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ABSTRACT
This paper presents the results of a comprehensive analysis of Environmental Assessment (EA) practices across Denmark, Germany, Spain, and Portugal, utilizing a best practices benchmark for integrating biodiversity considerations. The benchmark evaluates the degree of alignment between both Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) reports and best practices for biodiversity integration, offering insights into the effectiveness of current EA practices. We analyzed 191 EA reports, focusing on eight key themes: significance, knowledge, synergies and trade-offs, ecosystem services, goals and visions, uncertainty, mitigation and enhancement, and monitoring. The results highlight both areas of strength, such as the use of monitoring, and areas requiring improvement, such as the integration of ecosystem services and management of synergies and trade-offs. The findings provide a basis for enhancing EA practices and ultimately promoting biodiversity conservation in spatial planning.

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1. Introduction

Biodiversity plays a vital role in sustaining ecosystems and human well-being, and its conservation is a key aspect of sustainable development. This and the ensuing urgency of biodiversity conservation is recognized early on in the UN Convention on Biological Diversity (CBD) and lately e.g. the European Union's Biodiversity Strategy for 2030 (UN 1993; EU Commission 2020). Environmental Assessments (EAs), specifically Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs), are crucial instruments for achieving biodiversity goals (Treweek 1999; Treweek et al. 2005). This is also recognised by IPBES (2019) that positions EAs as support instruments to mitigate the impacts of development activities on biodiversity and to promote cross-sectoral approaches constructing pathways towards sustainability. Mandated by the EIA Directive (Directive 2011/92/EU, amended by Directive 2014/52/EU) and the SEA Directive (Directive 2001/42/EC 2001), these instruments legally require the integration of biodiversity considerations into decision-making processes for projects (EIA) and plans and programmes (SEA). Thus, in the EU, EIA and SEA are instruments for integrating biodiversity concerns into spatial planning and large development projects.

However, the legal requirement for biodiversity integration in EIAs and SEAs does not automatically translate into effective protection in practice. The real-world implementation of these directives often falls short (see e.g. Partidario and Monteiro 2019) as will be examined in Evolution of biodiversity integration in EIA and SEA, and it is essential to explore how well biodiversity is integrated into these assessments in practice. One of the most effective ways to evaluate this is using benchmarks – standards or indicators that assess the quality and comprehensiveness of biodiversity integration in EIA and SEA reports. Benchmarks are generally, '*the process of identifying the highest standards of excellence for products, services, or processes, and then making the improvements necessary to reach those standards commonly called "best practices"*' (Bhutta and Huq 1999, 254). In the present paper a benchmark is used to provide a systematic framework for understanding the degree to which biodiversity is considered in project design and planning. Strengths and weaknesses in current practices are highlighted and needs for improvements are identified to meet the legal and ecological objectives set forth by the EU.

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1.1. Evolution of biodiversity integration in EIA and SEA

The integration of biodiversity in EIA and SEA has evolved significantly. Driven by the focus sustainability and biodiversity e.g. stemming from the 1992 UN Conference on Environment and development and the CBD which entered into force in 1993, the integration has developed from early work calling for integration of biodiversity (e.g. Treweek 1999) translating into early guidance documents (e.g. World Bank 2000).

Early assessments, specifically in the United States, often viewed biodiversity narrowly, focusing on 'species' with limited considerations of ecosystem-level impacts (Atkinson et al. 2000). In Denmark, this narrow focus was found to first occur later and was linked to the implementation of the EU Habitat Directive (Larsen et al. 2018). A study from Larsen et al. (2018) revealed that biodiversity integration in EIA in Denmark post-2000 increasingly centered on species protection, compared to earlier EIA practice focusing more broadly on nature types and areas.

Over time, as the understanding of biodiversity's role in regulating natural systems grew, EIA and SEA began to expand their scope. As an example, the amendment of the EU Directive on Environmental Impact Assessment in 2014 meant a change from focusing assessment on flora and fauna, among other factors, to focusing assessment on biodiversity (Directive 2011/92/EU 2011; Directive 2014/52/EU 2014). Anticipating this change and FP7 European research project – BioScene – used strategic environmental assessment and sustainability assessment to explore scenarios for biodiversity, in the broad sense, in mountain areas in Europe (Sheate et al. 2008; Partidario et al. 2009).

Even so, Geneletti (2016) argues that while there has been progress in the inclusion of biodiversity in EIA and SEA, many assessments still lack comprehensive approaches. He highlights that assessments often focus on a narrow subset of species or habitats, without accounting for biodiversity at multiple scales or integrating ecosystem services sufficiently. As of very recently, Nykiel and Morrison-Saunders (2024) have called upon practitioners to provide natural systems with a voice in impact assessment and to shed the anthropocentric biases to allow space for eco-centric values.

1.2. Challenges in biodiversity integration in EIA and SEA

Despite advancements, significant challenges remain, and previous studies have indicated discrepancies between best practice guidelines and practice in integration of biodiversity in EA (see e.g. Swanepoel et al. 2019). Bigard et al. (2017) and Cares et al. (2023) identify ongoing issues in applying the mitigation hierarchy – avoidance, minimization, restoration, offsetting and enhancement (see also Larsen et al. 2018). Bigard et al. (2017) note that confusion often arises concerning the different mitigation stages, weakening biodiversity protection, and Cares et al. (2023) claim that a lack of monitoring of biodiversity impacts causes uncertainty in terms of the success of mitigation measures. Additionally, cumulative impacts and the role of ecological networks are often overlooked, limiting the effectiveness of biodiversity conservation goals such as 'no net loss' (Bigard et al. 2017; Cares et al. 2023). Assessments are found to tend to overlook the combined effects of multiple developments or stressors, which, when considered together, can lead to severe biodiversity degradation – commonly referred to as 'death by a thousand cuts' (Whitehead et al. 2016, 195). The accumulation of impacts exacerbates threats to species persistence, making it difficult to capture and mitigate these impacts effectively within standard EIA frameworks (Whitehead et al. 2016; Bigard et al. 2017).

Bond et al. (2021) further argue that EIA processes are often dominated by anthropocentric values, where socio-economic trade-offs overshadow the intrinsic value of biodiversity. This results in incremental biodiversity loss as decisions tend to prioritize human benefits over ecological integrity (Bond et al. 2021). Even with tools like Ecosystem Services Assessments (ESA) or biodiversity offsets, these frameworks often operate within a utilitarian model, limiting their effectiveness in safeguarding biodiversity (Bond et al. 2021).

The legal requirement to integrate biodiversity into EIA and SEA has driven significant scholarly attention and debate on the effectiveness of these assessments in practice. Scholars such as Gontier et al. (2006) have highlighted the challenges of translating the legal requirements into practice, particularly regarding the consideration of biodiversity impacts, and Gutierrez et al. remark on the need for 'setting explicit legal provisions for enforcement' (Gutierrez et al. 2024, 18). Geneletti (2016) identified persistent gaps in the integration of biodiversity, noting that while many EAs mention biodiversity, they often fail to provide concrete measures for its conservation or restoration. Similarly, Söderman and Saarrela (2010) as well as Swanepoel et al. (2019) have critiqued the lack of thorough biodiversity assessment in EIA reports, pointing to issues such as inadequate baseline data and connections between baseline studies and impact prediction, superficial mitigation measures, and insufficient monitoring and follow-up. Gallardo and Bond (2024) have benchmarked specifically tiering of biodiversity issues from SEA to EIA and found the practice lacking. This means that important information about biodiversity impacts is lost and its potential to influence project design is thus also diminished.

1.3. The importance of benchmarks in assessing biodiversity integration

Given this context, the use of benchmarks is essential in assessing how well biodiversity is integrated into EIA and SEA practices. In this paper, benchmarks serve as measurable standards that ensure key areas – such as biodiversity significance, ecosystem services, and mitigation measures – are addressed systematically in EIA and SEA reports. The application of benchmarks helps to provide clarity, reduce ambiguities, and ensure that biodiversity protection measures are aligned with EU legal requirements and general best practices.

This paper explores the integration of biodiversity into EIA and SEA practices in four European countries using a benchmark framework developed under the BioValue project (see https://biovalue-horizon.eu/). The central research question guiding this study is:

> To what extent do current EA practices in Denmark, Germany, Spain, and Portugal integrate biodiversity considerations in alignment with best practice benchmarks, and what are the key areas for improvement?

Using a comprehensive benchmark of indicators related to biodiversity significance, knowledge, synergies, ecosystem services, and mitigation, this study examines how well current EA practices align with best practice guidelines for biodiversity integration. The findings provide valuable insights into the strengths and weaknesses of current EA practices and highlight areas for improvement, with the aim of supporting more effective biodiversity conservation through EAs.

The methodology and framework for the study is presented in section two, with an emphasis on presenting the benchmark. In section three results are presented for each theme in the benchmark and in section four conclusions are drawn.

2. Methodology and framework

This section outlines the methodology employed for this study, which benchmarks the integration of biodiversity into environmental assessment practices across Denmark (DK), Germany (DE), Spain (SP), and Portugal (PT). The methodology is structured into three main subsections: the construction of a benchmark framework, the selection of EA reports, and the analytical process used to evaluate the reports.

2.1. The benchmark framework

The benchmark used in this study was developed under the BioValue project, with the aim of identifying best practices for integrating biodiversity into environmental assessment instruments, such as EIA and SEA. The benchmark is based on the BioValue project's comprehensive review of 12 key guidance documents and international best practice frameworks on biodiversity in EIA and SEA. The documents included are:

- Convention on Biological Diversity (2006) *Voluntary guidelines on Biodiversity-inclusive Environmental Impact Assessment*
- CBBIA-IAIA (2006) *Guidance Document on Biodiversity, Impact Assessment and Decision Making in Southern Africa*
- CBBIA-IAIA (2007) *Best practice guidance for biodiversity-inclusive impact assessment*
- Business and Biodiversity Offset Programme (2009) *The Relationship between Biodiversity Offsets and Impact Assessment*
- Irish Environmental Protection Agency (2012) *Final Report: Integrated Biodiversity Impact Assessment, Streamlining AA, SEA and EIA Processes. Best Practice Guidance*
- European Commission – EIA (2013) *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment*
- European Commission – SEA (2013) *Guidance on Integrating Climate Change and Biodiversity into Strategic Environmental Assessment*
- Multilateral Financing Institutions (2015) *Good Practices for Biodiversity Inclusive Impact Assessment and Management Planning*
- International Association for Impact Assessment (2018) *International Best Practice Principles – Biodiversity and Ecosystem Services in Impact Assessment*
- European Investment Bank (2018) *Guidance Note for Standard 3 on Biodiversity and Ecosystems*
- IAIA-GBIF (2020) *Best Practices for Publishing Biodiversity Data from Environmental Impact Assessments*
- IFC (n.d.) *A Guide to Biodiversity for the Private Sector*

These documents convey both legal requirements and practical recommendations for integrating biodiversity into assessments. The benchmark is derived from the recommendations in the documents through a grounded text analysis and reshaped into a list of themes, indicators, and elements that can be used to measure and advance good quality integration of biodiversity in EA (Larsen SV, Puibaraud IE, et al. 2022; Larsen et al. 2024).

The benchmark is structured around 10 key themes, of which eight are used in this study. Each theme represents critical aspects of biodiversity integration in EA practices, as shown in Table 1. Each theme is

Table 1. The benchmark's 10 themes and associated indicators and elements (Larsen et al. 2022/2024).

Themes	Indicators	Elements
A – Significance	What methodology is used to evaluate the significance of biodiversity impacts in the EA?	• Impacts are compared to reference situation/zeroalternative • Impacts are compared against thresholds, criteria, and targets • Impacts are compared to sensitivity of impacted entity
	Which types of parameters are used for evaluating significance of biodiversity impacts in the EA?	• Parameters related to characteristics of the activity/impact on biodiversity • Parameters related to characteristics of the impacted biodiversity entities
B – Knowledge	Which types of knowledge are used for working with biodiversity in the EA?	• Expert knowledge • Multidisciplinary knowledge • Local and indigenous knowledge
C – Synergies and trade-offs	How are synergies and trade-off between biodiversity and other sustainability aspects handled in the EA?	• It is acknowledged that synergies and trade-offs exist • Synergies and trade-offs are identified • Synergies and trade-offs are managed • Trade-offs are taken into account in decision-making
D – Ecosystem services	How are ecosystem services used in the EA?	• Acknowledging the importance of ecosystem services • Mapping ecosystem services • Identifying users/beneficiaries of ecosystem services. • Assigning values to ecosystem services • Evaluating impacts on ecosystem services from the activities • Mitigating impacts on ecosystem services • Monitoring ecosystem services
E – Goals and visions	How should biodiversity goals and visions be integrated in EA?	• Through including national and/or international goals and visions as significance criteria • Deciding on a 'vision' to which the SEA should contribute, with explicit goals, objectives, desired outcomes for biodiversity
F – Uncertainty	How should the EA process deal with 'the unknown'/uncertainty concerning biodiversity?	• Through ensuring transparency about lack of data, gaps in knowledge, and uncertainty • Through taking a precautionary approach to impacts • Through identifying gaps in knowledge and gathering additional information • Through managing uncertainty, e.g. using adaptive management, scenarios etc.
G – Mitigation and enhancement	How are biodiversity impacts mitigated in the EA?	• Biodiversity impacts are mitigated in accordance with the mitigation hierarchy • Biodiversity impacts are mitigated based on analysis of residual impacts • Biodiversity impacts are mitigated through enhancing biodiversity values
	To what degree are biodiversity impacts mitigated in EA?	• Biodiversity impacts are mitigated so that 'no net loss' is achieved • Biodiversity impacts are mitigated so that 'net gain' is achieved
	How are financial instruments used in the EA?	• The necessary financial settings for implementation of mitigation measures including compensation/offsetting are established • Financial incentives are provided for proponents to protect biodiversity • Financial settings for maintenance of biodiversity are established
H – Monitoring and follow-up	How does the EA specify monitoring of biodiversity impacts?	• Plans are established for monitoring biodiversity impacts • Clear targets, indicators, and responsibilities for monitoring biodiversity impacts are specified • Plans for monitoring are linked to sound baseline information • Plans for monitoring specify that stakeholders should be involved
	What is the monitoring of biodiversity impacts specified in the EA aimed at?	• Validating the predicted biodiversity impacts • Validating the outcomes of mitigation measures • Implementing adaptive management • Building knowledge for future EAs and planning • Checking compliance with conditions for approval

assessed through a series of indicators that reflect best practices, derived from the review of guidance documents. The more indicators met, the higher the level of alignment with the benchmark and, by extension, international best practices for biodiversity integration. These themes and associated indicators capture the range of biodiversity considerations that should be addressed in an effective EIA or SEA, and they include the following:

(A) **Evaluation of significance**: This theme focuses on a thorough and transparent significance evaluation. This includes a focus on what approach the EA takes in evaluating the significance of biodiversity impacts and what types of parameters are used in the evaluation against which to measure impacts.

(B) **Knowledge types**: The diversity and quality of knowledge used in the EA is essential for informed decision-making. The benchmark assesses the diversity of knowledge used, including expert scientific knowledge, multidisciplinary insights (e.g. ecological, social, economic), and local or indigenous knowledge.

(C) **Synergies and trade-offs**: This theme evaluates the extent to which EAs recognize and manage the synergies and trade-offs between biodiversity and other sustainability aspects, such as climate mitigation, human health, and land-use. The benchmark emphasizes that high-quality EAs should not only identify these interactions, but also incorporate them into decision-making processes to balance competing interests while safeguarding biodiversity.

(D) **Ecosystem services**: The benchmark evaluates whether and how ecosystem services are incorporated into the EA. Elements of good practice include identifying the ecosystem functions that support human well-being and evaluating how the proposed project or plan might affect these services as well as mitigating and monitoring where relevant. Integrating ecosystem services is seen to link biodiversity with socio-economic outcomes, making it a relevant issue for stakeholders and consultation.

(E) **Goals and visions**: EAs are assessed on whether they form and actively utilize a vision for biodiversity and/or use valued ecosystem services or broader biodiversity conservation goals (such as from national and international biodiversity strategies or regional/local conservation plan) as a framework to guide the assessment. The benchmark encourages the inclusion of explicit biodiversity goals to ensure that the EA contributes to internal and external long-term efforts.

(F) Uncertainty management: Uncertainty is inherent in biodiversity assessments, particularly due to data limitations and the complexity of ecological systems. The benchmark evaluates how well EAs disclose and manage uncertainty, including whether they adopt precautionary approaches when data gaps exist or impacts are difficult to predict.

(G) **Mitigation and enhancement**: Under this theme, it is assessed how EAs apply the mitigation hierarchy (enhancement, avoidance, minimization, restoration, off-setting) to address biodiversity impacts. The benchmark stresses the importance of prioritizing enhancement, avoidance, and minimization over offsetting, ensuring that the mitigation measures are based on analysis of residual impacts until achieving 'no net loss' or 'net gain' and establishing any necessary financial instruments.

(H) **Monitoring and follow-up**: Finally, the benchmark evaluates the extent to which EAs include clear, enforceable plans for monitoring biodiversity impacts post-implementation and whether it guides action based on monitoring results.

The specific indicators and elements for each theme can be seen in Table 1. The indicators are phrased as questions for the EA under analysis and the elements are possible answers to these questions. All are derived from the guidance documents.

The benchmark serves not only as a tool for evaluating the current state of biodiversity integration in EIA and SEA, but also as a guide for improving future assessments. By identifying gaps and areas of strength, the benchmark helps stakeholders explore where improvements are needed to improve integration of biodiversity into EA – and thus pursue biodiversity goals and strategies. Important for the integration of biodiversity in EA is also which definition of biodiversity the EA report under analysis applies. The benchmark as such does not direct which definition the EA reports should apply, in this paper and analysis the definition of biodiversity in the CBD has been applied namely that biodiversity is '*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*' (UN 1993). To deepen the understanding of the benchmark framework and its development, the full report from the BioValue project provides a detailed account of the themes, indicators, and guidance documents that form the foundation for evaluating biodiversity integration in EIA and SEA practices (see Larsen SV, Puibaraud IE, et al. 2022).

2.2. Selection of reports

Initially, a total of 201 EA reports from Denmark, Spain, Germany, and Portugal were selected for analysis. With these countries the analysis covers a geographical gradient in the EU (northern, central and southern Europe) and countries where the project team are familiar with the language and context. The selection process was further based on three key criteria:

(1) Geographic scope, with reports covering both terrestrial and marine developments, ensuring that a broad range of environments were represented.
(2) Type of EA, covering both EIA and SEA reports. For EIA reports, projects involving significant land use or land conversion were prioritized. For SEA reports, plans related to spatial planning were selected.
(3) Publication date, with reports from the last five years primarily selected to ensure the relevance of the analysis to current EA practices.

The choice of reports with a broad geographical scope, large land use/conversion, and spatial planning mean that we are expecting biodiversity to be a relevant topic for assessment in most of them. With the choice of recent reports, we are expecting them to be representative of current practice and relevant for comparison with best practice. Out of these 201 reports, 10 reports did not include any assessment of biodiversity and thus the detailed analysis was carried out on a total of 191 reports.

The distribution of reports included 111 from Denmark, 20 from Spain, 20 from Germany, and 41 from Portugal, as seen in Table 2. It is important to be aware of the uneven distribution of reports per country in the analysis and conclusions drawn on the basis of the study. Especially, the many reports from Denmark will pull overall results in the direction of any tendency in the Danish reports. These were further classified into SEAs, EIAs, and combined EIA/SEA reports to ensure a balanced representation of different types of EA reports.

The selected EIA reports cover the following:

- Linear infrastructure projects on land, including roads, railways, cables, and pipelines.
- Linear infrastructure projects at sea, including raw materials extraction, railways, cables, and bridges.
- Projects on land with large land coverage/conversion, including photovoltaic installations, coastal protection, industrial developments, agriculture, buildings, ports, and wind energy.
- Projects at sea with large land coverage/conversion, including wind energy, coastal protection, and ports.

The most prevalent types of EIA reports (more than 10 reports) are photovoltaic projects on land (especially from Denmark), roads, railways, and coastal protection both on land and at sea.

The selected SEA reports cover the following:

- Comprehensive plans on land, including overall spatial plans, land-use plans, and agricultural policy.
- Comprehensive plans at sea including overall spatial plans and marine spatial plans.
- Local area plans on land, including general local plans, an electricity transmission plan, and a climate action plan.
- Local area plans at sea, including wind energy installations, coastal protection, and nature protection.
- Programmes, including regional programmes and programmes of transboundary cooperation.

The most prevalent SEA report types (more than 10 reports) are the overall spatial plans and the general local plans. For both EIA and SEA reports it is important in the analysis and conclusions to be aware of the distribution of reports on types as this might influence results.

With the breadth in types of reports selected, it follows that different types of levels of authority are covered. Thus, the EA reports and processes are anchored at authorities from the municipal to the state level. The reports are distributed over the years from 2013 through 2023 with the majority being from 2020 to 2021. The distribution of reports by year of publication can be seen in Figure 1.

As seen in Figure 1, it has not been possible to only choose reports from the last 5 years, as this would have led to compromising with the criteria concerning types of reports. Instead, it has been chosen to prioritise the last 5 years but include earlier reports as needed to comply with the criteria for types. In this process, the latest reports have always been chosen.

Table 2. Distribution of analyzed reports based on country and type.

Country/Type	SEA reports	EIA reports	Combined SEA/EIA reports	Total
Denmark	45	50	16	111
Germany	10	10	0	20
Portugal	20	20	0	40
Spain	12	8	0	20
Total	87	88	16	191

2.3. Analysis of EA reports

The analysis aimed to evaluate how each of the selected EA reports integrated biodiversity considerations and to what extent each performed compared to the best practices included in the benchmark (see The benchmark framework). To achieve this, each report was subject to a text analysis and coding.

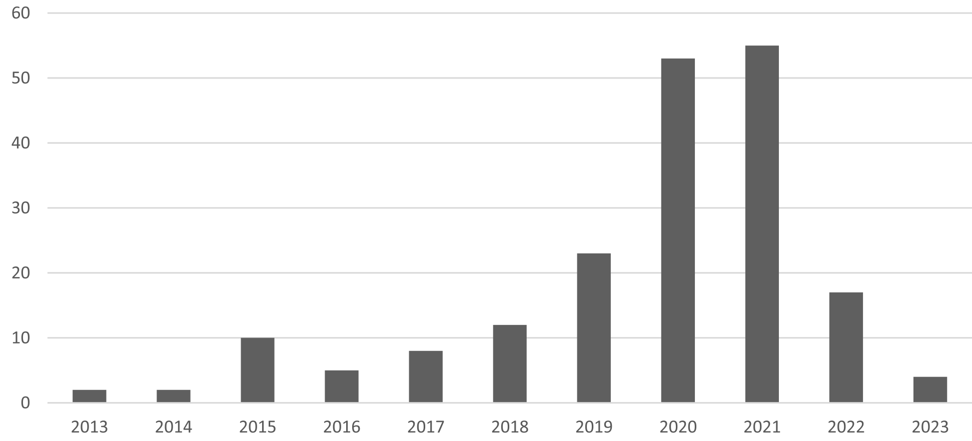

Figure 1. Distribution of selected EA reports on year of publication.

For each report, a registration was made of metadata including level of authority (municipality, province, region, state), type of report (SEA, EIA), place (off-shore, on-shore, both), and year of publication. Then, in all reports, sections related to biodiversity were reviewed. This included all parts of the reports concerning nature, ecosystems, protected areas, different species, etc. both terrestrial and aquatic. It did not include related issues such as landscape. After this, the benchmark data was collected using the themes, indicators, and elements from Table 1. Thus, for each of the reports, the task was to answer the questions formulated in the indicators by noting which of the elements were included in the report. In practice this task necessitated reading the selected parts of the report to register and label any text related to the indicators and elements. Based on this, the text was summarized in a spreadsheet of which elements were included, with key text copied in. There was also an option to fill in 'other' elements not foreseen in the framework but considered relevant for the analysis (at the discretion of the reviewers).

Due to the number of reports to be reviewed, the task has been performed by different researchers separately, necessitating measures to promote consistency. One measure is that all reviewers from all partners used the same framework and spreadsheet, which was jointly presented and discussed to agree on a common interpretation of its elements. In addition, during the review process, bilateral meetings and email correspondence have been used to discuss questions and align practice to promote consistency.

After the review of reports, the data was collected and analyzed by summarizing the results in the spreadsheets across e.g. types of reports and comparing the found practice to the benchmark of good practice, which was the goal. This analysis is presented in section 3.

3. Comparative analysis of environmental assessment practices

This section delves into the comparative analysis of the biodiversity themes. In the analysis, results are shown in tables distributed by country and type of report. The numbers in the left side of each table shows the percentage of reports that include one or more elements, and the right side shows the percentage of reports that include the specific elements.

3.1. Evaluation of significance of biodiversity impacts

Significance assessment is a crucial component of EA. The benchmark identifies three key methodologies: (1) comparing impacts to a reference situation or zero-alternative, (2) measuring against thresholds and targets, and (3) evaluating impacts relative to the sensitivity of impacted biodiversity entities. Further it focuses on which types of parameters are used for assessing significance.

The benchmark analysis provides insights into how these methodologies and parameters are used to assess biodiversity impact significance and the number of methods and parameters applied in EA across the four countries. The full overview of results can be seen in Tables 3 and 4.

Looking at the overall picture, the EA reports are performing well regarding assessment of significance, as the majority of reports document use of one or more methods and parameters for the assessment. A notable exception are SEA reports from Denmark and Spain, where approximately one third of reports do not document use of any structured method for assessment (see Table 3). Generally, Spain and Portugal often rely on single-method approaches in their SEA and EIA, primarily on reference situations. This could limit the ability of these countries to conduct comprehensive biodiversity assessments, potentially

Table 3. Results in percentages concerning the first indicator of significance: 'How is biodiversity integrated in the EA process?'

		No methodology		One methodology		Two methodologies		Three methodologies		Compare impacts to reference situation/0-alt		Compare impacts against thresholds, criteria and targets		Compare impacts to sensitivity of impacted entity	
DK	SEA	27	15	42	33	20	28	11	25	60	65	31	47	24	50
	EIA	6		26		34		34		69		58		68	
ES	SEA	33	**20**	67	**80**	0	**0**	0	**0**	58	**75**	0	**0**	8	**5**
	EIA	0		100		0		0		100		0		0	
PT	SEA	0	**2**	55	**58**	40	**39**	0	**0**	95	**95**	38	**27**	5	**12**
	EIA	5		62		38		0		95		15		20	
DE	SEA	0	**0**	40	**45**	50	**45**	20	**10**	80	**70**	30	**30**	60	**65**
	EIA	0		50		40		10		60		30		70	

Table 4. Results in percentages of reports concerning the second indicator of significance: 'Which types of parameters are used for evaluating significance of biodiversity impacts in the EA?'[1]

		No elements		One element		Two elements		Parameters related to characteristics of the activity/impact		Parameters related to characteristics of impacted biodiversity	
DK	SEA	29	16	24	18	47	65	71	82	47	67
	EIA	8		14		78		89		82	
ES	SEA	33	**20**	58	**75**	8	**5**	67	**80**	8	**5**
	EIA	0		100		0		100		0	
PT	SEA	0	**5**	81	**66**	14	**27**	33	**61**	86	**63**
	EIA	10		50		40		90		40	
DE	SEA	10	**5**	60	**30**	60	**80**	50	**75**	80	**85**
	EIA	0		0		100		100		90	

overlooking the cumulative aspects and sensitive nature of certain biodiversity impacts.

Denmark and Germany frequently employ multi-method approaches in both SEA and EIA, combining reference situations, thresholds, and sensitivity assessments. This multi-method approach enhances the depth and availability of biodiversity assessments, supporting both compliance with regulatory frameworks and species-specific protections. The prioritization of sensitivity considerations highlights the importance of evaluating the vulnerability of specific biodiversity elements, which best aligns with best practice – as it allows assessments to adapt to the unique ecological contexts of each plan or project.

3.2. *Knowledge types used for integrating biodiversity*

The integration of different types of knowledge is important to ensuring a comprehensive understanding of biodiversity impacts and trade-offs as well as mitigation options. The three primary types of knowledge referenced in the benchmark are: (1) expert knowledge with a typical involvement of technical and scientific input from specialists within biology, ecology, and related fields, (2) multidisciplinary knowledge drawing from multiple scientific disciplines such as technical and social science, providing a broader perspective on biodiversity impacts, and (3) local and indigenous knowledge with insights from e.g. local stakeholders and communities to add contextual understanding of biodiversity in specific areas.

The benchmark analysis shown in Table 5 reveals, across all countries and across both SEA and EIA, a strong reliance on expert knowledge. This reflects a common emphasis on technical expertise as the foundation for biodiversity assessments. This focus ensures that scientific and detailed ecological knowledge inform biodiversity impact evaluations. This is particularly the case for SEA, possibly because SEA operates at a strategic level where broad technical assessments are prioritized above detailed, localized insights. Thus, in terms of the benchmark where inclusion of more

Table 5. Results in percentages of reports concerning the indicator of knowledge: 'Which types of knowledge are used for working with biodiversity in the EA?'

		No types		One type		Two types		Three types		Expert knowledge		Multidisciplinary knowledge		Local and indigenous knowledge	
DK	SEA	0	0	73	54	27	46	0	0	60	65	31	47	24	50
	EIA	0		40		60		0		69		58		68	
ES	SEA	100	**95**	0	**5**	0	**0**	0	**0**	58	**75**	0	**0**	8	**5**
	EIA	88		13		0		0		100		0		0	
PT	SEA	10	**10**	29	**20**	62	**71**	0	**0**	95	**95**	38	**27**	5	**12**
	EIA	10		10		80		0		95		15		20	
DE	SEA	0	**0**	90	**95**	10	**5**	0	**0**	80	**70**	30	**30**	60	**65**
	EIA	0		100		0		0		60		30		70	

types of knowledge is desirable, generally the EA reports do not reflect best practice to a very high extent.

Regarding multidisciplinary knowledge, Portugal and Denmark make the most use, especially in EIA. This integration of perspectives from diverse scientific disciplines supports a more holistic understanding of biodiversity impacts, acknowledging social, economic, and environmental dimensions. Germany and Spain, however, exhibit minimal use of multidisciplinary knowledge, which may reduce the depth of analysis in understanding broader ecosystem implications.

Denmark is notable for incorporating local knowledge in EIA (58%), which enhances assessments by integrating context-specific information from local stakeholders. This practice is primarily related to citizen science efforts through the essential open access platform, 'arter.dk' (in English, *species.dk*), which is a community where all registered users can help find, record, and identify species. Currently, there are more than 33.5 million verified findings. Germany, Portugal, and Spain show limited to no use of local and indigenous knowledge in both SEA and EIA. This lack of local input could result in assessments that miss area-specific biodiversity insights and cultural perspectives.

3.3. Handling of synergies and trade-offs

The benchmark reports identified four approaches to managing synergies and trade-offs: (1) acknowledging that synergies and trade-offs exists and that potential interactions between biodiversity impacts and other environmental concerns exist, (2) identifying synergies and trade-offs, which lead to a determination and documentation of interactions, (3) managing synergies and trade-offs through which interactions are actively addressed and sought to be minimized, and (4) considering trade-offs in decision-making whereby trade-offs are integrated.

As illustrated in Table 6, reports from all countries show some acknowledgement that synergies and trade-offs exist, especially in SEA. This reflects a foundational understanding of the interconnectedness between biodiversity and other sustainability dimensions such as resource sustainability or the need for a stabile ecosystem. The fact that between 35% and 81% of reports do not include any elements from the benchmark still point towards potential for improvement compared to best practice. However, the depth of acknowledgement varies significantly between countries.

Germany's environmental assessment practice stands out as the most comprehensive, actively identifying, managing, and integrating synergies and trade-offs. This shows a mature approach and positions Germany as a model for how EA can incorporate sustainability interactions fully in decision-making. Both Spain and Portugal fall short in advancing to management and integration in decision-making; Spain focuses heavily on acknowledgement and identification, while Portugal includes moderate levels of both. Denmark has a low inclusion rate across all elements, reflecting a limited approach to handling synergies and trade-offs. This minimal use suggests that Denmark's EA practices are not yet geared toward comprehensive sustainability integration.

3.4. Use of ecosystem services

The benchmark categorizes the handling of ecosystem services in environmental assessment into eight specific elements to explore the extent of integration: (1) mentioning ecosystem services, (2) acknowledging their importance, (3) mapping ecosystem services, (4) identifying users/beneficiaries, (5) assigning values, (6) evaluating impacts, (7) mitigating impacts, (8) monitoring ecosystem services. These elements reflect a continuum from basic recognition to more active use.

As can be seen from the results in Table 7, across the countries, SEA reports include more ecosystem services elements than EIA reports, indicating a greater focus on ecosystem services at the strategic-planning level, rather than at the project-specific level. Looking at the overall level, the performance of the EA reports on use of ecosystem services compared to the

Table 6. Results in percentages of reports concerning the indicator of synergies and trade-offs: 'How are synergies and trade-off between biodiversity and other sustainability aspects handled in the EA?'

		No elements		One element		Two elements		Three elements		Four elements		It is acknowledged that synergies and trade-offs exist		Synergies and trade-offs are identified		Synergies and trade-offs are managed		Synergies and trade-offs are taken into account in decision-making	
DK	SEA	78	81	2	5	18	14	2	1	0	0	22	19	20	15	0	0	2	1
	EIA	83		6		11		0		0		17		11		0		0	
ES	SEA	33	**23**	33	**60**	33	**17**	0	**0**	0	**0**	67	**55**	33	**30**	0	**10**	0	**0**
	EIA	13		88		0		0		0		38		25		25		0	
PT	SEA	57	**71**	19	**15**	24	**15**	0	**0**	0	**0**	43	**29**	24	**12**	0	**0**	0	**2**
	EIA	85		10		5		0		0		15		0		0		5	
DE	SEA	40	**35**	20	**20**	10	**30**	30	**15**	0	**0**	40	**50**	50	**55**	10	**5**	30	**15**
	EIA	30		20		50		0		0		60		60		0		0	

Table 7. Results in percentages of reports concerning the indicator of ecosystem services: 'how are ecosystem services used in the EA?'

		No elements		One elements		Two elements		Three elements		Four elements		Mentioning		Acknowledging		Mapping		Identifying		Assigning value		Evaluating		Mitigating		Monitoring	
DK	SEA	100	96	0	2	0	1	0	1	0	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	EIA	94		3		2		2		0		6		0		3		0		0		1		0		0	
ES	SEA	42	**65**	0	**0**	50	**30**	8	**5**	0	**0**	58	**35**	42	**25**	0	**0**	0	**0**	8	**5**	17	**10**	0	**0**	0	**0**
	EIA	100		0		0		0		0		0		0		0		0		0		0		0		0	
PT	SEA	10	**10**	29	**20**	62	**71**	0	**0**	0	**0**	43	**27**	24	**15**	5	**2**	10	**7**	0	**0**	10	**5**	0	**0**	0	**0**
	EIA	10		10		80		0		0		10		5		0		5		0		0		0		0	
DE	SEA	70	**60**	0	**20**	10	**10**	10	**5**	10	**5**	30	**35**	30	**15**	0	**0**	20	**10**	10	**5**	0	**0**	0	**5**	0	**0**
	EIA	50		40		10		0		0		40		0		0		0		0		0		10		0	

benchmark is somewhat lacking, with the notable exception of Portuguese reports, where 71% of reports include two of the elements in the benchmark. For Spain results show more inclusion of ecosystem services in SEA than EIA, while Germany demonstrates a relatively balanced inclusion across both SEA and EIA, and in general the most comprehensive approach.

Denmark stands out with a minimal engagement with ecosystem services. In SEA, no reports include any of the elements, and in EIA, only 6% mention ecosystem services, with even lower percentages for mapping and impact evaluation. The results indicate that Denmark's EA practices lack a robust framework for addressing ecosystem services, possibly with a risk of undermining the protection and management of these services. Comparatively, Spanish SEA reports show a higher focus on ecosystem services; however, there is little engagement beyond the basic levels of mentioning and acknowledging their importance. Despite awareness, the practice lacks depth. The results from Portugal demonstrate a moderate engagement with ecosystem services in SEA, but this does not extend robustly to EIA.

To enhance the integration of ecosystem services, all countries could benefit from more comprehensive engagement with the elements beyond acknowledgement. This finding aligns with previous findings from the REFIT evaluation of the SEA implementation in 2019, which found limited effectiveness of SEA to support ecosystem services (EU Commission 2019). This would involve mapping services, identifying users, assigning values, evaluating and mitigating adverse impacts, and establishing monitoring.

3.5. Integration of biodiversity goals and visions

Integrating objectives in EA at the national, regional, and local scale is a way of ensuring that biodiversity impacts are assessed with political goals and visions in mind. Doing so recognizes that the plans and projects that SEAs and EIAs assess are not isolated from political contexts and should be held accountable for contributing to political visions. The extent to which these goals and objectives guide EA practice differs depending on the approach, broken into three elements: (1) through including conservation priorities and targets from existing strategies and guidelines, (2) through deciding on a 'vision' with explicit goals, objectives, and desired outcomes, and (3) through applying an ecosystem-based approach focusing on valued ecosystem services as goals.

Concerning 1) the priorities and targets could e.g. stem from the international level e.g. the SDG's or the Aichi Biodiversity Targets, the regional level e.g. the EU Biodiversity Strategy 2030 or local level strategies and guidelines.

Across the four countries, between 35% and 80% of EA reports use none of the approaches outlined in the elements, indicating a general underperformance compared to the benchmark of best practice. This can be seen in Table 8. Of the four countries, Germany stands out and exhibits the most integration of biodiversity goals and visions with 60% of the reports using one approach and 5% using two approaches. A little over half of the reports from Portugal use at least one approach, 7% of those using two approaches for integration. The remaining two countries demonstrate a lower integration of biodiversity goals and visions, as less than half of the reports use at least one approach, Denmark being the lowest at only 20%, and no reports in either Denmark or Spain exhibiting more than one approach. None of the four countries used all three approaches. In Spain and Germany, SEAs are primarily subject to the integration of biodiversity goals and visions, in Portugal the opposite is the case, while in Denmark there is no remarkable difference between plan and project levels.

It is primarily the initial element, using conservation priorities and targets from existing strategies and guidelines, that is utilized in both EIAs and SEAs. In Portugal and Germany, deciding on a 'vision' is used solely in the context of SEA and in Spain, solely in the context of EIA. No reports applied an ecosystem-based approach as integration of biodiversity goals and visions.

This shows opportunities for improving the alignment of EAs and the goals and visions there are on the societal level for enhancing biodiversity, or at the very least, making this link more explicit.

Table 8. Results in percentages of reports concerning the indicator of goals and visions: 'How should biodiversity goals and visions be integrated in EA?'

		No elements		One element		Two elements		Three elements		Including existing priorities and targets		Decising on a 'vision'		Applying an ecosystem-based approach	
DK	SEA	80	80	20	20	0	0	0	0	16	18	4	2	0	0
	EIA	80		20		0		0		20		0		0	
ES	SEA	50	**65**	50	**35**	0	**0**	0	**0**	33	**25**	0	**10**	0	**0**
	EIA	88		13		0		0		13		25		0	
PT	SEA	43	**49**	43	**44**	14	**7**	0	**0**	24	**34**	48	**24**	0	**0**
	EIA	55		45		0		0		45		0		0	
DE	SEA	10	**35**	80	**60**	10	**5**	0	**0**	70	**55**	30	**15**	0	**0**
	EIA	60		40		0		0		40		0		0	

Table 9. Results in percentages of reports concerning the indicator of uncertainty: 'How does the EA process deal with "the unknown"/uncertainty concerning biodiversity?'[2]

		No elements		One element		Two elements		Three elements		Four elements		Ensure transparency		Take a precautionary approach		Identify gaps in knowledge and gather information		Establishing follow-up with guidelines		Engaging stakeholders throughout the EA process	
DK	SEA	84	65	11	22	4	9	0	2	0	1	13	28	4	15	2	6	NA	NA	NA	NA
	EIA	52		29		12		5		2		38		22		8		NA		NA	
ES	SEA	8	**48**	75	**44**	17	**8**	0	**0**	0	**0**	8	**5**	92	**60**	17	**15**	NA	**NA**	NA	**NA**
	EIA	88		13		0		0		0		0		13		13		NA		NA	
PT	SEA	76	**73**	14	**20**	5	**2**	5	**2**	5	**2**	0	**10**	14	**7**	0	**5**	19	**10**	10	**5**
	EIA	70		25		0		0		0		20		0		10		0		0	
DE	SEA	0	**10**	70	**70**	20	**15**	0	**0**	10	**5**	70	**70**	30	**20**	30	**20**	NA	**NA**	NA	**NA**
	EIA	20		70		10		0		0		70		10		10		NA		NA	

3.6. Handling of uncertainty

Inherent to ex-ante assessments of developments, uncertainty has been identified as a challenge (see e.g. Larsen 2022). The benchmark identifies several elements that describe best practice of how uncertainty is managed in EA processes: (1) transparency with clarity about data limitations, gaps, and uncertainty, (2) application of a precautionary principle to potential impacts, (3) identification of knowledge gaps and gathering additional information as necessary, and (4) employing adaptative management, scenarios analysis, etc. Additionally, for Portuguese reports, two extra elements were considered: (a) Establishing follow-up actions with guidelines for monitoring, and (b) engaging stakeholders throughout the EA process.

Analyzing the results in Table 9, it becomes clear that Germany leads in comprehensive uncertainty management with high transparency and active management of uncertainty, especially in SEA, and may be a model for good practice of effectively managing data gaps and potential impacts. For the remaining countries between 40% and 73% of reports apply none of the elements of best practice, leaving room for improvement. Spanish reports prominently feature the precautionary approach but lack additional strategies like transparency and adaptive management. Spain seems to especially have an opportunity to expand its approach in EIA.

Portugal has a high proportion of reports without any uncertainty management, with especially SEA reports displaying minimal handling. The minimal handling of uncertainty in SEA is also the case in Denmark, focusing only on transparency and precaution. In Denmark, Spain, and Portugal, between 5% and 28% of reports show transparency about uncertainty, lack of data, etc. These are critically low numbers, if it is acknowledged that transparency is an important element of good decision support and of good practice in a democratic decision process in general. It can be an expression of a very high degree of certainty in data and assessments; however, if this is the case, the reports should explicitly state that fact.

3.7. Mitigation and enhancement of biodiversity impacts

Mitigation and enhancement are crucial parts of the EA process in terms of actual safeguarding and developing of biodiversity on-the-ground, in line with goals and strategies. In the benchmark several indicators and elements are derived from the best practice documents. First there is the question of how biodiversity impacts are mitigated in EA, whether they are (1) mitigated in accordance with the mitigation hierarchy, (2) mitigated based on analysis of residual impacts, and (3) mitigated through enhancing biodiversity values.

Overall, comparing to the best practice expressed in the benchmark, as seen in Table 10, it is discouraging that between 10% and 76% of the reports apply none of the suggested structured approaches explicitly. The mitigation hierarchy is the most used approach to mitigation, where between 13% and 75% of reports

Table 10. Results in percentages of reports concerning the first indicator of mitigation and enhancement: 'How are biodiversity impacts mitigated in the EA?'

		No elements		One element		Two elements		Three elements		Mitigation in accordance with the mitigation hierarchy		Mitigation based on residual impacts		Mitigation through enhancing biodiversity values	
DK	SEA	84	76	16	18	0	22	0	1	2	13	4	8	9	9
	EIA	71		20		5		2		20		11		9	
ES	SEA	50	**55**	50	**40**	0	**5**	0	**0**	50	**35**	0	**5**	0	**5**
	EIA	63		25		13		0		13		13		13	
PT	SEA	95	**51**	5	**41**	0	**7**	0	**0**	5	**49**	0	**0**	0	**7**
	EIA	5		80		15		0		95		0		15	
DE	SEA	20	**10**	80	**90**	0	**0**	0	**0**	50	**75**	0	**0**	30	**15**
	EIA	0		100		0		0		100		0		0	

explicitly use the mitigation hierarchy. Here, Germany stands out with 75% of reports explicitly applying the mitigation hierarchy. Basing mitigation on an explicit analysis of residual impacts to be handled is the least used approach, suggesting a lack of overview for an analysis of whether e.g. no-net-loss has been achieved.

This links to another indicator concerning to what degree biodiversity impacts are mitigated in EA, whether no-net-loss or net-gain are used as a frame of reference. Here, it can be seen in Table 11 that most of the reports use none of the frames of reference, pointing to a potential for improvement. The exception are German reports, seen in isolation where 65% of reports include a frame of reference for mitigation and Spanish reports where it is 50%. For those reports that do use a frame of reference, most often 'no-net-loss' is used, whereas 'net-gain' is much less used. Looking at the last indicator of how the implementation is supported by financial instruments, Table 12 shows that the majority of reports do not include any approaches to this. Those reports that do include an approach—75% of Spanish EIAs and 20% of Portuguese SEAs – are establishing the necessary financial settings for the implementation of mitigation measures. An issue in this concern is that there is no tradition for including any financial settings in EA reporting, as this is perhaps handled in other parts of the planning and decision-making processes. It is a discussion point whether it is necessary for transparency and securing implementation that the EA and its measures are coupled more clearly to the necessary financial settings.

3.8. Monitoring and follow-up

Monitoring and follow-up provide a crucial framework for ensuring that the predicted biodiversity impacts are managed and mitigated effectively, and that the potential enhancement measures are implemented. In the benchmark, this first indicator of how monitoring is specified in the EA is divided into four indicators: (1) specification of monitoring with plans to establish monitoring, (2) defining targets, indicators, and responsibilities for monitoring, (3) linking monitoring plans to sound baseline information, and (4) specifying involvement of stakeholders in the plans.

In terms of monitoring, Denmark stands out in a negative sense as only 16% of EA reports specify plans to establish monitoring, as can be seen in Table 13. This means that Denmark also has very few reports reaching the other indicators as they concern how monitoring should be implemented in more detail. In Denmark, more EIA reports than SEA reports include monitoring, while in Spain and Portugal it is the other way around (in Germany it is the same percentage of reports). It is interesting that this seems to be upside-down in Denmark, as a high use of monitoring in SEA could make sense at the more uncertain or open strategic level.

Aside from Denmark, the percentage of reports including monitoring range from 32% to 75%. This seems a reasonable practice compared to the benchmark. Monitoring is relevant in most cases but may sometimes be implemented through other processes

Table 11. Results in percentages of reports concerning the second indicator of mitigation and enhancement: 'To what degree are biodiversity impacts mitigated in EA?'

		No elements		One element		Two elements		Mitigation so that 'no net loss' is achieved		Mitigation so that 'net gain' is achieved	
DK	SEA	96	92	4	8	0	0	2	5	2	3
	EIA	89		11		0		8		3	
ES	SEA	75	**50**	25	**50**	0	**0**	8	**30**	17	**20**
	EIA	13		88		0		63		25	
PT	SEA	95	**54**	5	**41**	0	**5**	5	**44**	0	**7**
	EIA	10		80		10		85		15	
DE	SEA	30	**20**	50	**65**	20	**15**	60	**75**	30	**20**
	EIA	10		80		10		90		10	

Table 12. Results in percentages of reports concerning the third indicator of mitigation and enhancement: 'How are financial instruments used in the EA?'

		No elements		One element		Two elements		Three elements		Financial settings for mitigation measures are established		Financial incentives are provided for protection of biodiversity		Financial settings for maintenance of biodiversity are established	
DK	SEA	100	100	0	0	0	0	0	0	0	0	0	0	0	0
	EIA	100		0		0		0		0		0		0	
ES	SEA	100	**70**	0	**30**	0	**0**	0	**0**	0	**30**	0	**0**	0	**0**
	EIA	25		75		0		0		75		0		0	
PT	SEA	100	**100**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**
	EIA	100		0		0		0		0		0		0	
DE	SEA	80	**90**	20	**10**	0	**0**	0	**0**	20	**10**	0	**0**	0	**0**
	EIA	100		0		0		0		0		0		0	

Table 13. Results in percentages of reports concerning the first indicator of monitoring and follow-up: 'How does the EA specify monitoring of biodiversity impacts?'

		No elements		One element		Two elements		Three elements		Four elements		Plans to establish monitoring		Cleaer targets, indicators and responsibilities for monitoring		Monitoring are linked to sound baseline information		Plans for monitoring specify stakeholder involvement	
DK	SEA	91	84	9	9	0	7	0	0	0	0	9	16	0	5	0	2	0	0
	EIA	78		9		12		0		0		22		9		3		0	
ES	SEA	0	**0**	58	**75**	33	**20**	8	**5**	0	**0**	100	**90**	8	**5**	0	**0**	8	**5**
	EIA	0		100		0		0		0		75		0		0		0	
PT	SEA	29	**37**	33	**32**	33	**22**	5	**10**	0	**0**	67	**61**	19	**20**	24	**22**	5	**2**
	EIA	45		30		10		15		0		55		20		20		0	
DE	SEA	20	**25**	40	**45**	40	**30**	0	**0**	0	**0**	70	**70**	20	**15**	10	**10**	20	**10**
	EIA	30		50		20		0		0		70		10		10		0	

Table 14. Results in percentages of reports concerning the second indicator of monitoring and follow-up: 'What is the monitoring of biodiversity impacts specified in the EA aimed at?'[3]

		No elements		One element		Two elements		Three elements		Validating the predicted biodiversity impacts		Validating the outcomes of mitigation measures		Identifying strategic changes not initially foreseen	
DK	SEA	96	84	4	9	0	7	NA	NA	2	8	2	15	NA	NA
	EIA	75		12		12		NA		12		25		NA	
ES	SEA	0	**0**	33	**25**	67	**75**	NA	**NA**	92	**90**	75	**85**	NA	**NA**
	EIA	0		13		88		NA		88		100		NA	
PT	SEA	38	**41**	24	**22**	10	**22**	29	**15**	52	**54**	52	**44**	29	**15**
	EIA	45		20		35		0		55		35		0	
DE	SEA	70	**65**	30	**30**	0	**5**	NA	**NA**	30	**25**	0	**15**	NA	**NA**
	EIA	60		30		10		NA		20		30		NA	

such as general monitoring programmes. However, not many of the EA reports include more elements – namely clear targets, links to baseline information, and specification of involvement – pointing to a potential for improvement of the quality of the plans for monitoring.

Looking at what the monitoring is aimed at, both validating predicted biodiversity impacts and validating outcomes of mitigation are used, as seen in Table 14. In Portugal, an additional aim of identifying strategic changes not foreseen was added. This aim is only used in SEA reports and thus could be related to the specifically strategic approach to SEA in Portugal (see e.g. Partidario and Monteiro 2019). The benchmark, in Table 15, also highlights the relevance of deciding how monitoring and resulting data should be used. Here, most reports state that the use is implementing adaptive management, meaning adjusting the project etc. if new knowledge or unforeseen issues arise. Here again Portugal is the exception, where 29% of reports include the use of monitoring to check compliance with conditions. This may reflect differences in the way the planning and permitting system works in the various countries, whether it is mostly based on the EA or is a more separate system (as is e.g. the case in Denmark). Spain also stands out with 30% of reports stating that monitoring should be used for building knowledge for future EA and planning processes (for the other countries it is 0% to 5% of reports). Here, Spain is closer to the best practice established in the benchmark, at least in terms of documenting this use of monitoring.

Table 15. Results in percentages of reports concerning the third indicator of monitoring and follow-up: 'What is the monitoring of biodiversity impacts specified in the EA aimed at?'

		No elements		One element		Two elements		Three elements		Implementing adaptive management		Building knowledge for future EA's and planning		Checking compliance with conditions for approval	
DK	SEA	98	92	2	5	0	3	0	0	2	6	0	3	2	2
	EIA	88		8		5		0		11		5		2	
ES	SEA	8	**20**	83	**75**	8	**5**	0	**0**	42	**50**	50	**30**	0	**0**
	EIA	38		63		0		0		63		0		0	
PT	SEA	43	**44**	48	**34**	5	**17**	5	**5**	52	**49**	5	**5**	14	**29**
	EIA	45		20		30		5		45		5		45	
DE	SEA	50	**65**	50	**35**	0	**0**	0	**0**	50	**35**	0	**0**	0	**0**
	EIA	80		20		0		0		20		0		0	

4. Conclusion

In broad terms, the analysis shows a limited alignment with the best practice benchmark. It is not to be understood that there is no integration of biodiversity in EA, but rather that the practice does not measure well against best practice. In the context of the benchmark for most of the themes evaluated, often only one of the elements is included if even that.

A couple of themes are exceptions to this. One is assessment of significance where most reports include one of the parameters and a relatively high number include more than one. Monitoring is another theme where the reports generally perform well.

Based on the analysis of the remaining themes key areas for improvement can be suggested:

- Supplementing the use of expert knowledge with knowledge from other disciplines and local and indigenous knowledge. Perhaps the Danish practice of gathering local knowledge in a database can be an inspiration in terms of bridgebuilding between expert knowledge and local knowledge.
- Going beyond acknowledging synergies and trade-offs to identify, manage, and take them into account. Here German practice could be used as a model for strengthening practice in the other countries.
- Including ecosystem services in the assessment, from mapping them to monitoring them. The Portuguese approach especially to SEA could serve as inspiration perhaps to both SEA and EIA practice.
- Integrating biodiversity goals and visions as a framework for assessment. Here, again lessons could perhaps be learned from practice in Portugal, where reports are performing better compared to best practice.
- Ensuring transparency about uncertainty, as well as taking action to handle uncertainty. Here, again Germany SEA practice could be a model for improvement in the other countries.
- Going beyond mitigating to prevent harm and moving towards using a structured approach to mitigation as well as enhancing biodiversity.

It is difficult to conclude very specifically 'to what extent' practice lives up to the benchmark. However, the broad benchmark study does add value in pointing out key areas for improvement and pointing to good practice that could perhaps serve as inspiration. For the areas of improvement to be practicable, further study is needed e.g. of the practice in countries performing well, to determine whether it really is an example to follow and whether it is transferable to other contexts.

The strength of a benchmark study, such as this one, is the overview and possibilities of comparison at a large scale. On the other hand, using a broadly applicable benchmark means not being able to benchmark more detailed e.g. which impacts on biodiversity should be taken into consideration or which mitigation measures are appropriate. Such issues are very dependent on the specific project and context (geographical, biophysical, governance framework, etc.) and thus requires a more context specific benchmark with a much narrower applicability.

A broad study of this type and size necessitated cooperation between several independent researchers placed in different countries and contexts. This is positive in terms of getting many perspectives on the study, but it also poses a risk of multiple interpretations of the details in the benchmark, which may create bias in data collection. An example of how to partly mitigate this could be to establish as part of the benchmark a detailed definition of biodiversity, providing a joint point of departure.

Taken together, these findings suggest that while biodiversity integration in EA practice is progressing, it remains fragmented and uneven, echoing observations from recent international research on the challenges of operationalizing biodiversity considerations in assessment processes. The limited alignment with best practice benchmarks highlights a persistent implementation gap between conceptual and procedural commitments to biodiversity and their practical realization, as discussed by authors such as Geneletti (2016) and Swanepoel et al. (2019). The relative strengths found in significance assessment and monitoring mirror trends noted in the literature, where procedural requirements and regulatory expectations drive stronger compliance. Conversely, the weaker performance in themes such as ecosystem services integration, uncertainty handling, and biodiversity enhancement aligns with broader critiques that EA often remains reactive and confined to mitigation and rather than proactive and focussed on transformation (see e.g. Kørnøv et al. 2025).

These results reinforce calls within the field for more interdisciplinary and participatory approaches, and for stronger institutional mechanisms that embed biodiversity goals throughout the assessment process rather than treating them as add-ons. In addition, future research should examine how national legislative and policy frameworks for EIA, SEA, and biodiversity conservation shape practice across countries. Such analyais could reveal to what extent differences in legal and institututional settings explain variations in integration and standardisation observed in this study.

In this way, the study contributes to the growing body of evidence suggesting that meaningful biodiversity integration in EA requires not only methodological refinement but also shifts in governance structures, practitioner culture, and policy priorities.

Notes

1. In all the tables with results, the percentages in the right side do not necessarily equal 100% as reports can include different numbers of elements. If the numbers in the left side do not equal 100% exactly, it is due to rounding errors. Also in all tables, the numbers in the merged cells highlighted in bold text are percentages of the total number of EA reports (SEA and EIA combined).
2. NA is used here, as the last two elements were only analysed in Portuguese EA reports.
3. NA is used here, as the last two elements were only analysed in Portuguese EA reports.

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