but also to predict indirect impacts at the population level, including changes in survival rates and reproductive success. These losses underscore the need to include the coastal and terrestrial environment in the baseline of offshore wind farm projects.

Seasonality matters! The migratory periods of seabirds and coastal birds should be considered in the time scale of baseline. These periods influence not only the presence of the species, but also their movements, flight paths, feeding areas, and resting patterns. Collecting data at different times of the year is essential to capture seasonal variability and avoid underestimating risks for migratory species.

7.6 Social baseline

Offshore wind farms not only affect the natural environment, but can also significantly impact the social and economic uses and dynamics of the coastal zone. Therefore, the selection of priority components for the social baseline must include activities and assets sensitive to the changes brought about by the implementation of these projects. In the coastal context, fisheries, recreation and tourism, cultural heritage, including traditional communities and their ways of life, the economy, and the infrastructure necessary for local economic and social activities stand out as relevant components (Figure 7.7). Table 7.3 presents a synthesis of these components and their main indicators to be considered in the baseline, which will be detailed in the following subtopics. The table also provides preliminary predictions of the possible responses these indicators will exhibit to the project's impacts, identified during the elaboration of the causal chain (Chapter 5).

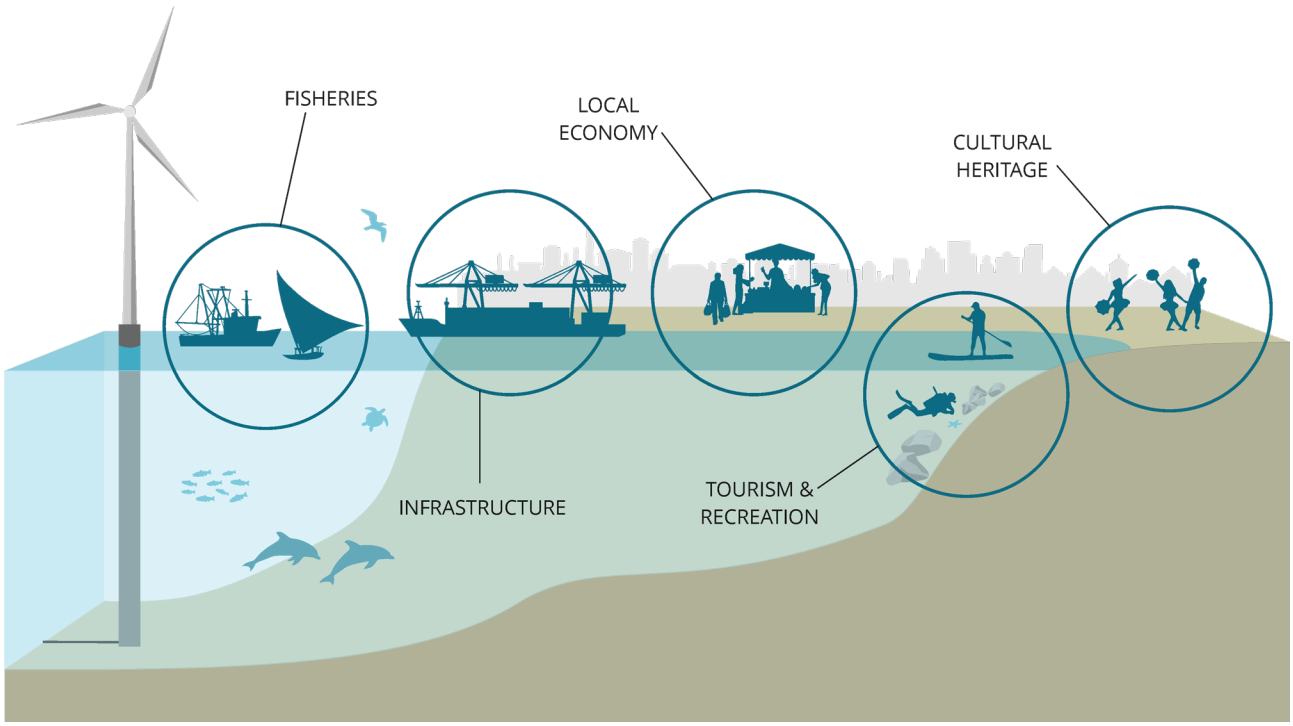


Figure 7.7. Main social components that may be affected by offshore wind farms.

Social participation and meaningful engagement should be considered from the earliest stages of impact assessment, including in the planning and definition of the components assessed. For detailed guidance, see Chapter 3.

Table 7.3. Main components and indicators to be considered for the social baseline, highlighting the expected responses (preliminary predictions) for each indicator to the expected impacts of offshore wind farms.

Priority components	Priority indicators	Preliminary predictions of the main expected responses
Fishing Activity	Fishing areas and routes	Restrict access to traditional areas; possible need to redirect the activity
	Fishing effort (number of vessels, days at sea, fire)	Need for adjustment in fishing practices; Likely changes in stock pressure
	Composition, abundance, and biomass (kg) of the species caught	Increase in the presence of target species in areas adjacent to the farm
Tourism and Recreation	Recreational use of the coast and sea (tourist flow)	Changes in visual attractiveness that may affect the recreation experience, either positively or negatively
	Tourism sector revenues	Increase in visitation by new audiences attracted by the changes, or a reduction in the flow and associated local income, with impacts on related services
	Public perception and opportunities	Possibility of creating new activities, such as embarking on a tourism trip to visit the parks
Infrastructure	Port infrastructure capacity	Risk of overloading ports with increased traffic and operations; Facility expansion or adaptation may be required
	Electrical Infrastructure capacity	Increase in demand for reinforcement of the transmission network and substations for the integration of the energy generated
	Local public infrastructure capacity	Probable growth in demand for public services may cause overload and a reduction in the quality of care
Local economy	Direct and indirect jobs; distribution of benefits; Local investments	Job creation tends to occur temporarily; economic benefits can be unevenly distributed
Culture and Heritage	Sacred sites, historical sites, and areas of symbolic value	Risk of decharacterization of cultural landscapes; interruption of the spiritual and identity bond with the territory
	Cultural practices associated with the sea (festivities, traditional crafts, orality)	Changes in access and use of the area can affect the continuity of cultural practices
Land Tenure and Property Rights	Residential occupancy patterns in the coastal strip	Pressure on local communities, with possible land conflicts and coastal land use changes
All	Restricted areas; freedom of movement for various uses	The definition of use zones can restrict access to certain groups, favoring some uses over others

7.6.1 Socioeconomic activities

The installation of offshore wind farms, even if planned to be located miles from the coast, can have significant impacts on coastal socioeconomic activities. Changes in the maritime landscape, restrictions on access to the sea, and the installation of submarine cables can directly affect productive sectors and socio-cultural activities.

The fisheries sector, encompassing fisheries and aquaculture, is vital to the economy and food security, especially in traditional and small-scale communities. In the social baseline of offshore wind farms, it is essential to collect detailed data on fishing areas and routes, species caught, and fishing effort in the project's area of influence. Integrating this information with the environmental baseline allows us to understand the ecological connectivity between organisms and territories. In addition, it is important to map access routes to fishing areas outside the project area, as exclusion zones can restrict or render these routes infeasible, raising concerns in the fishing sector (Szostek et al., 2025).

The installation of structures in the sea can significantly alter the landscape, compromising the aesthetics of the place and misaligning visitor expectations, leading to tourist demotivation, a drop in visitation, and economic losses for the region (Voltaire et al., 2017). In this context, it is essential to evaluate visitor flows, the busiest periods, the sector's revenue, and the main attractions that sustain local tourism dynamics. In addition, indicators such as the visual attractiveness of the landscape, the availability of recreational areas, and maritime safety should be considered, as access restrictions or changes in the use of marine space can directly affect the destination's attractiveness and competitiveness.

Learn more

A review of articles published between 2015 and 2019 indicates that the impacts of offshore wind energy on tourism and recreation are predominantly negative, mainly due to the change in the landscape (Machado; de Andres, 2023). However, positive perceptions were also recorded, depending on sociocultural factors, such as the degree of information of the population, the perceived local benefits, and the symbolism attributed to the energy transition. In contexts where elements of public participation and engagement are present, a reduction in the rates of opposition to the projects was observed. For more on social participation and engagement, see Chapter 3.

The presence and conditions of the region's ports directly influence the logistics of installation, operation, and maintenance of offshore structures. It is important to understand the physical characteristics of the port (e.g., depth, load capacity, quay length), port connectivity (e.g., distance from parks and suppliers, heliports, and road networks), and layout (e.g., expansion potential, areas available for use) (Akbari et al., 2017). When such criteria are not available, adaptation works or the construction of new facilities may be required, which can have significant impacts on coastal dynamics and land uses. Thus, the impacts of wind farms should be assessed through a more comprehensive regional analysis of infrastructure and suppliers, which can amplify environmental and social impacts.

In addition to the port infrastructure, the capacity of the local electricity grid to receive and distribute energy from wind farms is fundamental, often requiring reinforcements of substations and transmission lines, which can cause temporary or permanent urban impacts. Coastal land occupation must also be monitored, as operations can put pressure on residential, industrial, and environmental areas, requiring integrated planning to ensure quality of life. While the deployment of offshore wind farms can generate direct and indirect jobs and boost regional economic development, it can overwhelm public services (such as transportation, health, sanitation, and security) and cause speculative real estate appreciation, increasing the risk of gentrification and affecting local community accessibility.

7.6.2 Socio-cultural activities

The coastal zone is home to a diverse set of cultural, affective, and symbolic references built over generations by communities that maintain deep relationships with the sea and the territory. The arrival of large projects, such as offshore wind farms, can strain these bonds, reconfiguring landscapes loaded with meaning and affecting everyday practices, rituals, and forms of belonging. In this context, it is essential to recognize and understand the sociocultural elements that structure life in coastal regions, especially in the face of interventions that transform the use of space and the dynamics of traditional territories.

Among these elements, cultural ecosystem services stand out, such as the spiritual, identity, recreational, and aesthetic values associated with the sea and the coastal zone, which, although difficult to measure due to their intangible character, are essential for the ways of life of local populations and for their perception of well-being (Hooper et al., 2017). Although public opposition to large projects is more frequent in onshore wind farms, due to proximity to homes and land conflicts, for many coastal communities, the marine space represents a legitimate extension of their territory (Devine-Wright & Howes, 2010). The attachment to the place, which extends to the marine environment, encompasses memory, sustenance, and identity.

It is important to note, however, that opposition is not a universal response. Receptivity to offshore projects can vary significantly depending on the population's socio-cultural profile, the degree of community involvement in decision-making, and how the project is presented to the territory.

In some contexts, especially in Europe, there is greater acceptance of offshore wind farms, associated with public support for renewable energy and a positive perception of their environmental and economic benefits (Cronin et al., 2021).

In this sense, it is essential to identify sacred sites, historical sites, cultural landscapes, and areas of symbolic value, which can be degraded by alterations to the maritime and coastal landscape and the installation of new infrastructure (Figure 7.8). Such changes can break spiritual and affective ties with the territory, compromising the continuity of traditional practices. Cultural practices associated with the sea, such as religious festivities, traditional crafts, oral knowledge, and symbolic systems, which can be weakened or reinterpreted in the face of new spatial arrangements and access restrictions, should also be mapped.



Figure 7.8. Examples of social, economic, and cultural activities relevant to social baseline in offshore wind projects. A) Industrial and port activity; B) Cultural and religious practices in the coastal environment; C) Sports and recreational activities, such as surfing; D) Artisanal fishing and the activities of traditional populations. (Pexels).

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Chapter 8

DETERMINING THE SIGNIFICANCE OF IMPACTS

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Luis Enrique Sánchez

Offshore wind energy projects generate multiple impacts, both adverse and positive. However, not all of them are important for decision-making. Distinguishing significant impacts from other impacts is one of the main functions of project impact assessment. This chapter aims to present the basic concepts of determining the significance of impacts and their relationship with the stages of the Environmental Impact Assessment (EIA) process. Practical examples are also presented that illustrate how this determination can be accomplished.

THIS CHAPTER:

1 What is a significant impact?
2. What is the purpose of determining the significance of impacts?
3. What are the essential elements to determine the significance of impacts?
4. How to properly communicate the significance of impacts?

8.1 What is a significant impact?

To evaluate an impact is to interpret its "importance", here called significance. In the context of EIA projects, the adjective "significant" indicates a relevant impact to be considered in decision-making. This determination is directly related to the limit of acceptability of the impact and the need for measures to avoid, mitigate, or compensate for impacts (Chapter 9). Determining whether an impact is significant is one of the most important decisions in the EIA process.

Determining the significance of the impact can be called determining the importance or relevance of the impact. Although synonymous, in this chapter we use the term "significance of impact", leaving the term "importance" only as an attribute or characteristic of an environmental component.

The determination of significance reflects the potential impact that a project can have in a given context and depends, conceptually, on two variables: (i) the magnitude of the impact and (ii) the sensitivity, value, and/or vulnerability of the component (Figure 8.1). The magnitude depends on the characteristics of the project (in all its stages, from planning, installation, and operation to possible decommissioning), including the supporting infrastructures, and is generally easier to determine. The second variable depends on the environment's carrying capacity, vulnerability, and environmental and social value (or importance). Both variables (project and environmental characteristics) are directly related to the potential to cause significant impacts. The greater the pressures imposed by the project, the greater the potential for significant impacts. Similarly, the more sensitive (less resilient or more vulnerable) the environmental component, the greater the possibility of significant impact. These characteristics are detailed in section 8.3.

> **Significant Impact**
> It is a relevant consequence of an action, taking into account its environmental and social context. Determining whether an action will cause a significant impact depends on the magnitude of that impact and the sensitivity of the environmental or social component affected.

Do not confuse the importance of impact with the importance of the environmental component!!

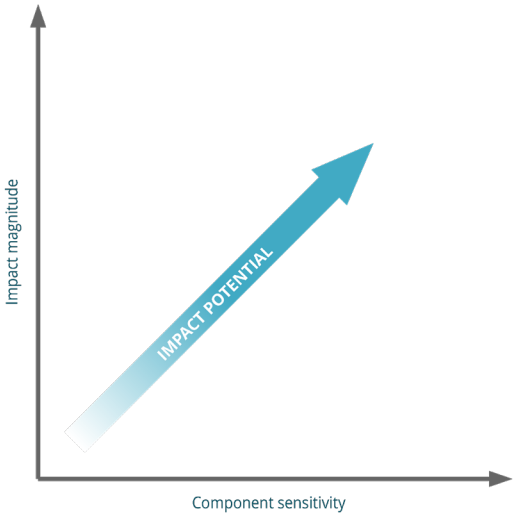


Figure 8.1. The potential impact of a project directly depends on the magnitude of the impact and the sensitivity of the environmental component. Source: based on Sánchez (2020, p. 91).

8.2 What is the purpose of determining the significance of impacts?

Determining whether an impact is significant or not depends on establishing a reference point of "acceptability", as illustrated in Figure 8.2.

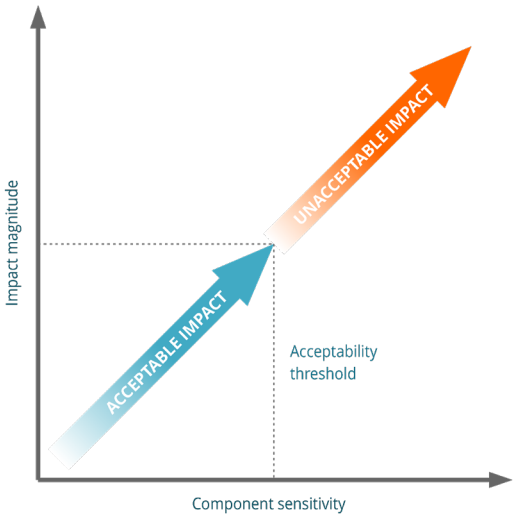


Figure 8.2. Conceptual illustration of the acceptability threshold of an impact in the Environmental Impact Assessment context. Source: based on Ehrlich and Ross (2015, p. 93).

The fact that an impact is not considered significant does not mean that this impact does not exist, but that it was not considered relevant for decision-making in the context of the EIA!

Determining significance is central to the EIA process, from screening through follow-up (Figure 8.3).



Figure 8.3. Relationship between significance determination and the different stages of the Environmental Impact Assessment process. Source: based on Noble (2020, p. 148).

The entire EIA process should be focused on the impacts that are significant for decision making!

In the screening stage, identifying the possibility of significant impacts is decisive in determining the need for in-depth studies, such as the Environmental Impact Study (EIS), to assess the project's impacts. In the scoping stage (Chapter 6), the likely significant impacts guide the planning of the EIA and the definition of the term of reference, determining what information is necessary to assess the acceptability of the project. The information from the baseline (Chapter 7) and the impact prediction, which are part of the preparation of the EIS, support the impact analysis stage, in which the determination of significance will confirm (or not) the expected impacts.

> **Significance Determination Objective**
> The determination of significance guides all stages of the EIA process, from screening to follow-up, and is related to the definition of project acceptability.

8.3 What are the essential elements to determine the significance of impacts?

The determination of significance can use a variety of terminologies and categories, but should always retain the concept of significant impact (Figure 8.1) and the need to characterize two variables, one variable indicating the pressures imposed by the project (magnitude) and the other indicating the sensitivity of the environment (considering carrying capacity, vulnerability, environmental and social values, legal aspects, among others), as illustrated in Figure 8.4.

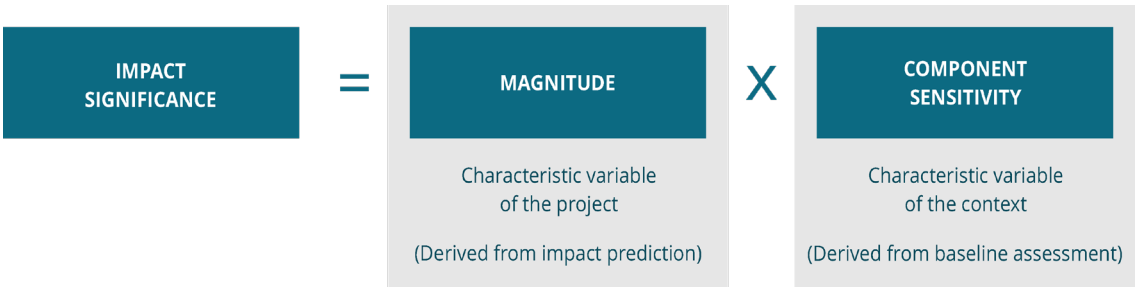


Figure 8.4. Variables used to determine the significance of environmental impact. Source: based on Sánchez (2020, p. 249).

These two variables are related, respectively, to the prediction of impacts (magnitude) and to the socio-environmental baseline (sensitivity). Impact prediction estimates the potential environmental impacts of a project. It is at this stage that the analysis of the causal chain (Chapter 5) of the project's actions is carried out, and the extent to which each action may impact each environmental component is determined.

The prediction begins by identifying the impacts and confirming (or not) those foreseen in the scope definition stage. Next, the impacts are characterized for better understanding by adopting different criteria, such as their nature (positive, negative), duration (short, medium, cyclical, for example); whether it is caused directly or indirectly by the action, whether it is reversible or irreversible, real or potential, and whether it will start immediately or in the medium or even long term. These characteristics help to understand the expected behavior of impacts.

There are a variety of methods for predicting impacts, each related to the peculiarities of the context, for example, the existence or non-existence of previous reference bases and databases. The methods can utilize both qualitative and quantitative approaches, such as computer modeling, simulation, comparison, extrapolation, and expert opinions. The choice of method is associated with the characteristics of the action and the related environmental aspect.

Whichever approach or method is chosen, it is important that the EIS clearly informs the uncertainties in each assessment. This step determines the area of influence of the impacts and supports the determination of the magnitude classes used to assess the impact's significance. An example is given later (**Box 8.3**).

On the other hand, the baseline studies, which describe the environmental components potentially affected by the project (**Chapter 7**), should support the definition of the sensitivity and value of the affected component. The baseline is carried out in a specific area (study area). It may involve various methods (depending on the component studied), such as satellite image analysis, field measurements, interviews, historical research, and environmental modeling. This step supports defining the component sensitivity classes used to determine the significance of the impact (see the example in **Box 8.4**).

Significance determination depends on information from two EIS previous analysis: baseline and prediction of impacts.

Retrieving the relationship between the determination of significance and the stages of the EIA process (**Figure 8.3**), the Impact Analysis stage begins by identifying impacts and determining which are significant (Sánchez, 2020). This determination can be broken down into six steps (**Figure 8.5**).

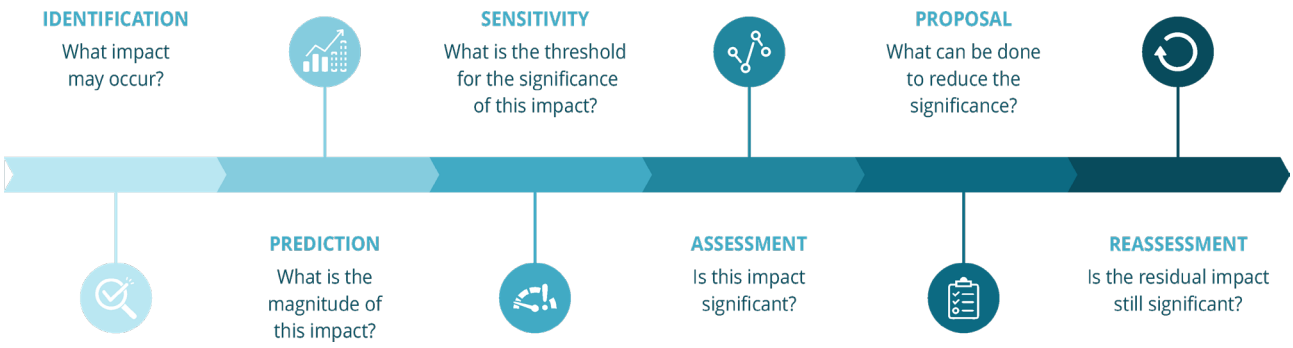


Figure 8.5. Impact analysis and significance determination steps.

The first two steps are the identification and prediction of impacts, which confirm (or do not) the expected impacts in the scoping stage and indicate the expected consequences. Next, the significance threshold is defined for each component: that is, given the component's sensitivity, at what point does this impact become significant? This definition should be based on the baseline (Chapter 7) and consider normative aspects of the context, social values, and strategic planning documents (Chapter 2). In cases where there are no regulatory limits, the competent EIA authority can define the significance thresholds for the impacts.

The threshold that determines whether a given impact is significant is not defined solely by "environmental significance" but must also consider the social values attributed to the component and the territorial planning of that context (Chapter 2). Therefore, the definition of acceptability preferably begins before the EIA process of projects (it can be based on strategic documents) and extends through all its stages, either as a result of the "environmental studies" or as "social values" identified with the stakeholders in the various stages of the EIA process (Chapter 3).

Based on information on impact prediction and component sensitivity, the significance is determined, i.e., whether the impact falls on the acceptable side of the acceptability threshold (Figure 8.2). This decision is then supported by information from the baseline (the definition of the component's sensitivity) and from the prediction of impacts (the future behavior of the actions' results, including their cumulativeness).

The significance of an impact is defined based on the relationship between the information from the impact prediction (impact magnitude) and the baseline (sensitivity of the environment) and is based on a threshold of acceptability of each component evaluated.

If there are unacceptable impacts, the next step is to assess solutions that can make the impact acceptable. The question can guide the proposal for adjustments: "*Can changes in the project and/or the establishment of mitigation measures make the impact acceptable?*" The significance of the impact can be reduced through changes in one or both variables represented on the axes of Figure 8.2. On the vertical axis, the magnitude of the impact can be reduced, for example, by modifying some technological alternative of the project that avoids it or by proposing mitigation measures (see Chapter 9). On the horizontal axis, you can change the project's location or layout, for example, from a more sensitive environment to a less sensitive one. In an offshore wind farm, an example would be relocating facilities (such as cabling) that affect sensitive seabed habitats (e.g., banks and rhodoliths) to a less sensitive location (e.g., a sandy bottom).

Figure 8.6 illustrates a conceptual example of a negative impact located at point "A" (unacceptable condition), which can be mitigated through measures to avoid, reduce, and/or compensate for its impacts, so that it is located at point "B" (acceptable condition). There is a relationship between the significant impacts and the proposed mitigation measures, a theme presented in Chapter 9.

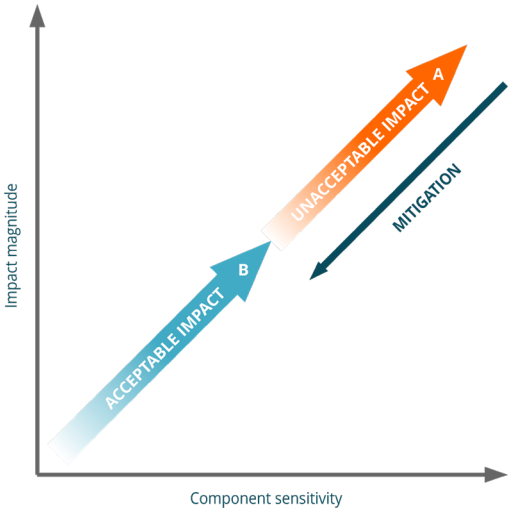


Figure 8.6. Relationship between mitigation measures and impact acceptability. Source: based on Ehrlich and Ross (2015, p. 93).

Figure 8.7 illustrates this example, including the relationship between significance and acceptability of impact. It is important to highlight that mitigation measures are proposed because they can be effective, as demonstrated by their successful use in another project. That way, even if a significant impact is deemed acceptable, it remains significant for follow-up purposes. Monitoring will verify that the impact occurs as expected, leading to possible adjustments to the measures if necessary. Monitoring is also fundamental to the learning process, as it assesses the effectiveness of the measures and determines the significance of the expected impacts (Chapter 11). Box 8.1 provides a practical example where a significant impact becomes acceptable following the implementation of mitigation measures.

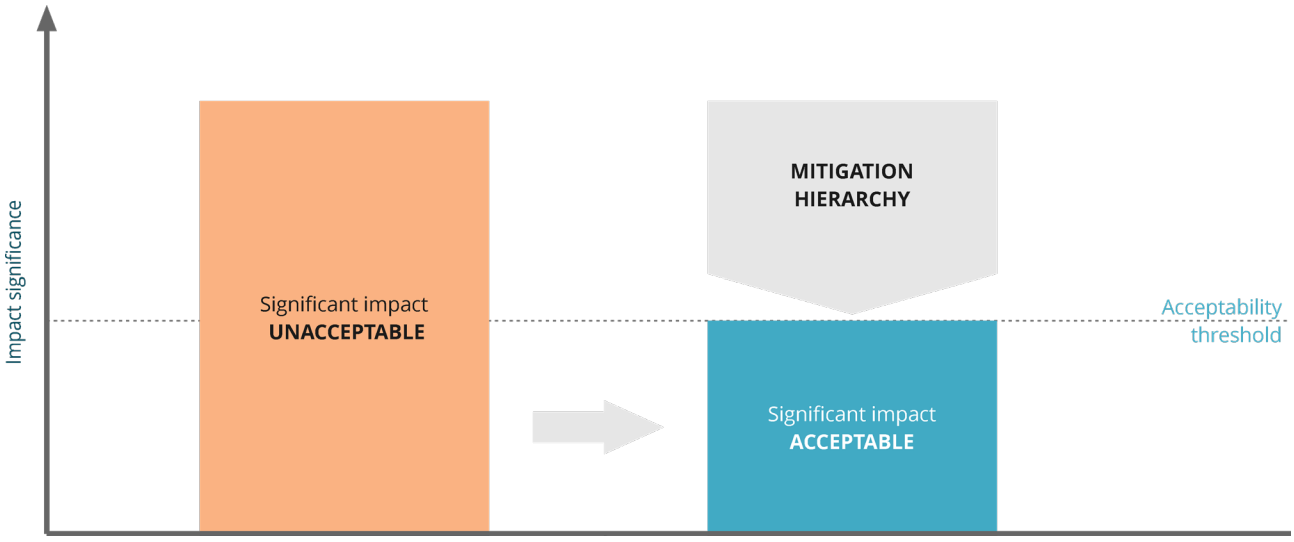


Figure 8.7. Relationship between significant impact, unacceptable, and acceptable impacts. Source: based on Government of Western Australia (2014).

Box 8.1. Practical example: significance of the impact of hearing loss on marine mammals

Morecambe Offshore Windfarm Generation Assets is an offshore wind power generation project planned for installation in the Eastern Irish Sea, approximately 30 km off the coast of Lancashire, with a nominal capacity of 480 MW (Royal HaskoningDHV, 2024b).

The impact of hearing loss due to underwater noise generated during piling was considered significant for marine mammals (porpoise, minke whale, gray seal, and harbor seal). From then on, mitigation measures were proposed, and the EIS concluded that the residual impacts on these mammals would become acceptable, as long as the measures were applied effectively.

Proposed measures:

- Definition of a pile driving schedule (no simultaneous pile driving).
- Soft-start pile driving, with gradually increasing hammer energy (allowing mobile species to move away from the area before the maximum hammer energy – associated with the highest noise – is reached).

It is important to note that, although this impact is considered acceptable, it must still be subject to follow-up. This follow-up (Chapter 11) refers not only to ensuring the execution of the proposed measures (implementing the driving schedule and the soft start of driving), but also to verifying their effectiveness (Chapter 9).

Whenever possible, the determination of significance should be supported by a combined approach, considering a technical analysis (with the definition of specific criteria for the context and the component evaluated), argumentative analysis (with a logical and coherent justification) and collaborative approach (involving the affected communities from the beginning of the stages of the EIA, including in the determination of significance) (Lawrence, 2007c). This combination ensures transparency, replicability, and representativeness in the process (Chapter 3).

The blended approach has the great challenge of considering the perspective of affected communities in determining significance!

8.3.1 Significance Matrix

Table 8.1 presents a theoretical example of a significance matrix. This statement concerns the acceptability of the impact already discussed, and therefore, this generic matrix composition must be adapted to the reality of each evaluated component. There are no clearly defined boundaries between categories; these must be stated for each variable and each component evaluated. For example, the yellow category was chosen to represent impacts that can be significant but acceptable with adequate mitigation.

The matrix is a tool to assist in judging significance, and its definition depends fundamentally on the attributes used to describe the two variables (impact magnitude and component sensitivity). In this configuration, magnitude of the impact, sensitivity of the component, and impact significance are divided into three classes. These attributes will allow you to answer questions such as: "Will environmental standards be met?" Will there be a compromise of environmental components?" What is the socio-environmental importance of these components?"

Table 8.1. Example of significance matrix.

Impact Significance Matrix				
Magnitude	High	Significance threshold	Significant impact	Significant impact
	Medium	Non-significant impact	Significance threshold	Significant impact
	Low	Non-significant impact	Non-significant impact	Significance threshold
		Low	Medium	High
		Sensitivity		

Box 8.2 presents an example where significance is divided into four classes. In this example, major or moderate impacts are considered significant for the EIA, while minor or negligible impacts are considered non-significant. Regardless of the type of matrix chosen, it is essential that the evaluation clearly indicate what it considers significant for each component evaluated.

Box 8.2. Practical example: significance matrix

The following table is the Significance Matrix of the impacts of an offshore wind farm project on Commercial Fisheries. This fragment is part of the EIS of Dogger Bank South Offshore Wind Farms (Royal HaskoningDHV, 2024a), designed to be installed in the Dogger Bank region of the North Sea (UK). In addition to presenting the relationship between the magnitude of the action and the sensitivity of the component, the matrix is accompanied by a definition of what each impact category means (specific to the component and the analyzed context). According to the method proposed in the EIS, the impacts evaluated as "major" and "moderate" are considered significant for the EIA. These general definitions should be adapted to the context of the impact assessment of each environmental component.

		Adverse magnitude				Beneficial magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	Major	Major	Moderate	Minor	Minor	Moderate	Major	Major
	Medium	Major	Moderate	Minor	Minor	Minor	Minor	Moderate	Major
	Low	Moderate	Minor	Minor	Negligible	Negligible	Minor	Minor	Moderate
	Very low	Minor	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Minor

Significance	Definition
Major	Significant in EIA terms. Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Significant in EIA terms. Intermediate change in receptor condition, which is likely to be an important consideration at a local level.
Minor	Not significant in EIA terms. Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	Not significant in EIA terms. No discernible change in receptor condition.
No change	No impact, therefore, no change in receptor condition.

Source: Royal HaskoningDHV (2024a).

8.3.2 Magnitude

Magnitude refers to the degree of change that occurs in an environmental component relative to a reference condition. This reference can be the component's condition before project implementation, or the condition according to normative standards and guidelines. Using attributes and forecasting methods appropriate to each component is essential to reduce the uncertainties of this prediction.

Regardless of the form of the attributes, whether the descriptions are quantitative or qualitative, it is essential to present clear definitions of the terms that delimit the magnitude classes and the parameters used to interpret each level. The definition of these terms may vary by component. It should be sufficiently clear to allow other evaluators to arrive at a similar description of the magnitude for the same component and context. An example is presented in Box 8.3.

Box 8.3. Practical example: description of the magnitude

The following table is part of the EIS for Outer Dowsing Offshore Wind (SLR Consulting, 2024). This project refers to an offshore wind farm designed for deployment in the North Sea, off the UK coast, west of the Lincolnshire coast. The table presents the description of the parameters used to assess the magnitude of the impacts on the quality of marine water. It can be seen that the magnitude classes are described and justified for the evaluated component (water quality) and are referenced to the baseline conditions.

Magnitude	Definition
High	Large scale change to key characteristics of the water quality status of the receiving water feature. Water quality status degraded to the extent that a permanent or long-term change (i.e., a WFD reporting cycle) occurs. Inability to meet EQS as a result of the proposed activities.
Medium	Medium scale change to key characteristics of the water quality status of the receiving water feature. Water quality status is likely to take considerable time (for example, a change in the annual average turbidity classification (Tyler-Walters et al., 2018) to recover to baseline conditions. Ability to meet EQS becomes compromised.
Low	Noticeable but not considered to be substantial changes to the water quality status of the receiving water feature. Activity is not likely to alter local status to the extent that water quality characteristics change considerably and/or EQS become compromised.
Negligible	Although there may be some impact upon water quality status, activities are predicted to occur over a short period. Any change to water quality status will be quickly reversed once activity ceases.

Source: SLR Consulting (2024).

Do not confuse attributes used to describe impacts with criteria used to determine significance! This is important because some attributes used to describe impacts (direct/indirect, permanent/temporary, etc.) are not good attributes to determine their significance because in some cases they can generate a mistaken analysis. For example, an indirect impact may be more significant than a direct impact.

8.3.3 Sensitivity

Determining the sensibility of a component is critical to assessing whether an impact is significant. For this determination, normative documents can be used, for example, such as a list of endangered species. Other characteristics can also be considered, such as ecosystem services related to the component (Chapters 1 and 5), which inform about its importance for the beneficiaries of these services. However, for many components, this determination is a major challenge.

In addition, the "value" of the affected component, especially the social value attributed to it, is highly subjective, which makes the participation of the various actors in this process fundamental, especially those affected by the action. It is important to consider that the plural aspect of the EIA, with several actors participating in the process, makes it even more difficult to define this value. These various actors may have different views on both the value of the affected component and the acceptability of the impact. The role of these actors in the EIA process influences these different views. For example, analysts from the competent authority responsible for EIA review may have a different perspective from those of environmental consultants and the impacted community. Also, the community itself may have individuals with different, equally important views, who attribute different values to a certain component.

In view of this difficulty, it is recommended that the actors in participatory processes (Chapter 3) discuss the definitions of the attributes and scales of values used to determine sensitivity. In addition, this process of defining the attributes must be clearly stated in environmental studies and public hearings. Box 8.4 provides an example.

Box 8.4. Practical example: description of sensitivity

The Five Estuaries Offshore Wind Farm is a proposed extension of an existing wind farm (Galloper Offshore Wind Farm), located in the North Sea, off the coast of Suffolk, England (GoBe Consultants, 2024). The project involves the installation of up to 79 wind turbines. The following table presents the definitions of the different sensitivity levels for avifauna. It should be noted that the sensitivity classes are defined and supported by the baseline.

Sensitivity	Definition
High	Ornithological feature (bird species) has very limited tolerance of and/or recovery from a potential impact, e.g. strongly displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Medium	Ornithological feature (bird species) has limited tolerance of and/or recovery from a potential impact, e.g. moderately displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Low	Ornithological feature (bird species) has some tolerance of and/or recovery from a potential impact, e.g. partially displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Negligible	Ornithological feature (bird species) is generally tolerant of a potential impact and can easily recover e.g. not displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.

Source: Gobe Consultants (2024).

Thus, the significance of an impact depends on the parameters and definitions used to assess the magnitude of the action and the sensitivity of the affected component. It is up to the team of experts responsible for preparing the studies to determine what is pertinent to each studied context. Box 8.5 presents an example of what was considered in determining the significance of the impact on the landscape.

Box 8.5. Practical example: determining the significance of visual impacts

The following example shows how the significance of landscape and visual impacts was determined in the EIA for the project *Development of an Offshore Wind Farm in Hong Kong*, proposed for installation in waters southwest of Lamma Island (Environmental Resources Management, 2010). The project consists of offshore wind turbines, submarine cables and associated infrastructure. The turbines were expected to be approximately 125 to 136 m high, representing a dominant element in the maritime and coastal landscape.

To determine the significance of visual impacts, the sensitivity of sensitive visual receptors was combined with the magnitude of landscape change.

Sensitivity: The main sensitive visual receptors were identified, including beaches, trails, urban areas and panoramic viewpoints. The sensitivity of each location was classified as Low, Medium or High, based on expert judgment and four criteria:

- **Value and quality of views:** Areas with highly natural views and high scenic quality were considered more sensitive.
- **Type and number of people:** Locations with a large concentration of residents or tourists were given greater weight than passing locations.
- **Duration and frequency of views:** The length of continuous exposure to the project was considered; for example, exposure from residential areas was classified as long-duration.
- **Degree of visibility:** The extent to which views of the turbines would be unobstructed.

Magnitude: Magnitude measured the severity of the physical change to the landscape and was categorized as Insignificant, Small, Intermediate or Large. Based on visibility analysis and visual simulations, magnitude was estimated by considering:

- **Compatibility:** The extent to which the project integrates with or contrasts with the surrounding environment.
- **Scale and distance:** The height of the turbines, the extent of the wind farm and the observer's proximity to the project.
- **Reversibility and blockage:** The potential for blocking important views and whether the change would be reversible in the long term.

Significance: The significance of the impact, classified as Significant, Moderate, Slight or Insignificant, was determined using a matrix that combines the magnitude of visual change and receptor sensitivity. The judgments were made by specialists and were based on how the community uses the space and relates to the landscape.

		Sensitivity to Change		
		Low	Medium	High
Magnitude of Change Caused by Project	Large	Moderate Impact	Moderate/Significant Impact	Significant Impact
	Intermediate	Slight/Moderate Impact	Moderate Impact	Moderate/Significant Impact
	Small	Slight Impact	Slight/Moderate Impact	Moderate Impact
	Negligible	Negligible Impact	Slight Impact	Slight/Moderate Impact

Source: Environmental Resources Management (2010).

It is important to highlight that the content presented in this chapter addresses the determination of the significance of impacts, considering a linear causal chain (activity - aspect - impact, as presented in Chapter 5), without considering cumulative impacts. Thus, an impact can be considered not significant when analyzed in isolation, but can be significant for a certain environmental component in a region where this component is already suffering pressures and impacts from other sources. The assessment of cumulative impacts is dealt with in Chapter 10.

8.4 How to properly communicate the significance of impacts?

The concern with clearly communicating the significance determination is related to the fundamental principles of the EIA (IAIA & IEA, 1999). The EIS constitutes a significant part of the information that the EIA process provides for decision-making. Thus, the information must be presented with a focused approach, focused on what is important (Chapter 6). In this sense, there must be coherence among the information presented in the EIS, with significant impacts as the main axis.

The term "significant impact" is inherently subjective and could not be otherwise, since it depends on the values (importance) attributed to the environmental components of each context. However, this subjectivity should not be confused with arbitrariness (Ehrlich; Ross, 2015); that is, the judgment of significance should take into account information from baseline and prediction of impacts, using, whenever possible, a combined approach (Lawrence, 2007c). In addition, all assumptions and criteria used must be justified.

The clear indication of information (attributes, methods, criteria, scales, assumptions, justifications, results, and uncertainties) provides transparency in defining what is significant. Using an approach that justifies this information makes the evaluation reproducible, and the inclusion of social values confers representativeness to the determination of significance and to the EIA process as a whole.

> The EIS should clearly communicate what the significant impacts of the project are, what was considered for the determination of significance, and what uncertainties were involved. This communication must be sufficient to ensure transparency, reproducibility, and representativeness to the process.

Despite the importance of determining the significance of impacts, this information is often considered a deficiency in EIS worldwide. For decades, research has evaluated the practice presented in EISs and identified important deficiencies. The evidence ranges from the complete absence of significance determination and the confusion between the magnitude and significance of the impact, to gaps, such as the absence of consideration of the sensitivity and environmental and social value of the impacted component (Anifowose, Lawler, van der Horst, & Chapman, 2016; Badr, Zahran, & Cashmore, 2011; Barker & Jones, 2013). In the Brazilian context, these deficiencies were recently identified by Orique and Veronez (2024), Demori and Montaño (2024), and Veronez and Montaño (2024). By analyzing 11 EIAs of offshore wind farms in England, Scotland, the United States, and Brazil, Veronez et al. (2026) identified a consistent lack of clarity on for whom the impacts are considered significant.

Learn more

For more information on determining significance, we suggest consulting Duarte and Sánchez (2020), Ehrlich and Ross (2015), Jones and Morrison-Saunders (2016), Lawrence (2007a, 2007b, 2007c), Noble (2020), and Sánchez (2020).

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Chapter 9

MITIGATION MEASURES

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The management of environmental impacts in development projects requires not only the accurate analysis of adverse impacts, but also the systematic application of strategies to avoid, minimize, restore, or compensate for these impacts. In this context, mitigation measures constitute a fundamental pillar of the Environmental Impact Assessment, guided by the hierarchy that prioritizes avoiding adverse impacts, followed by measures to minimize, restore, and, only as a last resort, compensate for residual adverse impacts. This chapter presents the conceptual and operational foundations of mitigation measures, with an emphasis on their application in the offshore wind energy sector, showing how these measures can be planned, selected, and implemented effectively, ensuring not only legal compliance but also concrete benefits for biodiversity, ecosystem services, and affected communities. Throughout the chapter, practical examples, scientific evidence, and international guidelines are used to illustrate best practices in mitigating impacts on marine environments.

THIS CHAPTER:

1 What are mitigation measures?
2 Choosing the best measures using the Mitigation Hierarchy
3 Mitigation measures for marine biodiversity in offshore wind energy projects
4 Effectiveness of biodiversity offsets

9.1 What are mitigation measures?

Mitigation measures are actions to avoid, minimize, restore, or compensate for adverse environmental impacts caused by a project. They are a fundamental part of a project's environmental management and are directly related to the acceptability of significant impacts by internalizing the costs associated with expected environmental and social impacts within the proponent's responsibilities, rather than transferring or externalizing these costs to society.

Mitigation measures are a way of implementing the Polluter Pays Principle, which is important in international environmental law and incorporated into the legislation of several countries.

The results of the socio-environmental impact analysis are essential for defining effective mitigation strategies. Impacts can manifest directly (e.g., habitat loss due to infrastructure construction) or indirectly (e.g., through ecosystem fragmentation, which affects ecological connectivity).

In addition, the cumulative impacts resulting from the overlapping impacts of multiple human activities in the same area must also be addressed through mitigation measures compatible with the expected condition of the affected components. It is from the detailed evaluation of these factors that it becomes possible to prioritize measures to avoid irreversible losses of biodiversity and ecosystem services, as well as impacts on environmental quality and the well-being of affected populations.

The determination of the significance of environmental and social impacts also guides the application of the mitigation hierarchy, ensuring that significant impacts are identified and appropriately sized to be avoided where possible, and that minimization and compensation measures are implemented strategically, proportionately, and effectively to reduce adverse environmental and social impacts. If impacts are not adequately characterized, the application of the mitigation hierarchy may not fulfill its role in internalizing the project's externalities. Underestimated impacts can lead to the proposal of insufficient mitigation measures, while overestimated impacts can lead to disproportionate mitigation measures and unnecessary costs for the proponent.

As illustrated in Figure 8.7 (Chapter 8), significant impacts can become acceptable through the application of a mitigation hierarchy. The acceptability decision is made taking into account the expected effectiveness of each proposed measure. In other words, the application of mitigation measures contributes to the project's socio-environmental viability. The follow-up step (Chapter 11) is essential to verify that the implementation of the measures yields the expected results, and to indicate adjustments where necessary.

9.2 Choosing the best measures using the Mitigation Hierarchy

The mitigation hierarchy organizes mitigation measures in a logical sequence, prioritizing, whenever possible, avoidance of impacts. This is followed by minimization, restoration measures, and finally by compensation.

> **Mitigation hierarchy**
> "The mitigation hierarchy is a sequential process of avoiding, minimizing, restoring, and compensating for environmental impacts, with the aim of achieving no net loss" (CSBI, 2015; IFC, 2012).

As indicated in Figure 9.1, which illustrates the mitigation hierarchy for impacts on biodiversity, the same impact can be managed through one or more of these combined measures. Initially, possible changes to the project and its activities should be explored to avoid the identified impacts. Subsequently, measures must be adopted to minimize unavoidable impacts, and only then should we proceed to propose restoration measures. Where feasible, restoration measures should be applied before compensation.

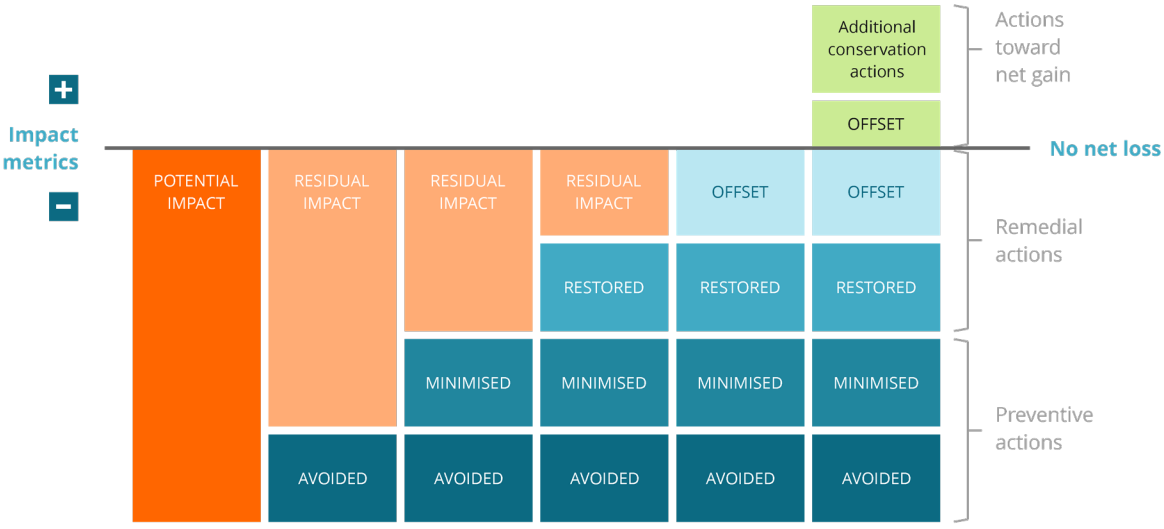


Figure 9.1. Schematic diagram showing the application of the mitigation hierarchy for impacts on biodiversity and ecosystem services. (Source: adapted from BBOP (2013) and CSBI (2015).

Avoid

Prevention is the most effective strategy within the mitigation hierarchy, as it seeks to eliminate impacts even before they occur. In studies conducted in the United Kingdom, researchers have shown that redesigning offshore wind farms can significantly reduce overlap with seabird migratory routes, thereby minimizing the risk of collisions and the displacement of sensitive species. The use of spatial modeling and avifauna sensitivity analysis allowed the identification of exclusion zones that guided the positioning of wind turbines in areas of lesser ecological relevance. This preventive approach reinforces the need to integrate ecological data from the initial planning phase, avoiding compromising critical ecosystems and reducing the need for later compensatory measures (Furness, Wade; Masden, 2013).

Minimize

When complete avoidance of impacts is not possible, minimization becomes an essential step in reducing the intensity, duration, and extent of environmental impacts. For example, the use of bubble curtains during underwater pile driving is considered effective in attenuating noise and protecting sensitive marine mammals, such as porpoises. During the construction of the Borkum West II offshore wind farm in the North Sea, the implementation of a bubble curtain significantly reduced noise propagation, reducing the acoustic impact on porpoises by up to 90%. This approach highlights the importance of mitigating the impacts when planning offshore projects.

Restore

Environmental restoration aims to recover the ecological functions (and affected ecosystem services) of areas degraded by human interventions, and is an essential step in the mitigation hierarchy. In the context of offshore wind farms, growing evidence shows that submerged structures associated with wind turbines – such as foundations and erosion protection systems - can function as artificial reefs, favoring colonization by benthic organisms and promoting increased marine diversity and biomass (**Chapters 5** and **7**).

A review study conducted by Langhamer (2012) highlights that such structures have contributed to the recovery of marine habitats and to the repopulation of species of commercial interest, such as lobsters, crabs, and reef fish. This potential for a positive ecological function underscores the importance of considering active restoration as an integral part of offshore project planning, especially in regions where coastal and marine habitat degradation may be even more intense

Offset

When residual impacts persist after the adoption of prevention, minimization, and restoration measures, offsets should be implemented to achieve neutrality or a net biodiversity gain. In the context of impacts on biodiversity and ecosystem services, when ecological compensation measures result in outcomes that achieve no net loss is considered, this type of compensation is considered an offset (Pope et al., 2021). For social impacts, the term "compensation" is used regardless of whether losses and gains are equivalent.

In Europe, compensation in offshore wind projects has included actions to create habitats, support protected areas, and restore marine ecosystems in regions other than those directly impacted. In addition, actions that lead to the reduction of environmental pressures, that is, improvement of environmental health and increase of the resilience of the socio-ecological system, such as the implementation of public policies for territorial planning (e.g., Master Plans, River Basin Plans, Protected Area Management Plans, and Coastal Management Plans) and the fight against sources of pollution (e.g.: Sanitation and Solid Waste Plans), are strategic to compensate for cumulative impacts on the coastal and marine environment.

However, several studies warn of the need to ensure criteria such as additionality, ecological equivalence, and permanence, as well as transparency in governance and continuous monitoring, given that compensation measures often involve long-term commitments and high ecological complexity (Vaissière, Levrel; Pioch, 2022).

DO THIS:

- Consider cumulative impacts when defining measures.
- Have traceability of impacts up to the application of the mitigation hierarchy.
- Monitor offset actions using metrics that enable tracking for measurable conservation results.

DON'T DO THIS:

- Don't skip steps in the hierarchy. Offsetting does not replace avoiding or minimizing.
- Do not treat offsets as a generic solution without an adequate technical assessment, including baseline information.
- Financial compensation is not a substitute for compensation for biodiversity and ecosystem services.

Table 9.1 presents a summarized view of the four stages of the mitigation hierarchy – avoid, minimize, restore, and compensate – with their respective objectives, practical examples applicable to offshore wind projects, and the critical factors for their effective implementation.

Table 9.1 Main objective, examples, and critical success factors of the mitigation measures applied at different levels of the mitigation hierarchy.

Levels of the mitigation hierarchy	Main objective	Practical examples	Critical success factors
Avoid	Preventing/Eliminating the occurrence of an impact.	(1) Redesign/micropositioning of the layout to avoid migratory routes/sensitive seabird areas (Furness et al., 2013). (2) Apply prevention measures from the beginning of planning (before site/design decisions), expanding opportunities to avoid sensitive areas (CSBI, 2015).	Planning and analysis of alternatives; zoning/environmental screening and availability of maps/data.
Minimize	Reduce the impact magnitude or modify the design to affect less-sensitive environments.	(1) Bubble curtains in pile driving to reduce underwater noise and temporary habitat loss for marine mammals (Dähne et al., 2017). (2) Quieter installation methods than traditional pile-driving techniques. (3) Real-time operational monitoring and adjustment to reduce collisions.	Appropriate technology; good construction practices; schedules compatible with ecological cycles; integration with adaptive monitoring and adjustments.
Restore	Recover directly affected areas.	(1) Structures/foundations and erosion protection functioning as "artificial reefs", favoring benthic colonization and increased diversity/biomass (Langhamer, 2012). (2) Use of biodegradable artificial reefs and structures to promote biodiversity (see Tree Reefs cases; Oyster Hubs; EcoWende).	Clear and measurable goals; baseline/indicators; selection of areas with potential; monitoring and course correction (monitoring and adaptive management).
Offset	Compensate for unavoidable residual impacts.	(1) Support for new/expanded protected areas or strengthening of management (where additionality is available) (World Bank Group, 2016). (2) Restoration/restoration of habitats (e.g., mangroves/seabed) as an offset activity (World Bank Group, 2016). (3) Creation of alternative habitats, support for protected areas and restoration, with an emphasis on criteria such as additionality/equivalence/permanence (Vaissière et al., 2022).	Additionality (gains beyond what would occur without offset) (World Bank Group, 2016). Equivalence (like-for-like; and, in specific cases, trading-up) (World Bank Group, 2016). Permanence with legal mechanisms and long-term financing (CSBI, 2015). Transparent governance, monitoring, and social participation (World Bank Group, 2016; CSBI, 2015).

Table 9.2 presents a concise menu of mitigation measures for typical impacts of offshore wind projects, linking each impact to the options available at each stage of the mitigation hierarchy. The impacts adopt a code and statement as per Table 5.2.

Table 9.2. Concise menu of mitigation measures for typical impacts associated with offshore wind projects.

Potential impact	Avoid	Minimize	Restore	Compensate
I08 Loss of benthic habitats and species	Avoid sensitive habitats in the layout and cable routing (Laurino et al., 2025).	Reduce the affected area; use HDD and less invasive techniques (NEC, 2024; NYSERDA, 2021; USACE, 2014).	Rehabilitate disturbed areas; promote benthic recolonisation (Langhamer, 2012; Dodds et al., 2022).	Restore/protect equivalent habitats, ensuring additionality and equivalence (WORLD BANK GROUP, 2016; Pope et al., 2021).
I06 Deterioration of water quality	Avoid routes and methods that cause greater seabed disturbance.	Control plumes; phase works; use HDD (NEC, 2024; NYSERDA, 2021; USACE, 2014).	Local recovery where feasible.	Only for significant residual losses.
I04 Behavioral disturbances in marine sound-sensitive species	Avoid sensitive areas/periods; select quieter methods.	Bubble curtains, seasonal windows, exclusion zones and monitoring (Dâhne et al., 2017; JNCC, 2025; MARINE SCOTLAND, 2019).	Generally not directly applicable.	Only in exceptional cases of significant residual impact.
I13 Increased bird and bat injury and mortality	Redesign layout to avoid migratory routes and sensitive areas (Furness; Wade; Masden, 2013; Croll et al., 2022).	Operational adjustments and real-time monitoring (Breuer, 2025).	Not usually applicable	Measures aimed at conserving affected habitats/populations.
I18 Changes in habitat use patterns in highly mobile species (birds, marine mammals, turtles and fish)	Avoid feeding, breeding and movement areas.	Traffic management, speed limits, observers and fauna detection (JNCC, 2025; MARINE SCOTLAND, 2019).	Possible only in some contexts.	Conservation actions in critical areas, with an ecological link to the impact.
I20 Changes in biodiversity composition (reef effect)	Avoid siting where the introduction of hard substrate would be undesirable.	Select more suitable materials/configurations (Dodds et al., 2022).	Use structures to promote local colonisation, without conflating this with full restoration (Langhamer, 2012; Martinez et al., 2026).	May form part of broader strategies where justified.
I01 Introduction and dispersion of exotic species	Avoid vectors and incorporate biosecurity measures.	Hull/equipment cleaning and early monitoring (Soares et al., 2022).	Early control or removal, where feasible.	Not usually the primary response.
I14 Increased conflicts related to marine space and use	Ensure compatibility with marine spatial planning and fishing-use areas (Liao, 2023).	Adjust operational areas; develop coexistence arrangements (Methrata, 2025; Szostek et al., 2025; Stelzenmüller et al., 2021).	Not usually directly applicable.	Financial compensation and livelihood support, depending on context (Jørgensenet al., 2020; Glasson et al., 2022).
I12 Visual impact	Select location/distance from shore to reduce visual intrusion.	Adjust layout and communication with users of the area (Machado; DE Andrés, 2023; Oh; Nam; Kim, 2023).	Not usually applicable.	Social/territorial compensation may be required.

The table should be read as a guiding instrument for selecting measures compatible with the nature of the impact, the ecological and social context, and the phase of the project's life cycle, and not as an exhaustive list or fixed recipe. It is worth highlighting that mitigation measures should prioritize significant impacts. Less significant impacts can be managed through standardized control measures.

For mitigation of impacts to be effective, the mitigation hierarchy must be applied iteratively and adaptively throughout the project cycle, from site selection to decommissioning. It is also necessary to have systematic monitoring to ensure adequate implementation and to evaluate, over time, whether or not the set of planned measures is, in fact, contributing to maintaining the impacts at the levels considered acceptable in the decision-making process. Monitoring should be based on clear, verifiable indicators sensitive to the site's environmental dynamics (**Chapter 7**), enabling adaptive adjustments when expected results are not achieved (**Chapter 11**). This process ensures not only compliance with the objectives of the EIA but also the legitimacy of the decisions made in the eyes of society and regulatory bodies (BBOP, 2013; CSBI, 2015; Duarte et al., 2027).

It is essential that the proposed measures be evaluated for their technical, environmental and legal feasibility, explaining the effectiveness and uncertainty expected for them to succeed in achieving the expected results. This evaluation is an important part of the decision-making process in the EIA, as it is directly associated with the decision on the acceptability of the residual impacts and trade-offs of the project as a whole.

While opportunities for prevention and minimization are more frequent in the early phases, restoration and compensation measures tend to occur later and can extend throughout the operation, requiring periodic reviews and course corrections when necessary:

Planning: identify sensitive areas (ecological and social), conduct screening/zoning, and consider location, layout, and scheduling alternatives to avoid impacts from pre-planning. Decision-making should be iterative, re-evaluating alternatives whenever there is a risk of non-mitigating impacts or excessive costs/risk in the later stages of the hierarchy.

Construction: implement the measures defined in the impact assessment stage and operationalize the minimization, with strict control of the pressures generated in the work. This includes, for example:

- Environmental windows (e.g., avoiding critical periods of reproduction/migration);
- Maritime traffic management (routes, speed limits, exclusion zones, and sighting/warning protocols);
- Noise and vibration reduction (good practices and mitigation technologies during installation);
- Control of sediment/turbidity dispersion (methods and real-time monitoring when applicable);
- Registration of non-conformities and adaptive response, adjusting procedures when environmental performance is below expectations

In construction, the hierarchy serves as an adaptive management structure, as monitoring results must feed back into decisions, adjusting methods, schedules, routes, and activity intensity to keep impacts within acceptable limits.

Operation: implement and continuously monitor the effectiveness of the proposed actions (e.g., operational adjustments, detection/monitoring of fauna, maintenance of areas of ecological relevance, and response protocols), with periodic review and adaptive management when necessary.

Decommissioning: plan closure early and ensure that assumed restorations and/or compensations are effective and sustainable in the long term, with defined goals, indicators, and responsibilities, and maintain adaptive management and correction mechanisms when results are not achieved.

Measures are often organized into environmental (or socio-environmental) management plans. The plans and their respective measures must be described in the EIS itself and are usually detailed in later documents, such as environmental and social management plans. Plans should include technical details on the implementation of the measures, including objectives, responsibilities, timeline, budget, expected results, outcome evaluation indicators, and guidelines for collection and interpretation, as well as forecasting performance evaluations (Sánchez, 2020).

Box 9.1. Seeking references for proposing mitigation measures

The definition of mitigation measures for offshore wind energy projects in tropical environments will likely require an initial period of experimentation and learning over the coming years, as these projects remain relatively rare in these contexts and evidence of mitigation effectiveness is limited.

In this context, selecting potentially effective measures requires combining caution and pragmatism: it is advisable to draw on accumulated experience in other offshore sectors (e.g., oil and gas, cables and pipelines, dredging, and shipping), where there is already a history of impact management, monitoring, and adaptive responses, and also to examine established practices in non-tropical regions, identifying which can be transferred consistently and which need to be adjusted to the ecological, social, and institutional particularities of tropical contexts.

At the same time, local technical-scientific knowledge should also be valued in the search for the best solutions in each context, as should traditional knowledge, which can be decisive in assessing the potential effectiveness of measures in some situations.

9.3 Mitigation measures for marine biodiversity in offshore wind energy projects

During construction, some of the main impacts stem from laying and burying submarine cables (Activity OF06, Table 5.1). The excavation of the seabed and the burial of cables in reef areas can alter calcareous algae and coral communities, as well as degrade benthic organisms, thereby affecting biodiversity and the integrity of marine ecosystems. To mitigate these impacts, recommended measures include avoiding critical periods for marine fauna, such as breeding or migration phases, and avoiding installation in sensitive or protected habitats. The identification of these periods and areas depends on the information obtained from the environmental baseline studies (Chapter 7).

Other measures include relocating sensitive organisms before activities begin and adopting less invasive installation techniques. Among these techniques, the installation of trenchless cables by horizontal directional drilling (HDD) stands out, especially in transition stretches between terrestrial and marine environments (landfall) or in environmentally sensitive areas (Figure 4.4). This technique reduces the need for trenching and direct seabed disturbance, minimizing sediment resuspension and increased turbidity (NEC, 2025; NYFTWG, 2021). The technique has been applied, for example, in the Block Island Wind Farm project (USA), whose environmental assessment describes the use of long-distance directional drilling for the installation of the cable landing section (USACE, 2014).

Also, during the installation phase, the intense movement of support vessels (Activity OF03, Table 5.1) can attract pelagic fauna species and increase the risk of mortality of marine mammals, fish, and turtles, mainly due to collisions. To reduce this risk, measures such as avoiding environmentally sensitive areas – even if this results in longer routes – and establishing speed limits for vessels as part of a Maritime Traffic Management Plan are recommended. In addition, systems for detecting and monitoring marine fauna, such as sonar and underwater cameras, can be used to warn of the presence of animals in areas of operation.

Another measure used in some projects is the installation of acoustic deterrent devices, such as pingers or seal scarers, which emit aversive sound signals to temporarily reduce the likelihood of marine mammals approaching during higher-risk activities. Such strategies have been adopted, for example, in Scotland, at the Beatrice Offshore Wind Farm and the Moray East Wind Farm (Marine Scotland, 2019).

These devices should be used with caution, in a targeted and temporary manner, to avoid excessive displacement or adverse impacts on fauna, and their application should be accompanied by an evaluation of effectiveness (JNCC, 2025).

During the operation phase, although the impacts may be less intense than in the construction phase, relevant concerns persist. These include changes in the landscape and the use of marine space, possible changes in the migratory routes of birds, marine mammals, turtles, and fish, and sound and electromagnetic disturbances associated with the continuous transmission of energy (Table 5.2). To mitigate these impacts, measures are needed to reduce the visual and physical interference caused by wind turbines, especially in areas with consolidated tourist potential or along migratory routes of sensitive species.

Among these strategies, design solutions that increase the visibility of turbines to relevant species stand out, including the judicious use of colors, shapes, and signage. It is also important to maintain ecological corridors that allow the safe migration of species. In addition, the implementation of systems capable of detecting the presence of migratory species in the vicinity of the turbines, and automatically adjusting equipment operation is identified an effective measure to reduce the risk of collisions and minimize the impacts on fauna in transit (IUCN, 2021; IPIECA, 2022), a measure also adopted in onshore wind farms.

These measures are primarily aimed at avoiding and minimizing the expected impacts, in accordance with the mitigation hierarchy. Their implementation should be integrated into specific environmental monitoring programs, enabling continuous monitoring and adaptation of strategies as needed (Chapter 11). When significant residual impacts persist after the application of these measures, the adoption of compensatory measures may be considered as the last step in the mitigation hierarchy.

Projects aiming to achieve positive impacts on biodiversity (described internationally as *nature positive* or *net gain*) should define a robust strategy for characterizing current environmental conditions (Chapter 7) and the gains to be achieved. Box 9.2 presents a case involving measures of this nature.

Box 9.2. Search for innovation and positive impacts on biodiversity

An offshore wind farm in the Netherlands, EcoWende, has been presented as a project that tests solutions to raise the environmental standards of offshore wind farms, combining mitigation measures with initiatives to promote biodiversity. Located 53 km offshore, the 760 MW project aims to supply approximately 3% of the Netherlands' electricity demand.

Ecological innovations include the use of biodegradable artificial reefs (Tree Reefs) and structures called Oyster Hubs to promote marine biodiversity, as well as the adoption of ecological protections against seabed erosion to minimize sediment disturbance.

Regarding of underwater noise during foundation installation, EcoWende reports on the evaluation and application of alternatives to reduce reliance on traditional impact pile-driving techniques. However, the project documentation itself recognizes that it may be necessary to complete the installation of monopiles with traditional driving if innovative techniques do not reach the required depth. In this scenario, noise mitigation measures associated with traditional pile driving are discussed, including the use of bubble screens and hammer dampers, among other solutions.

The project also describes tests of monitoring systems to track bird and bat activity and inform operational adjustments aimed at reducing the risk of collisions, as well as initiatives to make ecological data available and encourage transparency and applied research.

In addition, there is a collaboration with HUB Ocean to make ecological data publicly accessible, promoting transparency and supporting new research, thereby enhancing the monitoring system's capacity to support adaptive management.

In summary, the case illustrates how projects can combine: (i) classic measures of the mitigation hierarchy (avoid–minimize–restore–compensate) with (ii) innovation initiatives that seek to go beyond mitigating adverse impacts and enhance positive impacts, aiming for net gain for biodiversity.

With the first monopillar installed in December 2025 and the project expected to start operating by the end of 2026, the experience so far shows that part of these ambitions depends on technical feasibility and the conditions defined for the approval of the project, reinforcing the importance of explaining limitations, uncertainties, application criteria, and monitoring of effectiveness.

More information at: https://ecowende.nl/en/our-innovations/

9.4 Effectiveness of biodiversity offsets

The effectiveness of compensation measures depends directly on robust monitoring and evaluation mechanisms over time, addressed in Chapter 11. Biodiversity offsets have specific requirements due to the complexity of ecosystems and should not be seen as one-off or merely formal solutions, but as long-term commitments to measurable, verifiable conservation goals.

It is important to highlight the need for measurement and verification as essential to ensure the credibility and obtain demonstrable results. Otherwise, the compensation commitment becomes merely formal. It is critical to define clear ecological indicators, establish reliable baselines, and implement continuous monitoring plans, preferably with independent audits and social participation and engagement.

In addition, it is recommended to implement corrective measures if targets are not met to ensure the principle of "no net loss" is respected. The absence of adequate evaluation can compromise the legitimacy of compensatory actions and, ultimately, the integrity of the EIA process.

The effectiveness of compensatory actions is directly related to their ability to generate environmental results equivalent to, or greater than, the residual impacts they are intended to address. To this end, these actions must be designed on a solid ecological basis and implemented in areas that are feasible for recovery and relevant to conservation.

Effective offsets go beyond the simple creation of new protected areas or the terrestrial habitat restoration; they require clear goals, defined governance mechanisms, financial guarantees for their long-term maintenance, and transparency in the results achieved. Independent and periodic evaluations, combined with the involvement of local communities and scientific institutions, are essential to validate the effectiveness of interventions and promote adaptive adjustments when necessary. In this way, it is ensured that offsets fulfill their role as the last step in the hierarchy, making a tangible contribution to the maintenance of biodiversity and the affected ecosystem services.

The implementation of compensation measures requires high technical rigor and institutional commitment. Negligence in the implementation phase or the use of generic and decontextualized offsets not only can compromise the intended environmental outcomes but also undermine public confidence in the EIA process. Thus, the competent EIA authority, proponents, and consultancies must share the responsibility for ensuring that offsets are effective, integrated with public policies, and aligned with national and global biodiversity conservation goals.

Box 9.3. Offshore wind as part of a regional regeneration strategy

No In the context of offshore wind energy development, South Korea represents an emerging example of how large-scale renewable energy projects can contribute to broader coastal regeneration goals when properly integrated into regional planning and stakeholder engagement strategies. In Jeonnam Province, the government plans to install 8.2 GW of offshore wind capacity while advancing three pillars of regeneration: economic revitalization, community engagement, and environmental restoration.

Economic revitalization focuses on creating local employment opportunities and energizing coastal economies through new supply chains and blue economy sectors. Community engagement is promoted through participatory planning processes and benefit-sharing mechanisms to increase social acceptance and trust. Environmental restoration can support ecosystem regeneration and strengthen marine biodiversity, especially when combined with marine spatial planning and nature-based solutions. These components align with the mitigation hierarchy, suggesting that, if designed with a focus on regeneration, offshore wind projects can deliver net positive outcomes. The South Korean case reinforces the importance of early integration of regenerative strategies into the project cycle, ensuring that mitigation actions are not only preventive but also aimed at improving environmental quality and the quality of life of local communities.

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Chapter 10

CUMULATIVE IMPACTS

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When multiple projects are constructed and operate in the same area, their impacts can add up or interact, resulting in additive or synergistic cumulative impacts, respectively. If these impacts are not considered during the environmental assessment and decision-making process for a proposed project, the project's acceptability may be compromised. Integrated into Environmental Impact Assessment (EIA), Cumulative Impact Assessment (CIA) analyzes the incremental contribution of the proposed project to changes in the condition of selected environmental and social components, considering the existing impacts as well as those that may occur in the future from other activities. This chapter presents the fundamentals and provides practical guidance on CIA within an Environmental Impact Study (EIS).

THIS CHAPTER:

1 What are cumulative impacts?
2 What is the importance of assessing cumulative impacts on project Environmental Impact Assessment?
3 How to assess cumulative impacts at the project level?

10.1 What are cumulative impacts?

Cumulative impacts are changes in the condition or state of environmental components as a result of the sum or interaction of impacts from past, present, and reasonably foreseeable future actions, in conjunction with a project under analysis.

> **Example of cumulative impact:**
> The installation of offshore wind turbine foundations alters seabed habitats due to the introduction of artificial structures, resulting, among other impacts, in the loss of benthic habitat. When multiple offshore wind projects are deployed in the same region, the individual impacts accumulate, amplifying the magnitude of habitat loss.

Understanding the definition of cumulative impacts is important, as it will guide the basis of the analysis that will be carried out. Therefore, it is important to "adopt an operational definition before starting a study on the CIA (Sánchez, 2023, p. 17) addressing its fundamental elements."

CIA focuses on certain components of the environment (Figure 10.1), selected for their importance in the environment and/or considered of greatest concern from a scientific or sociocultural point of view. Depending on the context, the components can be subdivided into subcomponents (Box 10.1).

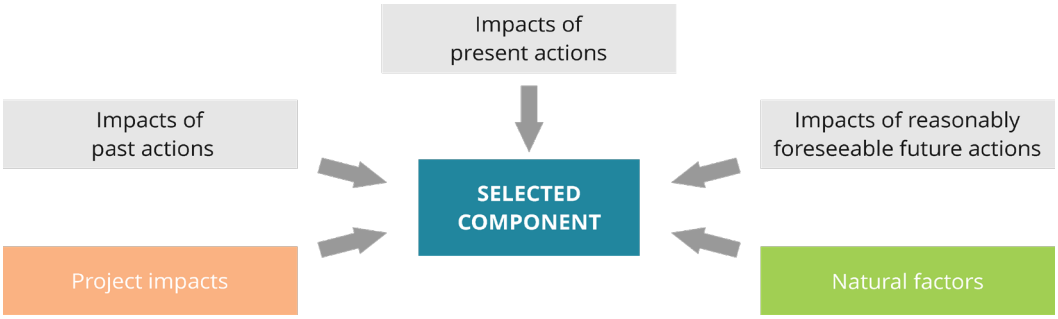


Figure 10.1. Focus of the Cumulative Impact Assessment.

Table 10.1. Examples of environmental and social components, sub-components, and cumulative impacts.

Environmental and social components	Subcomponents	Cumulative impact example
Birds	Pelagic birds	Habitat loss
Marine mammals	Cetaceans	Behavioral change
Cultural heritage	Historical heritage	Deterioration of cultural property
Natural vegetation	Forest	Loss of native vegetation

To assess cumulative impacts, it is essential to consider the impacts arising from multiple activities in a given region: remaining impacts from past activities, impacts from present activities, and impacts from future activities.

Cumulative impacts may result from the sum of similar impacts or from synergistic interaction between different impacts.

There are two main types of cumulative impacts (Figure 10.2). Cumulative additive impacts are impacts of the same nature arising from several activities that add up, resulting in an impact of greater magnitude. Synergistic cumulative impacts, on the other hand, arise from the interaction of impacts of different natures from various activities, resulting in another impact of a different nature.

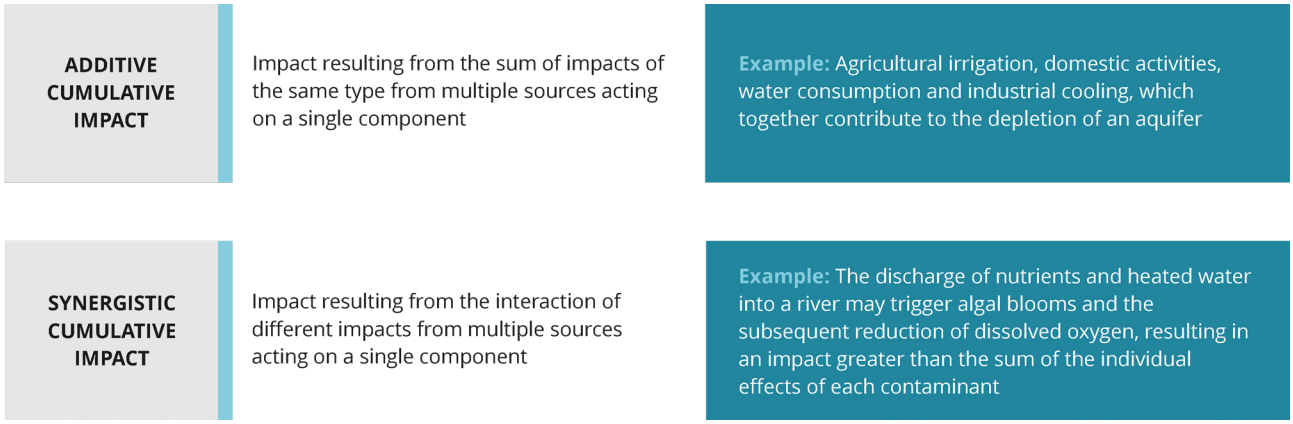


Figure 10.2. Main types of cumulative impacts.

In this context, CIA is a systematic process that aims to understand how certain environmental and social components are affected by various activities. The CIA is an assessment that can be carried out within various impact assessment instruments (Chapter 2), such as regional and strategic assessments, as well as impact assessments of several or a single project. Assessing cumulative impacts as part of an EIS is mandatory in several countries.

Learn more

Olagunju et al. (2021) present a survey of CIA requirements and practices in eight countries (Australia, Brazil, Canada, Ghana, Mexico, New Zealand, Nigeria, and the United Kingdom).

10.2 What is the importance of assessing cumulative impacts in the project Environmental Impact Assessment?

CIA is necessary when there is concern that a project may generate cumulative impacts on certain environmental and social components. In regions with a high concentration of projects, understanding the additional pressure each new project imposes on components already impacted by these activities is critical to defining what is acceptable (Gunn; Noble, 2012).

CIA at the project level is a key source of information for decision-making on proposed projects and has been applied in offshore wind developments (Willsteed et al., 2018). It enables decision-makers and stakeholders to assess whether the impacts of a new project, in combination with those of other activities, may exceed acceptable thresholds and compromise the sustainability of environmental components. If so, it is necessary to define which mitigation measures should be adopted by the proponent and which should be adopted by other private and public agents, within an arrangement of responsibilities that goes beyond what is usually addressed in project EIA, which focuses only on the obligations of a single proponent.

Thus, even where the CIA is not mandatory, it can be adopted voluntarily whenever components in an affected area need broader assessments to ensure maintenance of minimum levels of socio-environmental quality that the project EIA usually does not capture.

In summary, the CIA, as part of an EIS, contributes to understanding the project's consequences in a broader context, which is not isolated from other activities that affect the conditions of the components of interest. It is a tool that supports project proponents, decision-makers, and the public in situating a project within a broader temporal and spatial context to assess whether a new disturbance compromises the sustainability of the components.

Benefits of the CIA at the project level:

- Facilitate early identification of risks by recognizing environmental and social components that are vulnerable to cumulative impacts, enabling the timely implementation of effective mitigation and monitoring measures. It also reduces the need for additional mitigation requirements or project conditions to be introduced during advanced stages of project development.
- Allows for the assessment of the project's contribution against a broader scenario of other pressures, facilitating the assessment and communication of project responsibility.
- Guides effective collaboration among other proponents and interest groups for the collective implementation of mitigation and monitoring measures at appropriate scales.

10.3 How to assess cumulative impacts at the project level?

The methodological approaches to the CIA have a common foundation. In this guide, we primarily follow the recommendations of IFC (2013), Noble (2020), Sánchez (2023), and RenewableUK (2013) to present five fundamental steps for the concurrent construction of the CIA and the preparation of the EIS. Figure 10.3 presents a summary of the steps, with the following details. This proposal is appropriate when there is no predefinition of the components and cumulative impacts to be investigated in the scoping stage of EIA (Chapter 6).

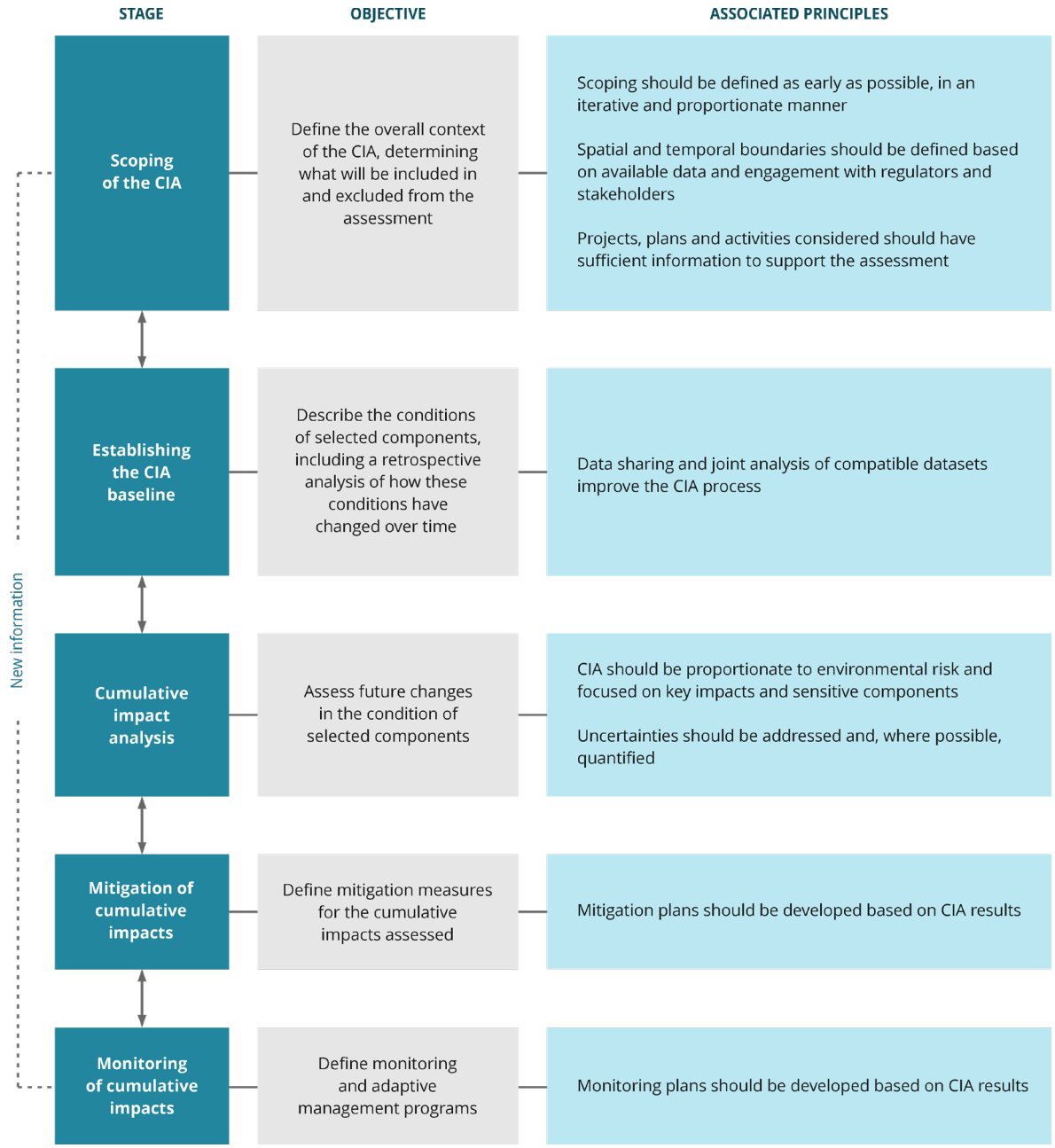


Figure 10.3. Steps, objectives, and principles associated with the Cumulative Impact Assessment (Source: Prepared based on Sánchez, 2023 and RenewableUK, 2013.

It is important to note that these steps can be carried out iteratively, that is, revised to refine the analyses, as new information is analyzed in different scenarios.

Unlike project EIA, which starts from the activities of a project to analyze its impacts, CIA focuses on understanding how the selected components are affected by the total impacts of multiple activities in a given location.

10.3.1 Step 1: Scoping of the Cumulative Impact Assessment

Scoping aims to define the scope of the study and involves the following tasks:

1. Identification and selection of the environmental and social components that will be the focus of the assessment;
2. Identification and selection of other activities, projects and drivers of change that affect the selected components;
3. Delimitation of the time limits of the assessment; and
4. Delimitation of the spatial limits of the assessment.

Selection of Components

The selection of components is one of the most relevant tasks in the CIA process. Due to its complexity, it should focus on a limited number of components, enabling a more in-depth and feasible analysis. However, there is no rule to define such a number.

The definition of the components may vary in scope, ranging from broad categories to specific elements, such as certain species. When broad components are selected, it is possible – and in some cases desirable – to associate subcomponents, enabling a more targeted assessment of potential cumulative impacts (see examples in **Box 10.1**).

> The components can be defined at different levels of specificity, from broad categories (e.g., terrestrial vegetation) to specific species of ecological, social, or vulnerability importance. Indicator species can be used to represent the state of the environment and predict impacts on other species or groups. This approach is valid, but it requires caution: different species and metrics (such as population density, birth/death rates, or habitat suitability) respond differently to environmental impacts (CEAA, 2015).

The selection of components must be guided by clearly explained criteria, with appropriate justification for each choice. The availability and quality of existing information are relevant factors to be considered in this process.

As a starting point, one can start the choice of components from the list of the most important impacts of the project of interest (Chapter 5), relating them to the components affected by each one, and then refine the selection by adopting criteria such as: i) regulatory interests; ii) the potential for interaction with other projects; iii) value for the conservation of biodiversity, social or recreational, economic and cultural, for use by Indigenous Peoples and of scientific interest (Gunn; Noble, 2012).

The practice of considering only those components for which significant impacts of the project have been predicted is criticized by several authors, since components affected by impacts considered not significant by a project can still be significantly affected when considering the impacts of other activities, plans, or projects. That is, even if an impact is not significant in isolation, it can contribute to significant cumulative impacts. Box 10.1 presents an example of an applied approach that considered all residual project impacts involving some degree of environmental change in order to assess their potential contribution to cumulative impacts.

It is also worth emphasizing the importance of public participation and engagement (see Chapter 3) in all stages of the CIA, especially in defining the components that will be the focus of the assessment. Box 10.2 presents a method for selecting components in collaboration with an Indigenous community.

Box 10.1. Example of criteria used for including impacts in Cumulative Impact Assessment

The EIS of for the Morecambe Offshore Wind Farm, located in the eastern Irish Sea with an installed capacity of 480 MW, considered all residual project impacts involving some degree of environmental change to assess their potential for cumulative impacts. Subsequently, the contribution of other projects and activities located within the reference population areas for marine mammals was evaluated to determine their contribution to cumulative impacts. The table below presents an excerpt of the rationale used to justify the inclusion—or exclusion—of impacts in the CIA for the marine mammals component.

Impact	Project alone residual effect	Potential for cumulative effect?	Rationale
Construction phase			
Impact 1: Direct disturbance and displacement	Minor adverse	Yes	The likelihood that there would be a cumulative impact is low because the contribution from the Project would be small and dependent on a temporal and spatial co-incidence of disturbance/displacement from other plans or projects. However, potential cumulative effects with the Morecambe and Morgan OWFs Transmission Assets did present a pathway given the proximity to the windfarm site.
Impact 2: Indirect impacts through effects on habitats and prey species	Minor adverse	No	The likelihood that there would be a cumulative impact is low because the contribution from the Project would be small and dependent on a temporal and spatial co-incidence of disturbance/displacement from other plans or projects. While there would be other projects in proximity and on a similar timescale, as no significant cumulative effects have been found on habitats and prey species there would be no significant effects on ornithology receptors.
Operation and maintenance phase			
Impact 1: Direct disturbance and displacement	Minor adverse	Yes	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Impact 2: Collision risk	No change to Minor adverse	Yes	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Impact 3: Combined collision risk and displacement	Minor adverse	Yes	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.

Source: Royal Haskoning DHV (2024a).

Box 10.2. Method for the selection of components involving an Indigenous community

A method for selecting components was developed in collaboration with the Metlakatla Nation Indigenous community (Canada), as part of a program to assess and manage the cumulative impacts on the community's traditional territory. The method consists of six steps:

- **Step 1:** Comprehensive scoping, with the identification of components through the analysis of various community and territory planning and policy documents.
- **Step 2:** Identification and application of selection criteria for the components and indicators, namely: traditional importance or other significance, sensitivity to the context of development, responsive, measurable, and practical indicators, representativeness of key habitats, key role in the ecosystem, and threatened species.
- **Step 3:** Engagement with Metlakatla managers and leaders, research collaborators, and experts to select the priority components, conducting a workshop.
- **Step 4:** Identification of criteria for the selection of potential components for the pilot project, these being the level of priority, competence, capacity to influence changes, and capacity and resources for monitoring implementation.
- **Step 5:** Selection of components for the pilot project, with the conduction of a second workshop.
- **Step 6:** Implementation plan to advance on the other priority components in the program.

Source: Kwon et al. (2024).

Selection of activities, projects and drivers of change

This task aims to identify other actions that can act as sources of cumulative impacts. To do this, it is essential to consider past activities — whose impacts may persist — as well as current and future activities that influence and/or may influence the conditions of the selected environmental and social components.

In the context of the implementation and expansion of offshore wind farms, it is important to consider the cumulative impacts of several wind farms, as well as other activities, such as fishing, navigation, and oil and gas activities, contributing to the Ecosystem-Based Management of the coastal and marine environment (Chapter 1). For identifying future actions, several public information sources can be considered. An important point is that government agencies play a fundamental role in indicating and validating the activities to be considered within the scope of the CIA (Dibo et al., 2018).

Sources of information for the identification of other actions in the coastal and marine environment:

- Projects submitted to EIA at the national and state levels;
- Marine Spatial Planning;
- Coastal Management Plans;
- Management Plans for Conservation Units;
- Sectoral plans and programs (such as energy, tourism, mining, transport) (see Chapters 2 and 6).

Consideration should also be given to activities that may be induced by the project under analysis, that are those that may occur if the project is approved. For example, the installation of an offshore wind farm can stimulate the expansion of local port infrastructure. When there is evidence that similar projects result in associated developments, these activities are considered reasonably foreseeable. In these cases, scenario analysis is a widely used tool to identify hypothetical actions — discussed on a conceptual or speculative basis, according to the available information. The objective is not to predict the most likely scenario, but to anticipate possible consequences under different future conditions, contributing to a more effective management of cumulative impacts.

The identification of other projects should not be restricted to those of the same type. The CIA of offshore wind projects may consider not only other offshore wind projects, but also any other projects or activities that take place in the defined spatial boundaries.

An example of a procedure for the selection of activities adopted in the United Kingdom involves: (i) the definition of a long list of other existing or approved activities; and (ii) the definition of a short list of other projects (UK Planning Inspectorate, 2025). An example of applying these two steps is presented in **Box 10.3**.

Box 10.3. Procedure for the selection of other actions to be considered in the Cumulative Impact Assessment

The EIS of the Dogger Bank South Offshore Wind Farm project located in the North Sea, considered the activities located in the zones of influence of each environmental component defined for the CIA. It was based on the following sources of information for the establishment of the long list of other actions in the offshore environment: geographic data, hydrographic data, consultation of the website of the authority responsible for the EIA of large projects of national interest (Planning Inspectorate), website of the oil and gas sector regulator (OPRED), and individual project websites. The classification of actions is on a five-level scale that reflects the level of uncertainty regarding their implementation and, consequently, the potential occurrence of cumulative impacts in combination with the project's impacts. The scale follows the guidelines of the United Kingdom Department for Environment, Food and Rural Affairs (DEFRA), as presented below.

Tiers	Development Stage
Tier 1	Built and operational schemes should be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and / or any residual impact may not have yet fed through to and been captured in estimates of "baseline" conditions, such as "background" distribution or mortality rate for birds.
Tier 2	Tier 1 + schemes under construction.
Tier 3	Tier 2 + schemes that have been consented (but construction has not yet commenced).
Tier 4	Tier 3 + schemes that have an application submitted to the appropriate regulatory body that have not yet been determined.
Tier 5	Tier 4 + schemes that have produced a PEIR and have characterisation data within the public domain.
Tier 6	Tier 5 + schemes that the regulatory body are expecting an application to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects).
Tier 7	Tier 6 + schemes that have been identified in relevant strategic plans or programmes.

Subsequently, the following criteria were adopted to define a short list of actions to be considered in the CIA:

Scheme Screened-in	Scheme Screened-out
• Scheme is considered as part of the baseline environment but has ongoing effects; • Potential for an impact-receptor pathway to exist; • Potential for a spatial effect interaction to exist; and/o • Potential for temporal effect interaction exists.	• Scheme included as part of the baseline environment (therefore not a consideration in the CEA); • Low data confidence (meaningful assessment cannot be undertaken); • No potential impact-receptor pathways exists; • No potential for a spatial effect interaction; and/or • No potential for a temporal effect interaction.

Source: Royal Haskoning DHV (2024b).

It is also important to consider other environmental drivers of change that may interact with projects impacts, such as droughts and floods, temperature variations, or even fluctuations in predator numbers, which can affect the conditions of biological components. Importantly, climate change can significantly impact several components (**Box 10.4**). Another example of a driver of change is invasive species, such as the Sun Coral (**Box 7.1**, **Chapter 7**).

Box 10.4. Climate change and cumulative impacts

Climate change is already recognized as a major driver of change (Ferguson et al., 2025; IPBES, 2021; Laurino et al., 2025). From this perspective, in the CIA, it is important to consider the influence of climate change, based on climate scenario projections (Byer et al., 2018; Brownlie; Treweek, 2018). In an example presented by Nogues et al. (2021), the combined impacts of marine renewable energy and climate change projects on ecosystem properties were assessed through Ecological Network Analysis. In this analysis, climate variables are directly integrated into fundamental ecological parameters, modifying baseline conditions, such as energy flows and trophic structure, and that influence how other pressures interact with the ecosystem. The study reinforces that CIA should incorporate climate scenarios as a structuring condition of the analysis, recognizing its role in defining the sensitivity and response of the components assessed.

Delimitation of temporal limits

Historical and future perspectives on the components' conditions must be considered when assessing the cumulative impacts. Therefore, limits should be defined both in the past and in the future for the assessment of each selected component, with a clear presentation of their respective justifications. This definition must be carried out in conjunction with regulators and stakeholders as part of the EIA scoping (Chapter 6).

Regarding the time horizon in the past, an important — and often limiting — issue concerns the availability of sufficient data and information to describe the historical trends of the components. A history that contemplates the conditions of the components before relevant disturbances — or, at least, a less disturbed state — should be considered. The definition of specific time frames, such as the implementation of a major project or significant change in land use, is useful for characterizing the trajectory of the conditions of the components (Sánchez, 2023), the focus of Step 2 of the CIA.

Assessing only the current conditions of components is not sufficient to understand how they change over time.

There is also a need to define future temporal limits, considering a long-term horizon that ideally extends beyond the assessed project's life cycle. The impacts of a wind farm, even after its operation ends, may persist through the reproduction cycles of species affected by the project, as time lags in the impacts may prolong their persistence. As an example, golden eagles (Masden et al., 2010) do not enter the reproductive population until they are 4 or 5 years old. In this case, impacts on immature juveniles or immature individuals may remain undetected for several years until these individuals reach maturity, thereby negatively influencing the population renewal rate.

Delimitation of spatial boundaries

The spatial delimitation in the CIA differs from the area used to assess project impacts and is usually larger. This must also be set for each selected component. Although there is no general rule, an important point is that these limits reflect the distribution or spatial pattern of the selected components. At the same time, these limits should be ecologically relevant, but not so comprehensive as to make analyses difficult (Bennun et al., 2024).

Indicated approaches by CEAA (2015) for defining spatial boundaries:

- **Component-centered approach:** spatial boundaries are determined for each component and consider the geographic extent and zone of influence of the project being assessed.
- **Ecosystem-centered approach:** where boundaries depend on understanding the characteristics of an ecosystem such as topography, climate, soil. This approach is generally employed in regional assessments due to its greater scope.
- **Administrative, political or other centered approach:** boundaries are defined by social and institutional criteria. They are usually used for socioeconomic and cultural components.

As with other tasks, involving stakeholders (Chapter 3) in defining spatial boundaries is highly recommended. An example of defining spatial boundaries is presented in Box 10.5.

Box 10.5. Zones of influence defined for the Cumulative Impact Assessment of the Ossian Offshore Wind Farm project (UK)

In the CIA of the EIS of the Ossian Offshore Wind Farm, located on the east coast of Scotland, cumulative zones of influence were defined for each component considered in the project EIA. These zones are based on the spatial scales of potential impacts and the dynamics of environmental components. With the definition of these areas, all projects, plans, and activities with potential for interaction with the Ossian project were identified. Some of the defined zones of influence are presented below:

Environmental Component	Definition of cumulative zones of influence
Fish and Shellfish Ecology	The fish and shellfish ecology CEA study area is defined as 2 tidal excursions from the Array fish and shellfish ecology study area. For the purposes of CEA screening, any plans or projects outside a zone of influence of 20 km were excluded from the long list for fish and shellfish ecology for all cumulative effects, excluding underwater noise. A larger zone of influence of 100 km has been used when assessing underwater noise.
Marine Mammals	The marine mammals CEA study area is defined by the Regional marine mammal study area based on the extent to which the potential connectivity exists considering the mobility of marine mammals. For the purposes of CEA screening, any plans or projects outside a zone of influence of approximately 739 km, the furthest distance of the regional marine mammal study area, were excluded from the long list for marine mammals.
Offshore Ornithology	The offshore and intertidal ornithology CEA study area is defined by the maximum foraging range of gannet plus one standard deviation, from the Woodward (2019) ranges. With the energy projects, especially offshore wind farms, directly affecting the migration and foraging of sea birds, the foraging range of gannet was used to set the maximum distance within which energy projects were to be considered. For the purposes of CEA screening, any projects outside a zone of influence of 1,400 km were excluded from the long list for offshore ornithology.

Source: RPS (2024).

10.3.2 Step 2: Establishing the baseline for Cumulative Impact Assessment

The establishment of the baseline for CIA focuses on preparing an analytical characterization of the selected components, considering the defined temporal and spatial scales. This baseline should: i) describe the trajectory of the historical conditions of the components to the current conditions; ii) characterize the sources of change in these conditions; and iii) project future trends of these conditions, in the absence of the project being analyzed (Sánchez, 2023).

The fundamental point of the analytical baseline is to retrospectively analyze the conditions of the components to understand the changes that occurred over time that led to the current state. This baseline should support the analysis of the cumulative impacts.

To this end, it is essential to define indicators of change that allow us to measure disruptions and identify the areas of greatest concern, where thresholds have already been crossed or are close to being crossed.

For example, data and information on forest areas that were suppressed over time can support analysis of the recovery trajectory of these areas, allowing assessment of whether the current condition represents a new state of equilibrium or corresponds to a stage of recovery (IFC, 2013).

Furthermore, the availability of information and resources is fundamental in this process. In general, proponents of a project should use existing information; however, if relevant gaps are identified, additional data collection should be carried out. The collection of new data should be limited and focused on indicators that enable identification of changes in component conditions (see Chapters 5 and 7).

> Considering that the baseline of EIS are commonly descriptive, a complementary baseline may be necessary to adequately support the CIA. Thus, the conduction of a planned baseline and already oriented to CIA would be an alternative, allowing an analysis of the trajectory of the conditions of the components to be carried out, as well as an assessment of their sustainability (Sánchez, 2023).

10.3.3 Step 3: Analysis of cumulative impacts

The cumulative impact analysis step assesses how the activities and projects in focus (defined in the scoping step) may affect the future conditions of the selected components. To this end, three tasks are carried out: i) identification of cumulative impacts; ii) prediction of the magnitude of the cumulative impacts; and iii) determination of the significance of the cumulative impacts.

A key aspect is that the analysis should not be restricted to the incremental contribution of the project under assessment, but should also consider the cumulative impact of the various activities and projects considered on the selected components. The main focus should be on whether acceptable limits of change can be exceeded in determining the significance of impacts.

To support the identification of cumulative impacts, it is recommended to establish causal relationships between the sources of pressure and the impacts on the environmental and social components of interest. In this way, it is possible to visualize the pathways that lead to cumulative impacts, that is, the mechanisms by which a change is generated from the source(s). Thus, it facilitates the understanding of the complex interactions inherent to cumulative impacts. **Box 10.6** presents an example of causal relationships in the air quality component, with emphasis on identifying impact-causing factors from multiple activities.

Among the main components affected by the cumulative impacts from wind farms, birds and marine mammals stand out. Examples of cumulative impacts on birds include:

- Cumulative habitat loss associated with the direct occupation of foraging habitats by the physical structures of wind turbines.
- Reduction in population density due to the displacement of individuals and functional loss of habitat due to the presence of structures and increased mortality from collisions with turbines, which can be intensified by vessel traffic.
- Loss of ecological connectivity due to the fragmentation of migratory routes and displacements between essential habitats due to the successive installation of wind farms.

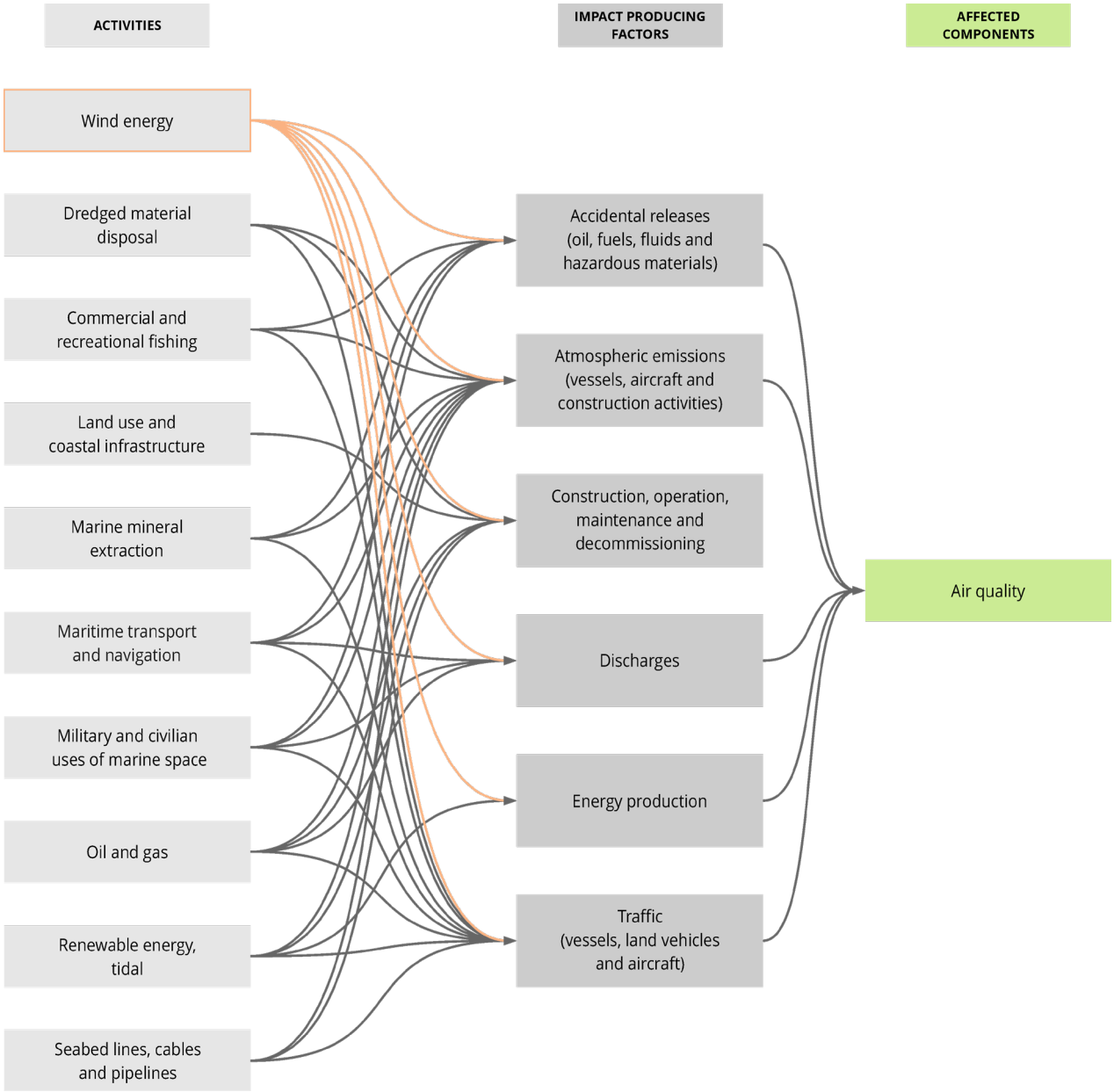
Box 10.6. Causal relationships and affected components

The Bureau of Ocean Energy Management (BOEM), the U.S. federal government agency responsible for managing energy, mineral, and geological resources on the Outer Continental Shelf, has prepared a technical document to establish a common framework of cumulative impact scenarios to be used when preparing impact assessments, focused on offshore wind energy activities.

Among the guidelines, the document identifies important cause-and-effect relationships between renewable energy projects and potentially affected resources.

To this end, as shown in the figure below, a relationship is established between the various activities, the impact producing factors and the affected components, which, in the example, is defined as air quality.

Factors causing impacts are understood as pathways through which an action or activity affects a given resource.



Box 10.6. Causal relationships and affected components (continued)

The technical document also presents a list of impact producing factors for each offshore activity considered, with a brief explanation, as shown below.

Air emissions • Aircraft • Onshore • Structures • Structures, generators • Vessels	Includes releases of gaseous or particulate pollutants into the atmosphere from stationary sources, vessels, vehicles, or aircraft, which can affect air quality and associated resources. Can occur both onshore and offshore.

Another form of representation of the relationship between activities and the impact producing factors that affect the air quality component is presented below. The consideration of climate change as a driver of change in the component's condition is highlighted.

Cumulative Impacts Scenario
Impact producing factors – Air Quality

	Dredge Material Ocean Disposal	Commercial and Recreational Fishing	Land Use / Coastal Infrastructure	Marine Minerals Extraction	Marine Transportation, Navigation, and Traffic	Military Ranges & Civilian Space Program Uses	Oil and Gas Surveys and Extraction	Renewable Energy-Wind	Submarine Cables, Lines, & Pipelines	Climate Change
Offshore Wind Energy Development impact producing factors										
Accidental releases	•	•	•	•	•	•	•	•	•	
Air emissions	•	•	•		•	•	•	•	•	
Discharges	•	•	•	•	•	•	•	•	•	
Energy generation, energy security								•		•
Port utilization	•				•		•	•		•
Traffic	•	•	•	•	•	•	•	•	•	
Cumulative Impact Scenario, Other impact producing factors										
Demolition/structure removal						•	•			
Port utilization, maintenance, dredging	•									•

Source: BOEM, (2020).

To predict the cumulative impacts, several methods can be applied, both quantitative and qualitative, based on the retrospective analysis performed. It is expected to understand how the selected components will respond to the pressures directly attributed to the proposed project, as well as those arising from other present or future projects and actions in the defined spatial delimitation. Therefore, it seeks to predict how indicators related to the selected components, such as a species' population or the water quality index (Noble, 2020), will respond to future pressures.

The significance of the cumulative impacts should be determined by considering the total effect on the selected components, i.e., the impact of the project, together with the other selected projects, adopting thresholds or acceptable change limits for each component. Therefore, it seeks to understand whether cumulative impacts compromise the sustainability of a component. To determine the significance of cumulative impacts, it is necessary to understand the tolerable level of change in the condition of the component (Noble, 2020).

10.3.4 Step 4: Mitigating cumulative impacts

At this step, mitigation measures for the assessed cumulative impacts are defined, and subsequent follow-up of these programs is conducted through adaptive management. Applying the mitigation hierarchy is also recommended for the CIA (Chapter 9).

For that, two main issues must be taken into account:

- The mitigation measures proposed for the project may not be sufficient for the cumulative impacts; e
- Since cumulative impacts result from the interaction between the impacts of various activities, mitigation measures must be implemented collectively, by other projects and actors.

In the United Kingdom, there is a recommendation that the mitigation measures that will be adopted within the scope of the project under assessment must be made explicit, individually. There is also a provision for ways to propose shared mitigation actions among those responsible for the pressures and impacts on a component (UK Planning Inspectorate, 2025).

10.3.5 Step 5: Follow-up of the cumulative impacts

At the follow-up step of cumulative impacts, mitigation measures must be implemented, and their effectiveness demonstrated (see **Chapter 11**). To this end, collaboration between diverse projects and stakeholders can be essential for the development of regional cumulative impact programs (for example, see **Box 11.2** in the next chapter). Finally, following the principles of adaptive management, it is necessary to adjust measures if the achieved results are not deemed sufficient.

From the above, it is essential to recognize that, for the management of cumulative impacts, defining governance is necessary to implement a collaborative management approach, with shared responsibilities.

Learn more

More information on the CIA process, we suggest to consult Sánchez (2023), Blakley e Franks (2021), Hegmann et al. (1999), IFC (2013) e Bennun et al. (2024).

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Chapter 11

FOLLOW-UP

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The main impacts of a project occur after its approval, when preparatory works, the establishment of construction sites, and construction itself begin, and continue through operations until the project's eventual decommissioning and closure. This chapter addresses the implementation of the mitigation measures defined in the Environmental Impact Study, monitoring, and other activities in the follow-up stage of Environmental Impact Assessment.

THIS CHAPTER:

1 What is the follow-up stage in Environmental Impact Assessment?
2 Monitoring as the centerpiece of the follow-up stage
3 Environmental monitoring
4 Social monitoring

11.1. What is the follow-up stage in Environmental Impact Assessment?

Follow-up stage in EIA process has as its main objective to enable the satisfactory implementation focusing on the mitigation measures and other conditions imposed in the approval (Chapter 9). In addition to enabling the prior assessment of the potential impacts of the activities, the EIA should be an adaptive process that guides the project's environmental and social management throughout its life cycle (Glasson, 2022). In decision-making about the project, conditions are established for its implementation and operation, to be observed during follow-up. Significant impacts (Chapter 8) must be considered under these conditions, evaluating the results of applying mitigation measures, and, if necessary, corrective measures are adopted.

The main functions of follow-up are (Glasson, 2022; Sánchez, 2020):

- Assess the effectiveness of mitigation measures and direct necessary adjustments, including actions to deal with unforeseen impacts;
- Obtain and analyze evidence that allows verifying the accuracy of the prediction of impacts;
- Contribute to learning processes, including improving the evaluation and management of other projects.

To conduct it, the follow-up answers questions such as: Was the impact prediction correct? Are the results of the proposed measures within expectations? Is any adjustment necessary? Are the affected communities fully informed about the project and agreed measures, and do they understand how they are affected? What have we learned from this process?

The follow-up involves five elements: monitoring, evaluation, management, communication, and governance (Arts & Morrison-Saunders, 2022; Pinto et al., 2019), as illustrated in Figure 11.1.

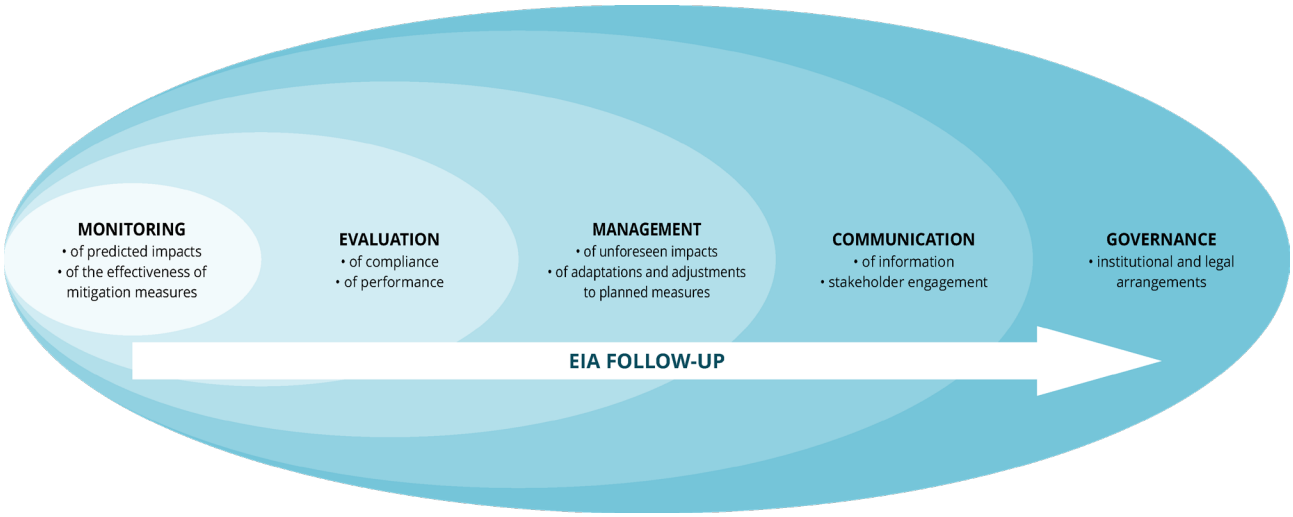


Figure 11.1. Elements that make up the follow-up stage of the Environmental Impact Assessment. (Source: adapted from Morrison-Saunders; Arts, 2005).

Monitoring involves the systematic collection of relevant data on the activities and impacts generated by the project, as well as on the effectiveness of the proposed measures (Arts & Morrison-Saunders, 2022; Glasson, 2022). The definition of what should be monitored is essential for efforts to be focused on obtaining data that, in fact, generate relevant information for project management. In other words, there must be coherence between the result of the impact prediction, the significant impacts, the proposed mitigation measures, and the monitoring, so that the indicators generated allow the comparison of the post-project condition with the reference condition (before the start of activities) (Chapter 7) (Glasson, 2022).

The data collected through monitoring must undergo evaluation to understand its meaning and inform management. Monitoring data can be assessed against both the baseline condition (Chapter 7) and anticipated impacts, as well as against legally defined standards, the project's expectations or objectives, and stakeholders (Arts & Morrison-Saunders, 2022). The effectiveness of the measures should also be evaluated, subsidizing management, which consists of making decisions and implementing actions in response to the information collected, for example, adjusting a mitigating measure to increase its effectiveness or modifying the monitoring itself (Arts & Morrison-Saunders, 2022). In this context, learning occurs through these evaluations, and adjustments are made in a cycle of continuous improvement, as shown in Figure 11.2. In this flow, the L1 cycle represents incremental operational adjustments, while the L2 cycle indicates strategic learning, with a review of assumptions and guidelines, evidencing a continuous process of improvement.

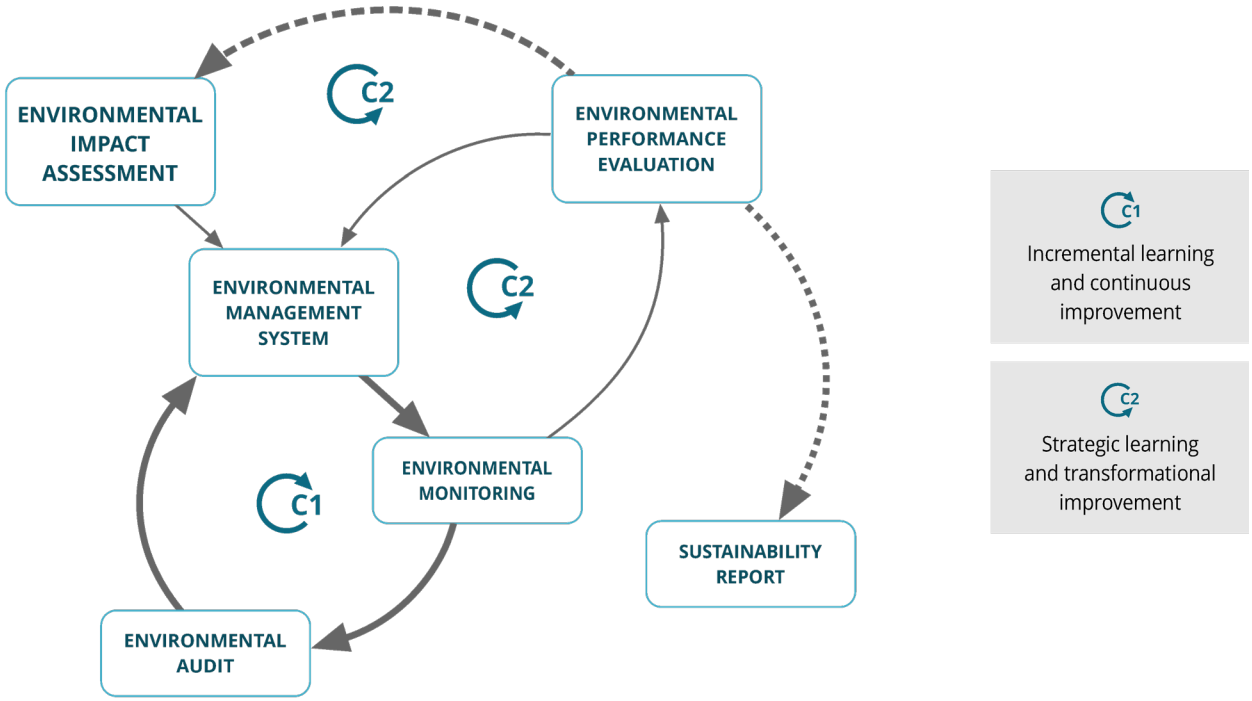


Figure 11.2. Learning cycles in Environmental Impact Assessment: feedback flows between Environmental Impact Assessment, environmental management system, monitoring, auditing, performance evaluation and sustainability reporting. Source: Sánchez (2012).

Communication should consider engagement with stakeholders (Chapter 3). It should not be limited to the steps preceding the approval of the project, but should continue throughout its life cycle, and contributing to improving the affected community's and other stakeholders' understanding of the residual impacts and the management measures adopted (Arts & Morrison-Saunders, 2022; Pinto et al., 2019).

Ideally, open and transparent communication mechanisms between the parties should be ensured, ranging from access to information to community participation processes, for example, through participatory monitoring (Glasson, 2022; Pinto et al., 2019). The creation of follow-up committees involving stakeholders is a model that can help with communication and engagement, especially with impacted communities.

Governance concerns the institutional and legal processes and arrangements for implementing the other elements of the EIA follow-up (Arts & Morrison-Saunders, 2022). These arrangements may differ across contexts, involving different stakeholders — usually project proponents, bodies responsible for the EIA process, and the community — and the distribution of responsibilities among them (Pinto et al., 2019). Although the distribution of responsibilities depends on the context, it will generally be the responsibility of the project proponent to implement all the conditions established during the decision-making process, which may include coordinating and conducting monitoring, evaluating the data collected, documenting and presenting information about compliance with the established conditions, and reviewing management activities.

The agencies responsible for the EIA, on the other hand, will often act in the evaluation and, in many jurisdictions, will have the function of inspecting, checking, and validating whether the project proponent is meeting its established commitments, such as the implementation of mitigation measures and the observance of the defined environmental limits. Often, these bodies can also impose sanctions on the project if the commitments are not met.

From the perspective of communities, it is important to establish mechanisms that guarantee access to information and to spaces for action by different sectors of society. In addition to preparing monitoring reports and submitting them to the competent body, it is also possible to define arrangements for community participation in the enterprise's management plans.

To illustrate an initiative to encourage participation in the EIA follow-up stage, Box 11.1 presents a Brazilian case in the offshore context.

Box 11.1. Environmental Education Programs in the oil and gas sector in Brazil as management processes

In the Brazilian context, Environmental Education Programs (EEPs) are required by the competent EIA authority as a mitigating measure for the impacts of offshore oil and gas projects. EEPs are implemented regionally and operate through continuous cycles of monitoring, community participation, and strategy reorientation. That is, they are organized to enable learning processes and their adaptation throughout the cycles.

The EEPs are structured into lines of action aimed at community strengthening, such as supporting social organization, promoting social control over resources, and stimulating public debate on local planning. This design allows the information produced by the communities themselves, throughout the execution of the program, to feed back into the monitoring process, adjusting methodologies, priorities, and approaches according to new needs and impacts that emerge in the territory.

In areas such as the Campos Basin, for example, the EEPs have been implemented by different companies in the oil and gas sector and have been directed to different priority audiences (women, quilombolas, young people, fishermen) for more than ten years, under regional coordination by the competent EIA authority.

Thus, the EEPs function as integrated systems of social and institutional learning in a structured, continuous way, promoting monitoring, listening to affected groups, identifying unexpected problems, and reviewing actions to maintain their effectiveness over time.

Studies show that, over more than a decade of implementation in the Campos Basin, these programs have strengthened community participation in environmental monitoring and management processes, influencing local policies and governance (Magalhães, 2024).

More information at: Technical Note DILIC/CGPEG/Ibama 01/10 and Ibama Normative Instruction - IN 02/12 (IBAMA 2010, 2012).

Learn more

See the "Principles of Good Practice for the Follow-up of Impact Assessment" (Arts & Morrison-Saunders 2022) and the guidance for implementing these principles (Morrison-Saunders, & Arts et al. 2024), published by the International Association for Impact Assessment (IAIA):

Best Practice: Impact Assessment Follow-Up - IAIA - https://iaia.org/best-practice-impact-assessment-follow-up/

Guidance for Implementing the Impact Assessment Follow-up International Best Practice Principles - IAIA - https://iaia.org/wp-content/uploads/2025/03/Guidance-for-Implementing-the-Impact-Assessment-Follow-Up-International-Best-Practice-Principles.pdf

11.2 Monitoring as the centerpiece of the follow-up stage

Among the elements that make up follow-up, monitoring plays a central role, as it provides the necessary evidence. Therefore, the choice of what to monitor and the planning of how to carry out the monitoring are fundamental and should be consistent with the determination of the significance of the impacts and the proposed mitigation measures.

To obtain quality, ensure consistency with pre-project monitoring, and enable the verification of real impacts of the project in the post-approval stage, monitoring during the installation, operation, and decommissioning stages should, whenever possible, be aligned with the parameters, methods, and sampling grid used in the baseline, promoting integration and coherence between planning and environmental management.

Cumulative impacts, as mentioned in Chapter 10, may require integration with regional initiatives, such as Marine Spatial Planning (MSP) or regional impact assessments, including Strategic Environmental Assessments (SEAs) and Cumulative Impact Assessments (CIAs). A good practice in the offshore wind sector has been designing regional mitigation and monitoring programs, as shown in Box 11.2.

Box 11.2. Regional mitigation and monitoring programs: Case of Programmatic Environmental Impact Assessment in the United States of America

In the U.S. EIA system applied to offshore wind farms, in the period after the auctions and concession of the areas, but before the approval of the installation and operation projects, the BOEM (Bureau of Ocean Energy Management), the body responsible for the evaluation of energy projects on the continental shelf, can prepare Programmatic Environmental Impact Assessments (PEIS). as occurred in the cases of New York Bright and California.

The PEIS makes an integrated assessment, considering the development of offshore wind projects in all areas intended for auction in a given region, evaluating the cumulative impacts, and identifying measures to avoid, minimize, mitigate, and monitor such impacts. In the PEIS already carried out, three alternatives were evaluated: no-development of the projects; development of projects with the implementation of regional mitigation and monitoring measures; and development of projects without such measures. In this way, it is possible to compare changes in impacts across regional measures.

The mitigating and monitoring measures proposed in the PEIS may be required as conditions of approval for the lessees' proposed activities in the Construction and Operations Plans.

Thus, still in the pre-approval phase of the project, it should be defined (Glasson, 2022):

- The key indicators to be monitored;
- The methods for data collection;
- The references to be used to assess the actual impacts and limits to be observed throughout the project life cycle (e.g., quality standard defined by legislation or defined in the study itself as the "acceptable" threshold for that impact);
- Definition of responsibilities, especially if there is an indicator whose monitoring is not the responsibility of the project proponent, for example, when it comes to the monitoring of cumulative impacts that involves the monitoring of projects located in the same region;
- Resources needed for monitoring;
- Mechanisms for sharing information with stakeholders.

As seen in Chapter 7, the selection of priority components and indicators for the baseline should already take into account what can be monitored later throughout the project life cycle. However, not all indicators used in the baseline stage need to continue to be monitored in the follow-up stage; monitoring should focus on the issues identified as most relevant, maintaining consistency with the significance determination of the impacts and the proposed mitigation measures (Figure 11.3).

In other words, each indicator to be monitored must be associated with a clear objective, which may be, for example: confirming the occurrence of an expected impact, verifying the effectiveness of mitigation measures, verifying the quality of the environment and/or its effective alteration, generating information on situations in which there are information gaps, uncertainties or risks, verifying the perception of stakeholders on sensitive issues for the community (Morrison-Saunders & Arts, 2024; Glasson, 2022).

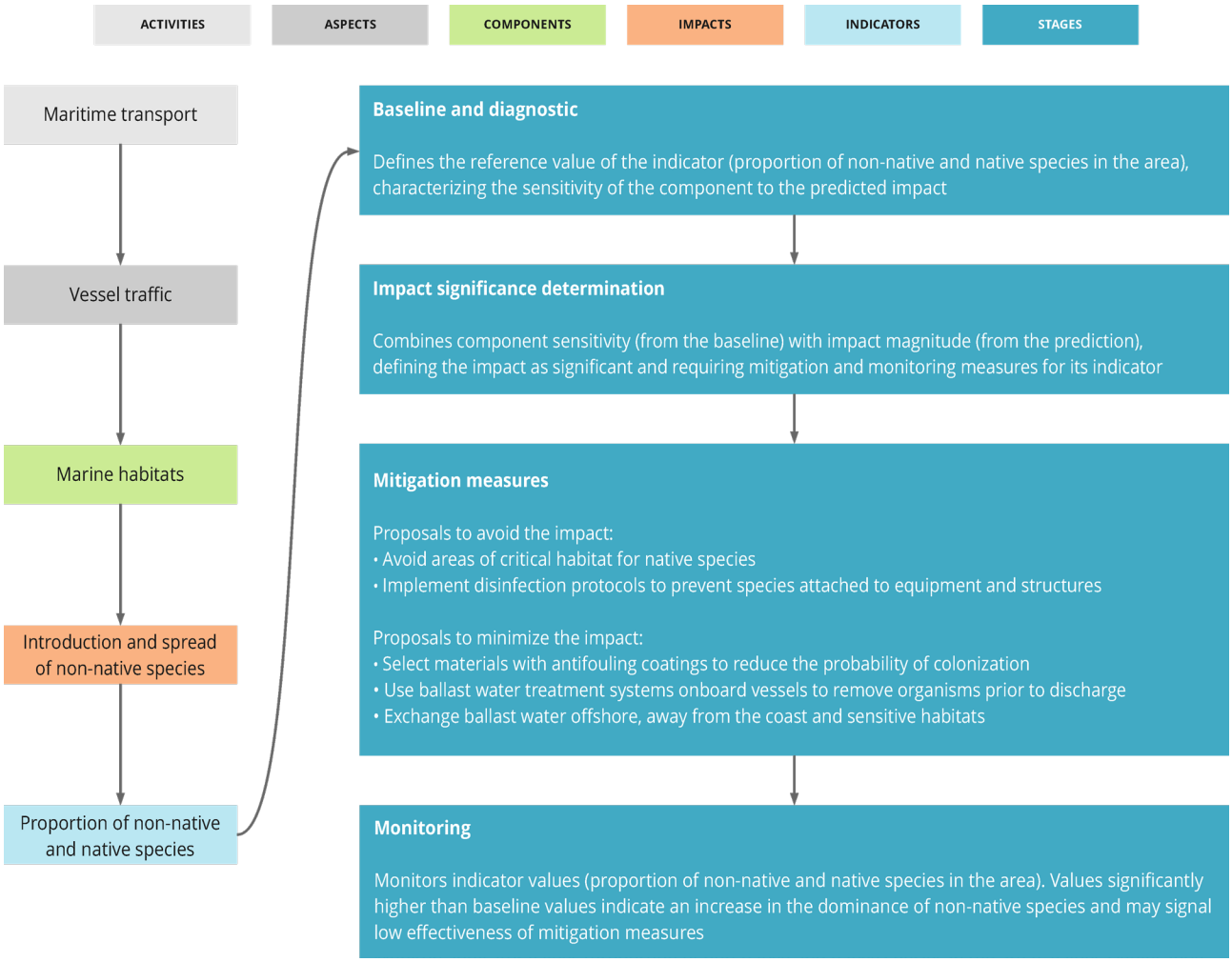


Figure 11.3. Example of impact (introduction and spread of non-native species) with the proposal of an indicator based on the causal chain, illustrating how to consider this impact in the different stages of the Environmental Impact Assessment: baseline, determination of significance, mitigation, and follow-up.

In addition to the relevance of the indicators, other important issues include defining an appropriate sampling grid to understand the cause-and-effect relationships between the project and the selected components/indicators. This involves defining a systematized sampling design for impact detection, ensuring adequate sample replication to enable statistically significant analyses of changes, and using appropriate techniques and equipment to collect information accurately. All these issues will be discussed in the following topics.

11.3 Environmental Monitoring

11.3.1. Sampling design for the detection of impacts

The definition of the sampling grid for monitoring environmental impacts on the components of the physical and biotic environment must be established in advance, along with the planning of the collection of primary data for the baseline.

This is justified because the baseline data express the reference conditions that can be monitored throughout the different monitoring programs. Therefore, the baseline sampling grid must include the same sampling points (or at least part of them) that will be used in monitoring.

It is precisely the statistically significant changes in the reference values of the indicators of these points, obtained at the baseline, that will signal the effective impacts during the installation and operation of the project.

Thus, the sampling grid of the different monitoring programs and, consequently, of the baseline, must be organized to capture cause-and-effect relationships between the project activities and the environmental components. This implies that a systematized sample design should be designed for each monitoring program.

For example, the BACI (*Before-After Control-Impact*) sampling design is a good way to organize the sampling grid to highlight cause-and-effect relationships (**Figure 11.4**). In this type of design, the selected indicators are sampled at points that are expected to be affected by the project (*Impact*) and at points that will not be affected (*Control*), both during the baseline (*Before*) and during the follow-up stage (*After*).

In this sense, in the event of an impact resulting from the project, the indicators may change at the *Impact* points during the *Before-After* comparison but remain unchanged at the *Control* points. When the behavior of the indicators at the Impact and *Control* points is similar in the *Before-After comparison*, there will be no evidence of the project's impact (Stephenson, 2021).

The points classified as *Control* are those within the so-called reference area (control area, without project influence). This area must have environmental characteristics as similar as possible to those of the areas where the points will be classified as *Impact*, so that the only difference between these areas is the project's influence. However, defining the *control* area is not easy, due to similar environmental characteristics and because other projects may influence its indicators.

In this sense, the definition of multiple control areas is considered more effective for detecting the project's impacts, which constitutes a variation of the BACI design known as asymmetric BACI (Underwood, 1994). With an area called *Impact* and several areas called *Control*, the natural local variations and the influence of other local developments can be better understood, facilitating the identification of the project's own impacts.

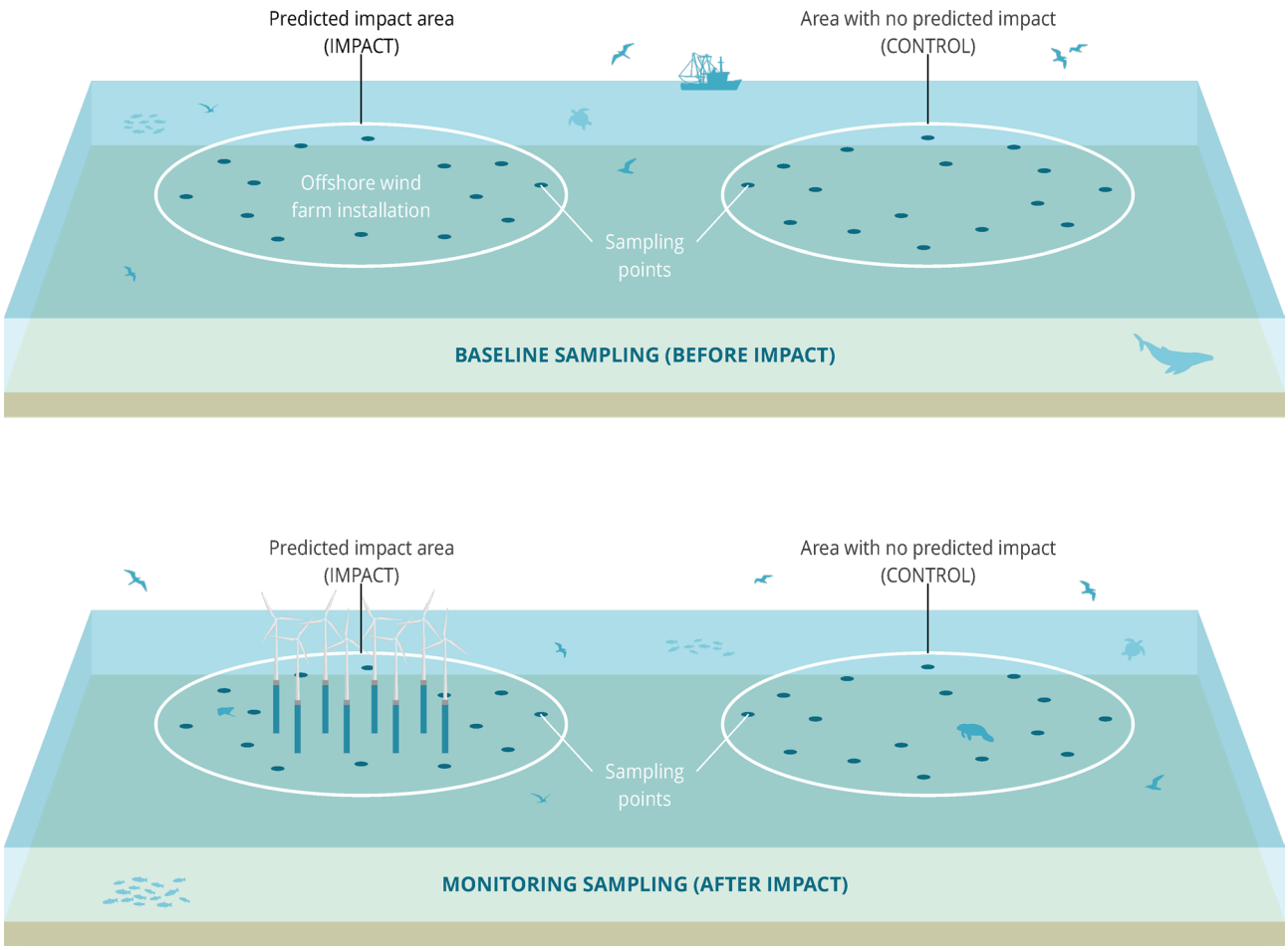


Figure 11.4. Schematic example of a sampling grid for environmental monitoring following the BACI (*Before-After Control-Impact*) design.

An alternative way to organize the sampling grid is the so-called BAG (*Before-After Gradient*) design, which is especially useful in components and places where defining control areas is difficult (Figure 11.5). In this type of design, the sampling grid for the different components and their respective indicators must be organized according to a gradient of project influence, that is, points distributed along a gradient of distance from the Directly Affected Area (Stephenson, 2021). Such a gradient should be organized and sampled at baseline (*Before*), then monitored in the follow-up stage (*After*).

The expected result, in case of project impact, is that the behavior of the indicators along the gradient changes after the start of the project's installation and operation, mainly due to changes in indicator values at points near the beginning of the gradient (closer to the project). The gradient design is even more interesting because it allows the construction of meshes at different scales (multiscale design). For example, it is possible to create point gradients with respect to the distance from a specific turbine to identify microscale process changes, and with respect to the distance from the wind farm as a whole to identify mesoscale changes (Figure 11.5).

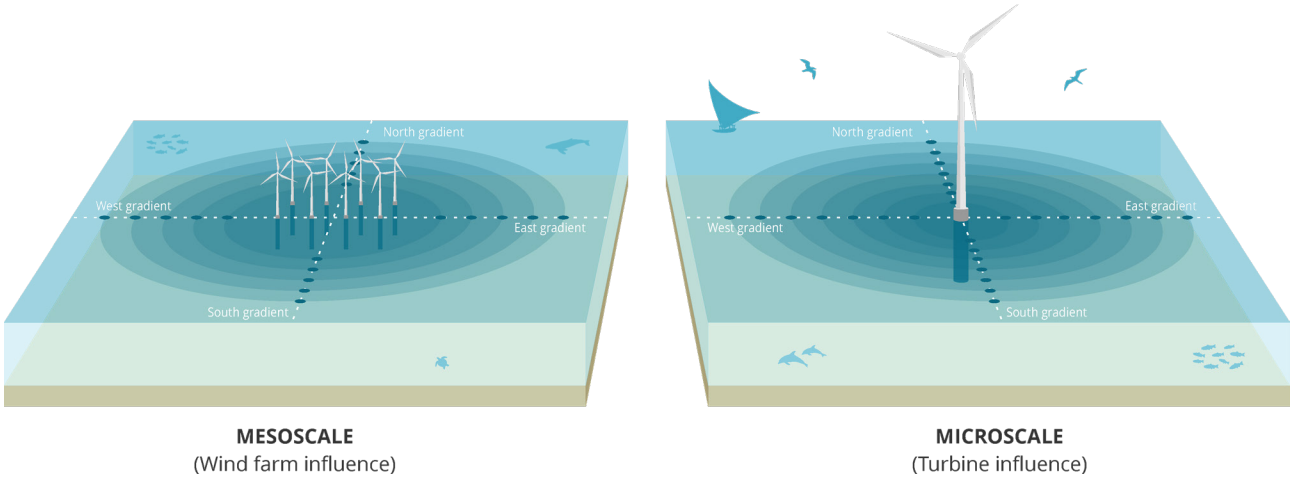


Figure 11.5. Schematic example of a sampling grid following the design of multiscale gradients, aiming at the monitoring of biodiversity at the wind turbine (microscale) and wind farm (mesoscale) scales. In the example, four gradients are drawn per scale, following the north, east, south, and west directions.

11.3.2. Replication and statistical sufficiency

When defining the most appropriate sampling design for monitoring the selected components and indicators, it is necessary to establish the spatial sampling unit to be replicated across the collections. For example, imagine that a BACI delineation is established, with an Impact area and a Control area, to monitor the benthic community before and after the start of the project installation.

Each of these areas is considered a treatment (totaling two treatments, in this example), and the benthic community will be sampled with a bottom grabber (a dredge). In this case, the bottom grab sample is the sampling unit for monitoring and must be replicated. That is, multiple samples (replicates) of the sampling unit will be collected for each treatment.

The number of replicates of the sampling unit per treatment may vary across monitoring programs for each component. However, in all cases, it is necessary to maintain a minimum level of replication sufficient to make the project's impacts statistically testable. Usually, monitoring programs sample in triplicate (three replicates of the sampling unit per treatment). In the example in the previous paragraph, this number may be insufficient to support statistical analyses capable of detecting reliable project impacts. A total of 10 replicates per treatment is usually sufficient to ensure statistical robustness and can be used as a general rule. However, it is most recommended to use specific techniques to test sample sufficiency on a case-by-case basis (Gotelli & Ellison, 2016).

Learn more

Consult the book "Principles of Statistics in Ecology", by Gotelli & Ellison (2016), for a deeper understanding of the most varied types of existing sample design and how to apply them with replication, sample sufficiency and appropriate statistics. Remember that the monitoring of environmental impacts is based on hypothesis testing (is the impact occurring or not?), which is strongly anchored in scientific principles of statistics and ecology.

For gradient designs, such as the BAG, replicating the sampling unit is unnecessary if the gradient is sufficiently large to ensure an adequate sample size. For example, instead of the BACI design, the BAG design can be used to monitor the benthic community before and after the start of the project installation. In this case, the sampling unit remains the bottom grab sample, but only one sample is collected at each distance from the wind turbine array, without replicating the sampling unit. As more samples at different distances are included in the gradient, more robust and reliable the statistical analysis will be. This is possible because the BAG design arranges samples continuously in space, with multiple samples at different distances from the project. The BACI design, on the other hand, organizes samples in a spatially categorical way (Impact and Control treatments), requiring replication within each category/treatment to ensure adequate sample size. In this sense, what is most important to replicate in the BAG design is the gradient itself, which can be sampled in different directions (north, south, east, west). This ensures that the project's surroundings are more thoroughly monitored, as illustrated in Figure 11.5.

11.3.3. Biodiversity sampling techniques

Effective sampling of biodiversity indicators in the field is essential for the observed responses to the project's impacts to be as reliable as possible. Indicators such as the abundance of a given group and the richness and diversity of species are usually obtained through sample collection techniques, individual counting, and appropriate taxonomic identification. Some indicators, such as movement routes and habitat use, are more difficult to assess and require specific techniques to obtain. An important initial step is to conduct a bibliographic review of existing documents that discuss the occurrence, richness, abundance, habitat use, and behavior of species in the study area, as this can reveal key data for monitoring local species. From this pre-analysis, primary data can be sampled using techniques commonly used in monitoring biodiversity in offshore wind farms, as presented in Table 11.1 and briefly explored below.

Table 11.1. Summary of the main sampling techniques used to monitor the impacts of offshore wind farms on biodiversity, highlighting which components can be sampled by each technique, and which are the main impacts that they can monitor.

Sampling techniques	Key Target Components	Main impacts monitored
Filming of the background via fixed cameras or by ROV (Remotely Operated Vehicle).	Epibenthic invertebrates; demersal fish; benthic habitats.	Aggregation of organisms in the project area (reef effect and refuge effect); changes in the composition of the benthic community; colonization of non-native species; changes in behaviors.
Collection by Van Veen bottom grabber and/or box corer.	Benthic community (especially sediment infauna).	Benthic enrichment; degradation of the seabed; changes in the composition of the benthic community.
Visual censuses by diving.	Epibenthic invertebrates; demersal and pelagic fish; sea turtles; marine mammals.	Aggregation of organisms in the project area (reef effect and refuge effect); changes in the composition of the benthic and nektonic community; changes in behaviors.
Fishing gear (gillnets, bottom trawls, and mid-water trawls).	Demersal and pelagic fish; epibenthic invertebrates.	Aggregation of organisms in the project area (reef effect and refuge effect); changes in the composition of the community; changes in fish stocks.
Trawlers with plankton nets in the water column.	Phytoplankton and zooplankton.	Changes in primary and secondary productivity; changes in the trophic web.
Acoustic Monitoring	Marine mammals; bats.	Avoidance or aggregation in the project area; habitat loss.
Visual censuses by fixed point or transect by aerial route or ship.	Marine mammals, sea turtles, and birds.	Changes in the composition of the community; changes in habitat use and behaviors
Environmental DNA	Fish; marine invertebrates; marine mammals; sea turtles.	Changes in the composition of the community; Change in habitat use
Tracking techniques (telemetry)	Birds; marine mammals; sea turtles; fish (especially sharks and rays).	Deviation of local and migratory movement routes (barrier effect); change in habitat use; loss of connectivity between habitats.
Thermal detection systems, image intensification (night vision), video cameras, and acoustic monitoring.	Seabirds and bats.	Avoidance of turbines; increased mortality due to collisions.
Coastal visual censuses (monitoring of beaches and other coastal ecosystems)	Marine mammals; sea turtles; Coastal birds	Increased mortality (stranding rate); loss of habitat for food and reproduction; reduction of reproductive success (turtles).
Installation of mist nets on the coastal and terrestrial area associated with the project.	Shorebirds and bats	Changes in habitat use, loss of onshore-offshore connectivity, and community composition.
Active search for traces and living organisms; camera traps; capture traps; pitfall traps.	Terrestrial fauna (terrestrial mammals and herpetofauna)	Habitat loss and fragmentation due to onshore substations and the transmission line.

To evidence of the benthic organisms aggregation in the project area (turbines and submarine cables), monitoring can be carried out using technologies such as remote monitoring via fixed cameras or ROVs (Remotely Operated Vehicles), vehicles equipped with cameras operated remotely (Viswambharan, 2024) (Figure 11.6).

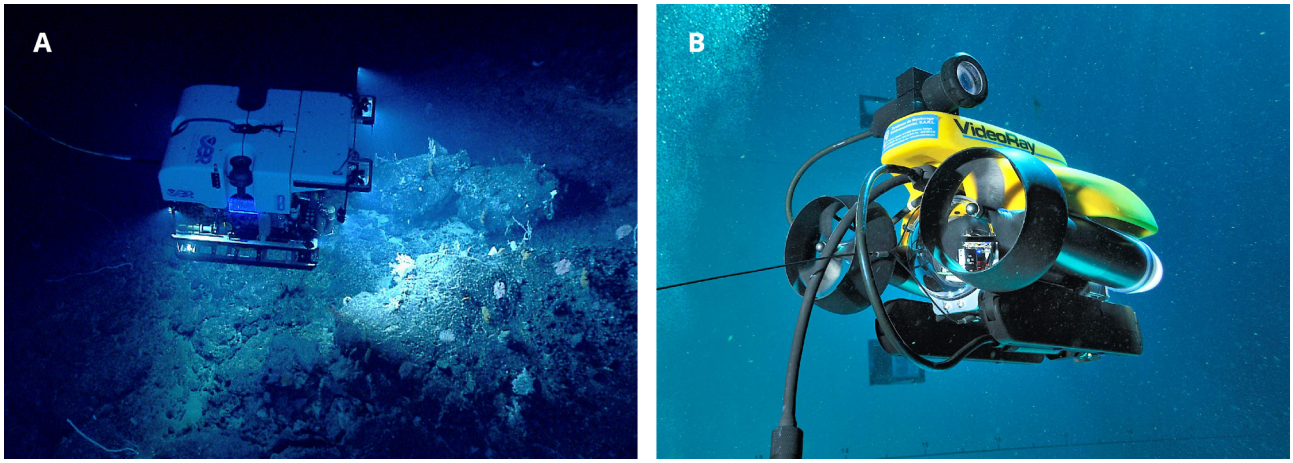


Figure 11.6. Examples of Remotely Operated Vehicle (ROV) used in submarine monitoring. (Source: Wikimedia Commons, National Oceanographic and Atmospheric Administration, and Olivier Dugornay).

Software that works with these underwater images is used to identify biodiversity and can show changes in the pattern of aggregation, composition, diversity, and richness of the communities. In addition, the more traditional methods of sampling and research are still widely used to assess changes in the benthic community, including sediment collection with a Van Veen grabber and/or a box corer, and diving techniques for monitoring fauna (Eleftheriou & McIntyre, 2005).

For fish, different gear-based approaches are used to assess variations in the abundance and richness of pelagic and benthic species (Jawad, 2018), which may indicate a reef or refuge effect near the project. These approaches include gillnets, bottom trawls, and mid-water trawls (Figure 11.7).

Nets are also the primary method for plankton sampling (Castellani & Edwards, 2017), with vertical trawls (capturing organisms throughout the water column) or horizontal trawls (focused on specific depths) conducted using mesh sizes appropriate for the target groups (phytoplankton and zooplankton).

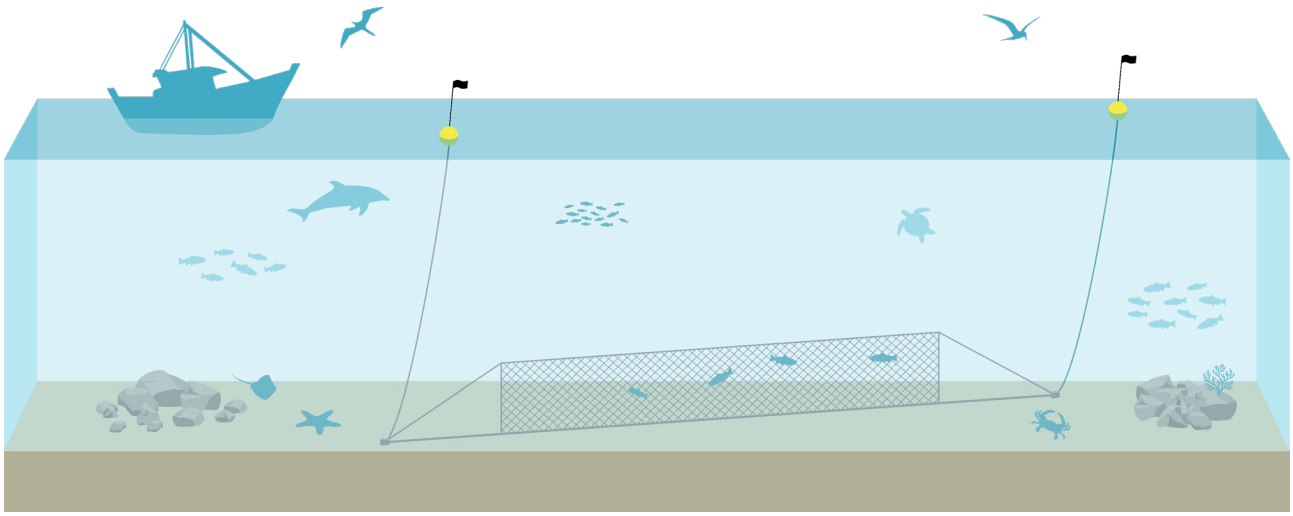


Figure 11.7. Diagram illustrating the gillnet used to collect fish species present in the project area (Source: Wikimedia Commons).

There are several techniques to monitor disturbances in marine mammals (Evans & Raga, 2001), especially those associated with underwater noise, such as acoustic monitoring and echolocation detectors (hydrophones), which can be used in the offshore wind farms context. These tools allow you to track changes in the presence of these organisms before and after activities, such as pile driving. Acoustic monitoring techniques can also be employed for bats (Kunz & Parsons, 2009) to detect potential changes in their use of the offshore environment resulting from the project's installation and operations.

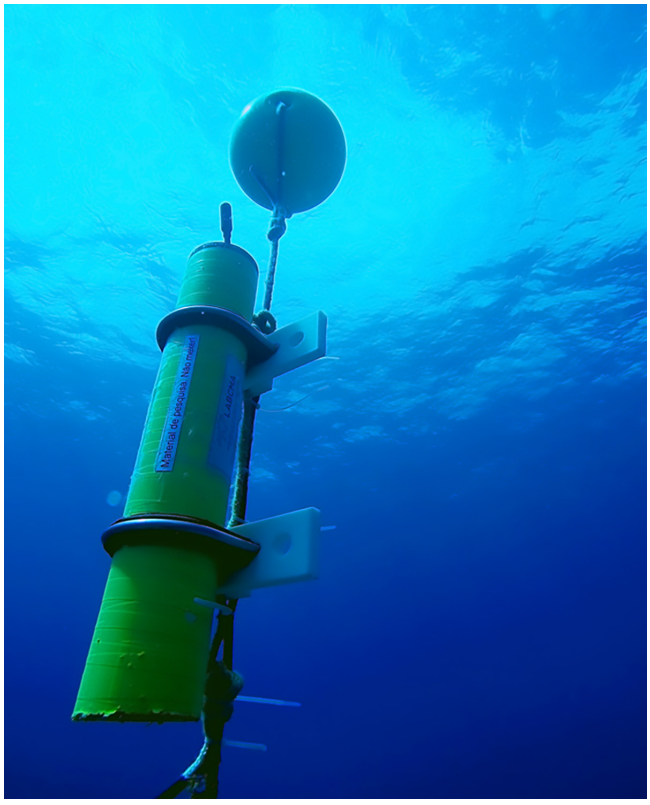


Figure 11.8. Autonomous Underwater Sound Recorder (AUSR) used in the acoustic monitoring of cetaceans. It captures the sounds emitted by the animals through an underwater sound recorder to identify which species are present in the region. (Source: Santos, 2021).

Changes in the species richness of mammals, turtles, and birds can be identified through visual observations in censuses aboard vessels or aircraft equipped with high-resolution cameras, manned or unmanned, which allow mapping large areas in a short time, recording relative abundance and different behaviors, such as resting, flying, or foraging (Walsh et al., 1995; Evans & Raga, 2001; Nahill, 2020).

More advanced techniques, such as environmental DNA, have also been used in the context of offshore wind farms, especially in studies with fish (Fu et al., 2021). This non-invasive technique (no organisms need to be collected) can evaluate changes in species occurrence by collecting water at specific points, and can also serve as an estimator of changes in habitat use.

Tracking techniques, such as telemetry (Carlson et al., 2023), are highly recommended for all high-mobility groups, including birds, turtles, mammals, and fish (especially sharks and rays), as this is sometimes the only technique capable of revealing potential deviations in local and migratory movement routes. In these cases, radars and laser rangefinders can be used to measure flight height (for birds), penetration depth into the water column, and the direction and intensity of movements.

In addition, these individual marking and tracking techniques allow the detailing of displacement patterns at different scales, making it possible to verify changes that indicate avoidance of wind farms or overlap of routes with the turbine activity zone, as well as potential impacts on connectivity and habitat use.

For birds and bats, evasion rates under low-visibility conditions can be measured using thermal detection systems, image intensification (night vision), video cameras, and acoustic monitoring. These methods record the approaches of birds and bats to the turbines, quantify evasions in front of the structures, and, in some cases, document collisions and account for a potential increase in local mortality (Desholm et al., 2004).

For coastal birds, such as waders, and bats, sampling should cover feeding areas in intertidal zones and areas of movement between coastal and marine sites. Standardized censuses on beaches, coastal forest remnants, estuaries, and marshes, carried out by counting at fixed points or transects, allow for changes in the abundance, richness, and seasonal use of these environments, providing data to identify critical impacts on onshore-offshore connectivity and habitat use.

The installation of mist nets to capture birds and bats is also a widely used technique for measuring these parameters in the coastal and terrestrial areas (Walsh et al., 1995; Kunz & Parsons, 2009).

Monitoring through coastal visual censuses (especially on beaches) is also necessary to detect a potential increase in strandings of turtles and marine mammals in the area (Evans & Raga, 2001; Nahill, 2020), which may indicate higher mortality of these organisms due to the installation and operation of the project. Such censuses are also essential for identifying turtle reproductive events on beaches and for quantifying a potential impact of the project on the reproductive success of these organisms (Nahill, 2020).

For terrestrial fauna, established monitoring techniques include camera traps (especially for large mammals) and active searches for traces (feces and footprints) and for living organisms (especially for herpetofauna). The installation of traps for small mammals (such as Sherman and Tomahawk traps) or pitfall traps (which also capture herpetofauna) is also frequently used (Wilson et al., 1996; Gent & Gibson, 2003). The combination of these techniques enables the detection of potential habitat fragmentation or loss resulting from the installation and operation of onshore substations and the onshore transmission line.

11.4 Social Monitoring

As with environmental monitoring, social monitoring plays a key role in the follow-up stage. It enables the evaluation, throughout the project life cycle, of the actual impacts on the social, economic, cultural, and institutional dynamics of the affected communities. In addition, it enables verification of the effectiveness of measures to mitigate socioeconomic and sociocultural impacts.

11.4.1 Social Monitoring Program

The social monitoring program must be prepared during the project's pre-approval phase and implemented throughout the follow-up stage, serving as the methodological basis for EIA follow-up. The program must be directly aligned with: (i) the social impacts identified in the EIA; (ii) the proposed mitigation measures; and (iii) the demands, expectations, and vulnerabilities of potentially affected communities. It is a structuring instrument that defines what will be monitored, how it will be monitored, how often, and institutional responsibilities (Vanclay, 2003; Glasson & Therivel, 2019; Noble, 2015).

In preparing the program, the first step is to select priority social components (see Table 7.3, Chapter 7), based on both the prior identification of socio-economic and socio-cultural impacts and on dialogue with stakeholders. These themes represent central axes of analysis throughout the project life cycle. Among them, the following stand out: employment and income; health and well-being; public services and infrastructure; safety and mobility; tourism; artisanal fishing; traditional use of the territory; community organization; local governance; and social perception of the risks and benefits of the enterprise.

The plan should also identify the social groups that may be affected in different ways: traditional communities, women, youth, vulnerable groups, and affected actors in general. Defining these groups is essential to ensure distributive justice and equity in the follow-up process (Noble, 2015).

A third essential element is the definition of data collection methods, which can combine quantitative techniques (statistics, administrative data, surveys of percentages in historical fishing series, and data on health, education, employment, and income) with qualitative techniques (structured and semi-structured interviews, focus groups, direct observation, participant observation, oral reports, participatory mapping, narrative analysis, and social perception). The choice of methods should reflect the nature of the impacts and ensure comparability before and after the project's implementation (Vanclay, 2003; Morgan, 2012; Arce-Gomez et al., 2015).

The periodicity of data collection must also be consistent with the dynamics of expected impacts. Indicators with seasonal variations (such as fishing effort) require more frequent monitoring, while indicators of social transformation (such as health and well-being) are monitored less frequently. However, the periodicity should be sufficient to enable prompt corrective actions.

Social participation mechanisms should also be detailed in a social monitoring program to ensure transparency, legitimacy, and responsiveness. These mechanisms include follow-up committees, participatory monitoring, public meetings and feedback, and platforms for information access.

Continued stakeholder participation strengthens the credibility of results, builds trust between communities and the proponent, and improves the quality of management responses (see **Chapter 3**). Several authors emphasize that participation is one of the most transformative elements of modern EIA. Yet, it remains limited by numerous factors, including lack of engagement, limited access to information, non-inclusive processes, and restricted participatory windows (Glasson & Therivel, 2019; Noble, 2015; Vanclay, 2003; Arts & Morrison-Saunders, 2022).

Finally, the program must specify the institutional responsibilities (who collects, who analyzes, who validates, and who communicates) and the formats for recording, documenting, and communicating the results (technical reports, public panels, community meetings, and reports to the competent EIA authority). These elements are essential to ensure traceability and evaluation throughout the process.

Thus, the social monitoring plan guides the selection and application of indicators, sustains adaptive management, enables continuous monitoring of mitigation measures, and prepares for the identification of unexpected impacts. Structured in a clear, participatory way, the plan ensures a response to the social changes that emerge during the project's implementation and operation.

Learn more

To better understand how to structure follow-up programs, see the book "Introduction To Environmental Impact Assessment", by de Glasson & Therivel (2019), and "Introduction To Environmental Impact Assessment: A guide to principles and Practice", by Noble (2015). The works present chapters on follow-up, social monitoring, indicators, participation and adaptive management.

Glasson, J. & Therivel, R. *Introduction to Environmental Impact Assessment*. 5. ed. London: Routledge, 2019.

Noble, B. *Introduction To Environmental Impact Assessment: A guide to principles and Practice*. 3rd ed. Oxford: Oxford University Press, 2015.

11.4.2 Social Impact Indicators Development

The development of social indicators is essential for defining what will be observed throughout the project life cycle. These indicators must capture, in an integrated way, the main socioeconomic, sociocultural, and territorial changes associated with the implementation and operation of the activity. In addition, they must be aligned with the possible significant social impacts. They should be: relevant and sensitive – capturing meaningful change in the community; measurable and clear – consistently and unambiguously applicable, and balanced between quantitative and qualitative.

Depending on the indicators selected, measurements can use both direct empirical data from regulatory agencies, productive registries, and local associations, and information obtained through participatory monitoring and community perceptions (collected using the methodologies defined in the Monitoring Program). The use of well-constructed indicators enables evaluation of real impacts and analysis of trends, supporting adaptive management. **Figure 11.9** illustrates social components and example indicators for each component.

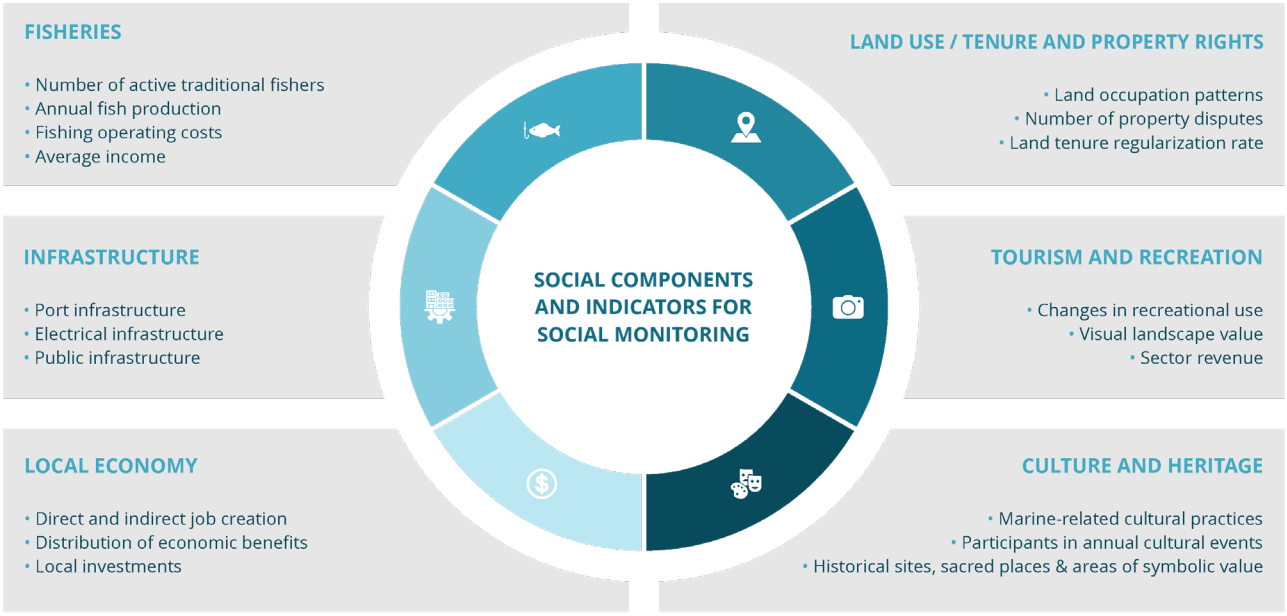


Figure 11.9. Examples of social components and indicators for monitoring.

Although the definition of indicators should be done during the preparation of the monitoring program, other indicators can be incorporated later to reflect territorial specificities and emerging concerns. In this sense, best monitoring practices recommend continuously asking questions such as: "Do the indicators measure what really matters?"; "Are there more appropriate ways to measure this change?" or "Is anything important to be measured missing?"

To establish the relevance of social impact indicators in a given location, it is essential to ensure the involvement and validation of all stakeholder categories, so that monitoring reflects what the community considers relevant (Vanclay, 2003; Arce-Gómez et al., 2015; Noble, 2015). For offshore wind energy projects, for example, indicators for the fishing component must be developed to capture changes in total fish catch, considering composition, abundance, and biomass, along with metrics related to fishing effort, such as the number of vessels, days at sea, and pelts. Other relevant indicators include operating costs, fishing routes and areas, travel time to port, revenue earned, livelihood stability, and economic well-being.

For the components associated with tourism and recreation, indicators that capture changes in the recreational use of the coast and the sea, as well as transformations in the landscape's visual attractiveness, stand out. These factors influence the recreational experience, the average length of visitor stays, aesthetic perception, and the overall quality of the tourist experience. It is also important to monitor tourism sector revenues, including indicators such as revenue, the occupancy rate of accommodations and services (food, transport, and local commerce), as well as public perception and the emergence of new opportunities, assessing how residents, visitors, and tour operators view changes in the territory as potential opportunities for additional activities in the sector.

Global Fishing Watch (GFW) - Transparency for a Sustainable Ocean is an international fisheries transparency platform that uses data from AIS (Automatic Identification System), VMS (Vessel Monitoring System, where available), satellite imagery and advanced algorithmic models to track in real time the movement and behavior of vessels around the world.

As the system relies mainly on AIS signals, it detects medium and large vessels with greater accuracy, while artisanal fishing, mostly without AIS, tends to appear in a limited way. Even so, by offering historical series and specialized information on routes, intensity of use of marine areas, patterns of fishing effort and fleet concentrations, GFW can be incorporated as a complementary source of data in fisheries monitoring programs, supporting the construction and feeding of fisheries indicators.

In the infrastructure component, monitoring must include indicators that express the capacity of: port infrastructure; electrical infrastructure; and public infrastructure - reflecting overload risks, identifying the need to expand or adapt port facilities, energy networks, and substations due to operations and the arrival of new workers, and the need to increase the supply and quality of public services such as health, education, transportation, and sanitation.

Indicators related to the socioeconomic components help to understand the degree of integration of the project with the territorial economy. Thus, monitoring should include indicators that measure productive dynamics and the distribution of benefits in the territory, such as: generation of direct and indirect jobs - allowing the evaluation of both the creation of new job opportunities and the redistribution of labor among local sectors; distribution of economic benefits - financial gains, compensation, partnerships, and contracting with small, medium, and large segments; and local investments - investments in infrastructure, support for the surrounding economy, and stimulation of production chains.

For components related to the cultural and heritage aspects, the indicators developed must capture transformations in sacred sites, historical sites, and areas of symbolic value, especially those at risk of decharacterization of cultural landscapes and the possible rupture of spiritual and identity bonds that connect communities to the territory.

Likewise, it is necessary to track changes in cultural practices associated with the sea, such as festivities, traditional crafts (including productive activities, practical knowledge, and artisanal and manual techniques), narratives and oral knowledge, social and symbolic relations, and community rituals. Since changes in access to and use of coastal areas can affect the continuity of these cultural manifestations, monitoring using indicators of this type enables identification of shifts in cultural vitality, belonging, and the preservation of material and immaterial references that structure the collective memory and ways of life of local populations.

The use and possession of land and property rights should be assessed using indicators that track changes in residential occupation patterns in the coastal strip and their impacts on territorial dynamics. These indicators should be aligned with the capture pressures on local communities, including risks of land conflicts, real estate valuation or speculation, and changes in the use and destination of coastal land. Monitoring these indicators allows the identification of possible displacement of families, restrictions on access to traditionally used areas, and shifts in the balance among residential, tourist, commercial, and community uses. Together, these indicators help to understand how the presence or expansion of coastal enterprises can influence the security of tenure and the permanence of communities in their territories.

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GLOSSARY

Adaptive Management: A management process in which measures and procedures are reviewed and adjusted based on evidence obtained through monitoring and learning during implementation.

Additionality: Criterion according to which the environmental gains of an offset must occur beyond what would happen in the reference scenario, without the proposed intervention.

Aspect (environmental): Element of an organization's activities, products, or services that interacts or may interact with the environment (ISO 14001:2015).

Associated facilities: Facilities that are necessary for the construction, operation, or decommissioning of the project and that would not have been built or extended had the project not been built.

Barrier effect: Occurs when the presence of a project impedes the movement of fauna, altering local movement or migratory routes of organisms such as mammals, turtles, birds, and fish.

Baseline: A set of information on the reference conditions of the area likely to be affected by a new project, obtained in a previous study (before the start of the construction and operation of the project), related to ecological and socioeconomic parameters of selected components, which can later be used as indicators of impacts throughout the monitoring stage.

Biodiversity: Variability of living organisms at genetic, species, and ecosystem levels, including their interactions.

Coastal zone: Area of interaction between land, sea, and air, characterizing a band of continuous transition between terrestrial and marine environments. Coastal zones are densely occupied regions with great socio-environmental complexity, requiring specific management instruments.

Cumulative impacts: Changes in the condition or state of environment components resulting from the sum or interaction of impacts from past, present and reasonably foreseeable future actions, in conjunction with a project under review.

Ecological equivalence: A criterion that seeks to ensure that the gains generated by offsetting are comparable to the losses caused, in terms of components, functions, and ecological relevance.

Ecological Offset or Biodiversity Offset: Measure applied as the last step in the mitigation hierarchy to counterbalance significant residual impacts, seeking outcomes such as no net loss or net gain in biodiversity.

Ecosystem services: Benefits that people derive from ecosystems, commonly classified as provisioning, regulating, cultural, and supporting services.

Ecosystem-based management: A holistic, integrated, and participatory management approach that considers the interaction between the ecological and social dimensions of a given system, across scales, in order to promote the sustainable use of its resources.

Impact magnitude: Characterization of the intensity and scale of an impact, which may include its extent, duration, frequency, and reversibility, in relation to the pressures generated by the project.

Indicators (environmental and social): Measurable variables used to characterize the baseline, track changes, and assess the effectiveness of measures and the evolution of impacts.

Marine areas under national jurisdiction: Defined by the United Nations Convention on the Law of the Sea (UNCLOS), these are the maritime spaces over which coastal States exercise sovereignty, sovereign rights, or jurisdiction. They comprise the Territorial Sea, the Exclusive Economic Zone, and the Continental Shelf.

Marine spatial planning: A comprehensive and strategic process for analyzing and allocating the use of marine areas to minimize conflicts between human activities and maximize benefits while ensuring the resilience of marine ecosystems (UNESCO-IO, 2021).

Mitigation measures: Actions taken to avoid, minimize, restore/recover from, or compensate for adverse impacts caused by a project, in a proportionate and significance-driven manner.

Mitigation hierarchy: A decision structure that prioritizes, in sequence, avoiding, minimizing, restoring/recovering, and, only as a last step, compensating for significant residual impacts, guiding the systematic management of impacts in EIA.

Nature positive: A global societal goal defined as 'halt and reverse nature loss by 2030 on a 2020 baseline, and achieve full recovery by 2050" (Nature Positive Initiative).

Net gain: An outcome in which the biodiversity gains generated through mitigation, restoration, and/or compensation exceed the losses caused by the project.

No net loss: An outcome in which biodiversity losses caused by the project are balanced by equivalent gains obtained through restoration and/or offsetting.

Permanence: Criterion that requires that the gains generated by offsetting be maintained in the long term, with legal instruments, governance, and financial guarantees.

Principle of proportionality: This principle requires Impact Assessment to be scaled to what is necessary and sufficient to inform decision-making and meet regulatory requirements, avoiding both excessive and insufficient levels of assessment. It applies to both the Impact Assessment process and its outputs, guiding the preparation of clear, concise studies and reports focused on impacts that are significant and relevant to the decision-making.

Reef effect: Occurs when the presence of the project's artificial rigid structures (turbines, cables, offshore substations), installed in the marine environment, functions as an artificial reef, promoting the aggregation of organisms in its vicinity.

Reference condition: The state of a socio-ecological system before project construction and operation, described using ecological and socioeconomic parameters that may later serve as indicators for assessing impacts during follow-up.

Refuge effect: Also called the reserve effect, it occurs when restrictions on fishing activities in the project area create refuges for organisms affected by fishing pressure, such as fish and epibenthic invertebrates, allowing them refuge from fishing.

Significance: Interpretation of the importance of an environmental or social impact that a project may cause in a specific context.

Strategic Environmental Assessment: Instrument forassessing the environmental and socioeconomic risks and impacts of policies, plans and programs (PPPs) that may result in significant effects on the environment.

Terms of reference: A document that outlines guidelines for preparing an Environmental Impact Study, for example, defining its scope and methods.

Tiering: The transfer and use of relevant information across levels of planning and among the impact assessment instruments applied at each level.

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Environmental and Social Impact Assessment of Offshore Wind Energy Development in Tropical Environments

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