bioagora

Bio Knowledge Agora: Developing the Science Service for European Research and Biodiversity

A Framework for assessing the state of knowledge on biodiversity

D3.1. Assessing the state of knowledge and establishing a baseline of biodiversity policy needs to support the BDS2030 and the biodiversity research agenda

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Meaning / Full text
AI	Artificial Intelligence
BDS 2020	EU Biodiversity Strategy for 2020
BDS 2030	EU Biodiversity Strategy for 2030
DC	Demonstration case
DG	Directorate General
EC	European Commission
EU	European Union
IE	Information elements
KCBD	Knowledge Centre for Biodiversity
MS	Member State
SSBD	Science Service for Biodiversity
A1, A2 etc.	Specific actions of the BDS 2030

BACKGROUND: ABOUT THE BIOAGORA PROJECT

BioAgora is a collaborative European project funded by the Horizon Europe programme. It aims to connect research results on biodiversity to the needs of policy making in a targeted dialogue between scientists, other knowledge holders and policy actors.

Its main outcome will be the development of a Science Service for Biodiversity. This new service will fully support the ecological transition required by the European Green Deal and the European Union's Biodiversity Strategy for 2030.

The BioAgora project aims to develop a science service for biodiversity (SSBD) to ratchet up the EU Biodiversity Strategy 2030 (BDS 2030) by orchestrating science-policy interactions which can link expert knowledge more efficiently with EU policy making and implementation. To strengthen the link between scientific knowledge and policymaking, and make knowledge more accessible to policymakers, BioAgora developed an umbrella of actions. The project helped the European Commission's Knowledge Centre for Biodiversity (KCBD) set up a ticketing system to allow staff from the European Commission (EC) to submit requests. The project builds a network of experts to answer those requests, establish case studies called Demonstration Cases (DC) to test the Science Service, and finally, gather and synthesize policy-relevant knowledge already available both within and outside the EC.
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NON-TECHNICAL SUMMARY

Biodiversity knowledge plays a pivotal role in comprehending the evolving patterns and challenges related to European biodiversity and ecosystems. A vast amount of knowledge already exists, but for this knowledge to be truly impactful, it must be tailored to specific purposes, guiding the development, design, and implementation of European policies and strategies, translating to local level decision making within the EU countries. Moreover, beyond its role of shaping policies and strategies, knowledge on biodiversity is indispensable for assessing the efficacy of policies and monitoring the progress towards predetermined policy objectives and milestones.

As scientific pillar of the EC and KCBD, one of the ambitions of the SSBD is to become the primary gateway of biodiversity knowledge to the EC. In this context, the main objective of this task is to **identify policy-relevant information linked to biodiversity knowledge, and to extract lessons learned on processes to be put in place by the future science service, especially the web-platform, for a streamless access to policy-relevant information on biodiversity to both experts and policymakers**. In this context, this deliverable presents a comprehensive framework designed to collect and use "*actionable biodiversity information*", defined as information that is or can be used to make effective policy decisions aiming for positive nature outcomes, and thus, contribute to implement biodiversity commitments.

This work behind this deliverable is meant in supporting the SSBD to (1) **answer requests** from the EC, (2) **retrieve actionable information** to avoid the knowledge to get lost, avoid duplication and identify needs for updates, (3) **link knowledge with biodiversity commitments**, and (4) **identify knowledge gaps** which can be further used in **research prioritization** for the EC. Through this work, we designed a framework that addresses three primary inquiries: (1) the **identification of methods to gather and retrieve biodiversity knowledge** which involves the use of AI tools for the collection of key Information Elements (IEs) - textual segments associated with a typology of information that can contribute to the BDS 2030, (2) the **assessment of knowledge gaps and bottlenecks** to pinpoint knowledge deficiencies within the BDS 2030, aiding in their resolution, and (3) the **examination of information use and relevance**, exploring its potential for policy applicability and for experts to facilitate responses to EC requests.

The main outcomes of this deliverable are (1) the **typology of actionable information** that describes the information needed for effective policy making and knowledge synthesis in ANNEX 1, (2) a **guidance document on the collection of this information**, presented in ANNEX 2, as well as the (3) **recommendations** to the establishment of the future SSBD and **web-platform on the use of AI tools** for a better knowledge management in Chapter 6.

EXECUTIVE SUMMARY

1. Introduction

Nowadays, policymakers face an overwhelming amount of information, making it challenging to process and use it effectively, which can hinder evidence-informed decisions. Thus, there is a need for better organization and synthesis of knowledge, especially at the EU scale where the amount of policy-relevant information produced is tremendous (EU-funded projects, JRC and EEA reports, etc.). We suggest here a framework to improve the management of biodiversity knowledge and ensure that relevant insights reach policy makers in a timely manner. Providing the best available knowledge entails the integration of several sources of knowledge, as essential for addressing complex environmental issues, particularly to support the EU Biodiversity Strategy for 2030. Assessing the state of knowledge also goes with the identification of knowledge gaps and bottlenecks, critical to avoid misinformed policy decisions. To ensure we don´t miss any relevant information, we first identified biodiversity knowledge producers and the information they generate through documents. We defined a protocol to capture the information that can be policy relevant, also mentioned as *actionable information*. To know what to collect, we designed a typology of actionable information that can be relevant for both policy makers and the Science Service for Biodiversity (SSBD) experts, that will help answering policy-relevant requests. This protocol was tested in section 3 with an example serving Action 42 in Target 11 of the BDS 2030 regarding rivers´ connectivity.

The aim of this deliverable is to set a framework to analyse the current state of available knowledge related to the BDS 2030, identify knowledge gaps and recommendations including best practices for better implementations. This work is described in three steps: (1) developing the framework to assess biodiversity knowledge with the identification of policy-relevant information within documents and their classification into two typologies: a *typology of actionable information*, and a *typology of use* of actionable information, (2) testing a protocol to assess knowledge by linking our work with Demonstration Cases (which build networks of actors per topic and test the SSBD functions) and (3) future perspectives and concrete contribution to the SSBD.

2. Developing the framework to assess knowledge

To assess what kind of knowledge can be pertinent to EU policymaking, we considered a study from Stepanova et al. (2020) which identified three knowledge domains: **local community knowledge**, **professional knowledge** and **scientific knowledge**. To ensure that no knowledge domain is left aside, we associated different knowledge producers that can contribute to each of these domains. Six knowledge producers relevant to EC policy making have been identified: **businesses**, **governmental agencies**, **civil societies**, **citizens**, **local communities** and **scientific bodies**. These stakeholders cover all knowledge domains and most of them are already active in EC policy making via the European Biodiversity Platform launched by DG ENV. We focused exclusively on traceable, documented knowledge, referred to as formal knowledge. To assess the knowledge generated by these actors and identify gaps that hinder effective policy formulation, we analysed the data and information they produce. This included reviewing the Evaluation of the EU Biodiversity Strategy to 2020 (European Commission, 2022), examining reports related to Target 11 on free-flowing rivers as part of a collaboration with the freshwater DC, and mapping the various actors within the knowledge landscape. Based on this, we developed a typology of actionable information, which we believe is relevant to both EC staff and the Science Service for Biodiversity expert community for responding to policy requests (ANNEX 1). This typology encompasses **31 types of actionable information** produced by the six knowledge producers identified (Table I). This typology will need to be refined by getting feedback from the concerned users (e.g. via survey). The **usage of each of the information type** has been assessed, adapted from a framework developed by (Jagannathan *et al.*, 2023a), which includes six steps: **observe**, **understand**, **inform**, **plan**, **fund**, **implement** (Table II). To retrieve relevant information that aligns with our typology of actionable information, we defined **information elements** – textual segments that capture key data within documents. We propose a framework to streamline the management of information elements and associated metadata into a *"knowledge database"* that could be established after the BioAgora timeline. These information elements can be categorized by type and keywords, with metadata that facilitates the identification of knowledge gaps and bottlenecks (e.g. inadequate spatial or temporal resolution), as well as their relevance for EU policies (e.g. Habitat directive, BDS

2030 Targets, etc.) (Figure I). This knowledge database would enable the users of the SSBD to efficiently retrieve information and provide the EC staff with direct access to preliminary information before submitting a request (e.g. direct access to relevant documents). Further insights of what can be done will be addressed in Section 6 on Future perspective and contribution to the SSBD.

Table I. *Generation of actionable information by different knowledge producers.*

Knowledge actors / **Information types**	**Businesses**	**Governmental agencies**	**Civil societies**	**Citizens**	**Local communities**	**Scientific bodies**
Data and platforms	x	x	x			x
Drivers of change			x			x
EU citizens initiatives			x	x		
Frameworks	x	x	x		x	x
Gaps - capacity		x	x			x
Gaps - knowledge		x	x			x
Indicators and variables			x			x
Initiatives			x *(campaign)*	x	x	x *(petitions)*
Innovations	x		x		x	x
Management practices	x	x	x		x	
Networks	x	x	x			x
Policy documents		x				
Policy briefs			x		x *(Saami people)*	x *(via IPBES, EU Project)*
Polls		x				
Public consultations		x	x		x	x *(via surveys)*

Projects			x	x	x
Recommendations	x	x (*across scales*)	x	x	x *(via ipbes)*
Reports	x	x	x	x *(Saami people)*	x
Research papers					x
Research synthesis					x
Scenarios					x
Spatial planning tools	x	x	x	x	x
Policy instruments		x			

Table II. *Relation of typology of actionable biodiversity information identified through the framework and typologies of actionable climate information and typologies of use.*

Typology of actionable biodiversity information	**Typology of use of actionable information** *inspired from Jagannathan et al. (2023b)*	**Typology of use definitions**
Data and Platforms	Observe	Published database, data-platform or any qualitative observation made by the knowledge actors, that can be then analysed.
Polls		
Variables	Understand	Processed data and observations that can allow us to better understand the system.
Indicators		
Drivers of change		
Scenarios		
Policy briefs	Inform	Knowledge synthesis with the use of the information provided by "Understand" to inform practitioners and decision makers.
Public consultation		
EU citizens´ initiative		
Research synthesis and papers		
Reports		
Recommendations		
Frameworks	Plan	The information produced until this step can be used to develop planning reports or undertake future implementation plans *(vulnerability assessments, resource availability plans, infrastructure design plans, best management practices, etc.)*
Spatial planning tools		

Funds	Fund	Funding is unlocked based on previous information and give room for implementation.
Policy documents	Implement	Policymakers and practitioners are taking action and implement diverse policy, scale-up innovations or new management practices to create a change towards sustainability.
Management practices		
Innovations		
Compensation payments and offsets		
Regulations and standards		
Rights based and customary norms		
Subsidies and incentives		
Taxes and charges		
Tradable permits		

DOCUMENT	**IE**	**DESCRIPTION OF THE IE**					**CLASSIFICATION**			**CONTRIBUTION TO BDS 2030**		
Document ID	**Information Element**	**Keywords**	Spatial scope	Temporal scope	Update frequency	Reference	Output	**Typology of information**	If the IE is a gap, has this gap been fulfilled?	Pillars	Actions	Additional EU policies
BDS 2020 evaluation	Costs of maintaining the Natura 2000 network	HABITAT AND BIODIVERSITY PROTECTION, protected areas network	EU, MS	2008-2010	unkown	*Milieu, IEEP, ICF (2016). Evaluation study to support the Fitness Check of the Birds and Habitats Directives, final report*	text	indicator	-	Pillar 1	Action 2	Habitats Directive, Birds Directive
Dam removal, benefits for nature and people	Research on greenhouse gas emissions and methane emissions monitoring	FRESHWATER, CLIMATE CHANGE IMPACT	worldwide	2021	none	*Dam removal, benefits for nature and people*	text	knowledge gap	no	Pillar 2	Action 42	-

Figure I. *Main entries suggested for gathering information in the context of the BDS 2030. Entries in bold are being addressed in specific sections of the deliverable. Coloured lines reflect the relevance of different entries for the SSBD functions. The blue line reflects relevance for the building up evidence and knowledge base on topic function, the red line is relevant to the answering request's function, the yellow line is relevant to the establish research prioritization function, the green line is relevant to the linking up with biodiversity commitment's function.*

3. Testing the framework to assess knowledge

Two exercises were conducted to test the framework. We first addressed the ability of our framework to capture actionable information. We tested 1) the type of information that can be relevant to collect, 2) how to collect it, 3) the functions of the SSBD we can support via the collection of the information elements and metadata. To identify different types of information proven to be policy relevant for the previous biodiversity strategy, we first reviewed the BDS 2020 evaluation report (European Commission, 2022), identifying 15 of the 31 information types (ANNEX 1). In the section 3.1, we present some results on the proportion of the use of information mentioned in the BDS 2020 and **provide a visual example of what could be an interactive display on the SSBD web platform**, which could

represent the information relevant to each Target or Action of the new Strategy 2030 (Figures II). The outcome of this first testing phase is a **guidance document to collect actionable information and associated metadata** that can help the SSBD users to help ratchet up the BDS 2030 (ANNEX 2).

The second exercise was performed with the Freshwater DC. In this exercise, we evaluated the **framework's ability to address Action 42 in Target 11 of the BDS 2030**, which aims to provide a document that supports Member States in identifying obsolete barriers for removal (e.g., dams). To gather the necessary knowledge for this Action, we used two documents recommended by the Freshwater DC. These documents helped us (1) identify additional information types that may have been overlooked and (2) determine the use of each actionable information type within the *information use process* (Figure III). We collected information elements from the reviewed documents into a Google sheet that serves as an applied example of our framework (ANNEX 3). Through this exercise, **we successfully provided recommendations that were similar to those provided in the official guideline document** that completed the Action 42 (Directorate-General for Environment, European Commission, 2022) (ANNEX 6). Overall, gathering information from the table through filtering processes was extremely fast**, reducing the time from weeks to minutes** when mobilizing formal knowledge. On the contrary, the process of collecting information from documents to populate the Google sheet form in ANNEX 3 was labour-intensive.

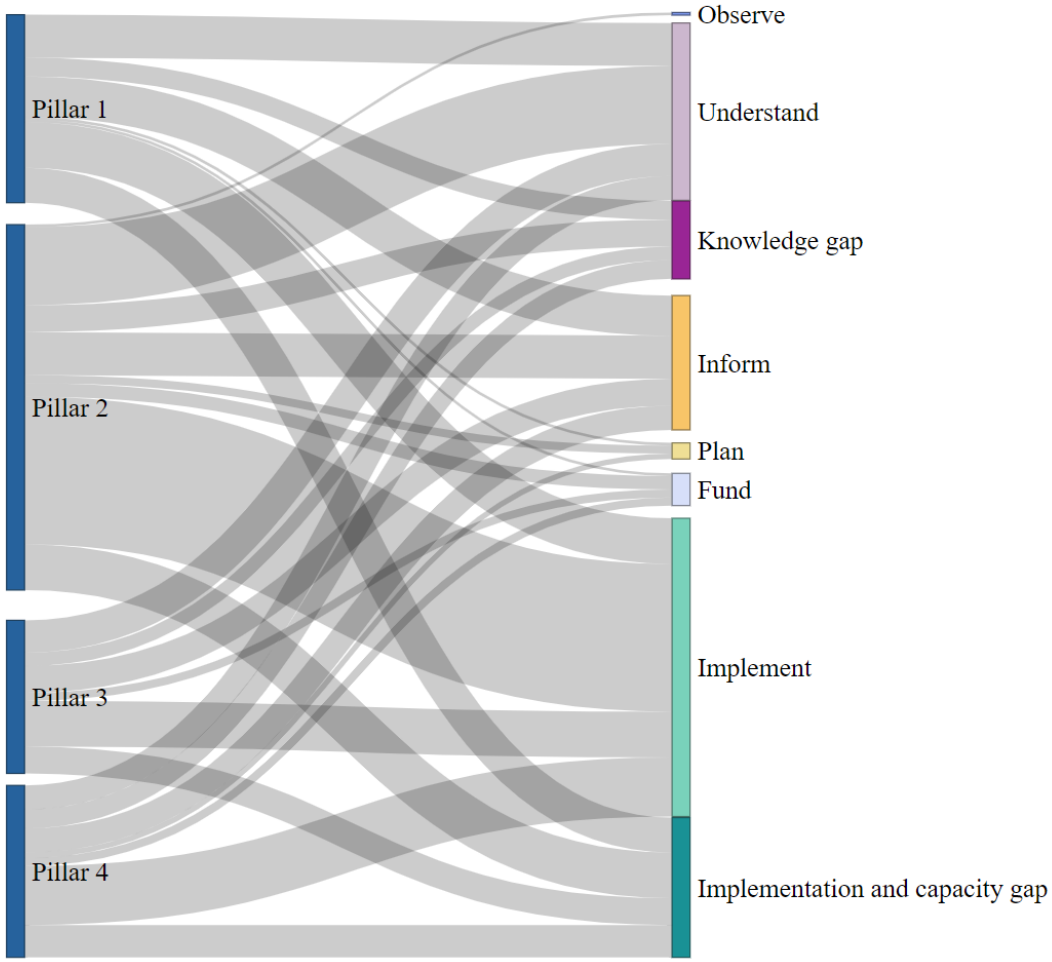

Figure II*. Typologies of actionable information used to evaluate the Targets of the BDS 2020 that could be relevant for the BDS 2030 (European Commission, 2022).*

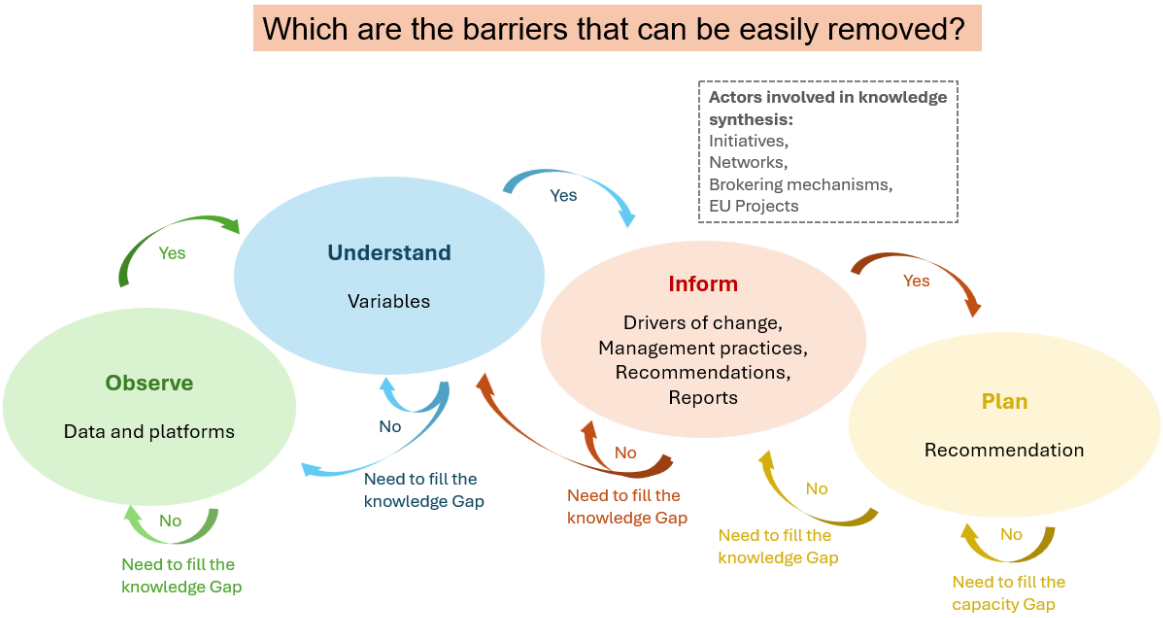

Figure III. *The information use process – actionable information and their application to answer the Action 42.*

4. Contribution to the Science Service for biodiversity

This framework serves **four functions** within the science service, namely the (1) **building up an evidence and knowledge base on the topic function**, (2) the **answering requests support function**, (3) the **linking with biodiversity commitments function**, and (4) the **horizon scanning and research prioritization function**. This work is central to "building up an evidence and knowledge base on the topic", as the mission of this function is to make existing knowledge easily accessible and actionable through innovative mechanisms for knowledge gathering and synthesis, supported by AI engines, to prevent knowledge from getting lost, duplicated, or outdated. This function directly supports the "answering requests" function, especially urgent requests, by providing the information needed for knowledge synthesis to the SSBD community. This framework also links actionable information to EU directives and other biodiversity commitments, such as the Biodiversity Strategy for 2030 (BDS 2030) (Figure I), supporting the "link with biodiversity commitments" function. One of our objectives was to assess knowledge gaps and bottlenecks, which is part of our framework. Thus, by uncovering gaps assessed in reports or other documents, this work can also serve to support the identification of future research needs and participate in "research prioritization".

5. Future perspectives

One of the objectives of the future Science Service is to be the main entry point for biodiversity knowledge for the EC. This framework aims to provide tools to support establishing a web platform capable of effectively delivering on this commitment and serving several **users** of the SSBD: the **EC staff and governmental agencies**, the **scientific community**, **NGOs**, **knowledge brokers**, as well as **businesses** and **practitioners**. The EC staff could have access to the basic information they need at their disposal if a **large language model** is implemented. Like ClimateQ&A, this large language model could provide a summary and answer basic questions based on the search of hundreds of trusted documents (e.g., EEA and JRC reports, IPBES, IPCCs, etc.). On the other hand, a ***knowledge database*** could be more relevant to the rest of the SSBD community to answer urgent requests, as it would provide specific information and better fit experts' needs. To reduce the tremendous work needed to populate such a database, **we suggest automated solutions by training a machine learning algorithm for text extraction and classification**. An

AI could be trained to **classify information elements** based on **the typology of actionable information** defined in this deliverable. Several challenges have been identified, ranging from short to long term. This includes setting up a quality assessment to determine what information should not be integrated into the future knowledge database and designing a **business plan** that integrates the maintenance and update of the suggested product in the long term. The implementation phase of the proposed solution would require involving key business experts in AI solutions (as for example Ekimetrics, a leading pioneer in data science and AI-driven solutions aimed at enhancing sustainable business performance).

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1. Introduction

1.1. Assessing the state of knowledge

Knowledge is a broad concept that remains challenging to define (Bolisani and Bratianu 2018). According to Coker and Macaulay (2020), knowledge is perceived as an embodiment of learned behaviour built upon careful observation of phenomenon, factual information or data stored, or skills acquired through practice or education. Another term is the concept of information. Information and knowledge operate at different levels, as individuals use various types of information to construct their own knowledge (Prabha Singh, 2007). According to the Data, Information, Knowledge and Wisdom pyramid, data is used to create information, information is used to create knowledge and knowledge is used to create wisdom (Bratianu, 2015; Frické, 2018). We focus here on data, information and knowledge produced in all fields related to biodiversity, which can be used to address the EU Biodiversity Strategy for 2030.

During the last decades, many scholars have advocated for better integration of scientific knowledge into environmental policymaking. This has come with several challenges within the scientific community, such as the growing needs for interdisciplinary research to tackle complex issues around biodiversity loss (Cortner, 2000), but also to improve communication skills and interactions with the policy community (Topp *et al.*, 2018). However, in its interaction with policymaking, scientific knowledge had the tendency to overshadow other knowledge sources. The legitimacy of this monopoly has been reconsidered by the recognition of its limitations, emphasizing the need of the incorporation of local and indigenous knowledge in policy making (Sutherland *et al.*, 2014; Tengö *et al.*, 2014). Indeed, knowledge from local communities are critical to validate and enrich data-based support. Even though science is constantly progressing, it often suffers from limited information as well as spatial, temporal and taxonomic biases, plus socio-cultural aspects (see e.g. Rayne et al., 2020).

The literature already identified several knowledge systems that can help solving environmental issues, *"made of agents, practices and institutions that organize the production, transfer and use of knowledge that impacts policy"* (Cornell et al. 2013 p.61). Stepanova et al. (2020, 2014) emphasised three dominant knowledge domains articulated by stakeholders through the lens of conflict resolution in urban planning and natural resource management: (1) local and lay knowledge, (2) administrative / expert / indigenous / managerial / professional knowledge and (3) scientific knowledge. In a case study on coastal conflicts, Stepanova (2014) described those knowledge systems, where local knowledge was defined as "*mostly informal* [i]*, based on practice, observation and experience of residents, fishermen and landowners*", administrative / managerial knowledge was specified as "*the knowledge used in all management forms and formally organized policy making in governmental and non-governmental organizations, integrating components of scientific and practical knowledge",* and scientific knowledge was framed as *"disciplinary and interdisciplinary knowledge related to resource management (environmental science, engineering, economics, etc.)"*. In her work, Tovey (2008) pointed out differences between 'lay knowledge' and 'local knowledge' where lay knowledge is associated with practices of resource use while 'local knowledge' is specific to a local area. Lay knowledge is thus not necessarily location dependent but is associated with a community applying this knowledge.

Knowledge coproduction on biodiversity is key to provide the most accurate evidence on threats to and trends in biodiversity and ecosystems, while being effective in identifying knowledge and capacity gaps. It can be tailored to inform the development, design, and formulation of European policies and strategies. As now, numerous key knowledge providers are supporting environmental European policy units of relevant EC Directorates-General (e.g. DG ENV, DG AGRI, DG CLIMA, DG RTD, DG MARE), as well as agencies such as the European Environment Agency (Moersberger *et al.*, 2022). This knowledge support is ensured by an extensive list of actors, such as the European Environment Information and Observation Network (Eionet), Eurostat, the JRC, Biodiversa+, non-governmental and intergovernmental organisations including IPBES, GBIF, Dryad, NGOs such as those assembled in the European Habitats Forum, as well as numerous European projects funded under the Horizon Europe program that contribute to addressing diverse policy needs (Moersberger *et al.*, 2022). As highlighted by the BioAgora T2.1 deliverable, biodiversity knowledge can originate from a wide range of stakeholders including private land managers, strategic environmental and spatial planners, protected areas managers, field experts who can work for businesses, civil societies governmental agencies or even academia, communities as well as indigenous people (BioAgora D2.1, D'Amato, Rantala, and Korhonen-Kurki 2023).

1.2. From knowledge to actionable information

Policymakers currently have more data and information at their disposal than ever before. Yet, this abundance of information is impossible to process given the limited amount of time at their disposal, hindering evidence-informed policymaking (Topp *et al.*, 2018; Albrecht *et al.*, 2020). Walgrave and Dejaeghere (2017) studied politicians strategies to deal with information overload. They found that the most employed method is to filter and prioritize information through personal procedures and heuristic use. Hence, policymakers face the responsibility of assessing the quality of information and determining the legitimacy of using certain scientific pieces over others, with the risk of favouring 'evidence' that backs their position (Walgrave & Dejaeghere, 2017; Hallsworth *et al.*, 2018; Topp *et al.*, 2018). This situation underscores the need for the knowledge holder community to organize themselves and provide the most robust and relevant knowledge for policymakers (Topp *et al.*, 2018).

DG RTD reported in an internal database that more than a thousand of European relevant projects linked to biodiversity were funded between 2015 and 2024 (considering Biodiversa+, Life projects, Mission Oceans and Horizon 2020). Each of those projects should have engendered at least one report addressed to policy makers, generating a tremendous amount of knowledge. Yet there is no mechanism to synthesize the knowledge produced, and thus, there is also no clear view on what knowledge is missing within the EC. Besides making EC resource use inefficient, this lack of oversight complicates the orientation of future Horizon funding. Before setting up Horizon calls, the European Commission consults the member state representatives and in 2024 it targeted biodiversity aspects by further consulting EUBP representatives. The eventual content of Horizon calls also depends internal discussions within the EC, as well as experiences, opinions and networks of individual people within the DGs. However, the extent to which the experts participating in these processes and consultations are aware of the existing knowledge base, especially regarding the latest projects, is unclear.

"The truth is that you can never really see, read, follow, understand, study and discuss all of it at the same time."

"There is proof for everything out there. You find thesis and antithesis. And you will find enough credible sources to support both points of view... . The point is how to deal with it rather than what it says. That is the most important task for a politician."

Belgium policymakers statements, Walgrave and Dejaeghere (2017)

Using knowledge to inform policy is a complex challenge relying on a myriad of factors such as interdisciplinary collaboration, contextual adaptation, resource and time constraints, stakeholder involvement, translation and knowledge percolation (Nutley *et al.*, 2007). In addition, this challenges the translation of stakeholders' knowledge into actionable steps, all aiming to address the application of knowledge to achieve tangible outcomes (Ferreira & Klütsch, 2021). Knowledge that is specifically designed to be implemented in the real world is defined as *actionable knowledge*, linking understanding to decisions and actions, making it practical and relevant for creating change (Gerber *et al.*, 2020; Jagannathan *et al.*, 2023b). Actionable knowledge is used to define specific, relevant, and timely information that can influence or determine actions. It can be either context-dependent, tailored to address a specific problem or decision-making scenario, or applicable across various decision-making contexts (Mach *et al.*, 2020). In essence, while knowledge provides the foundation for understanding, actionable knowledge translates that understanding into specific, guided actions tailored to achieve desired outcomes, serving as a roadmap for applying those insights effectively in real-world scenarios (Stepanova et al., 2020). (Jagannathan *et al.*, 2023a) identified typologies of *actionable climate information* with the aim to assist climate stakeholders working on climate-informed resource management. These typologies have several uses, ranging from aiding in the understanding of climatic issues and processes to their policy impact (e.g. changing regulations or management strategy). Building on this concept, we developed a typology of *actionable biodiversity information* and its use. This typology comes from the three knowledge systems and their associated actors, which generate *actionable information* that flows into European policymaking (see section 2.2).

1.3. The key role of knowledge in the context of the EU Biodiversity Strategy to 2030

The EC staff has access to multiple tools to get biodiversity knowledge. The European Environment Agency and the Joint Research Centre represent the scientific expertise to answer the DGs' scientific needs, combined with the expertise brought by the EU research community via EU funded research projects and Eurostat, the statistical office of the EU which collects and provides information that enable comparisons between countries and regions on a wide range of topics (economy, population, health, education, and environment) (Marei Viti et al. 2024). The EC captures EU citizens'

knowledge through public consultations via a dedicated portal (Public Consultations and Feedback (europa.eu)) and opinion surveys conducted by the Eurobarometer, to help the EC institutions in framing policies and communication strategies. NGOs and other initiatives are also consulted, even though mostly from an informal manner.

The EU Biodiversity Strategy to 2030 (BDS 2030) is a comprehensive and ambitious long-term plan aimed at protecting nature, reversing ecosystem degradation, and setting Europe's biodiversity on a recovery path by 2030 through specific actions and commitments. To assist the Commission in implementing the BDS 2030 and provide general advice on EU environmental policy, DG ENV established the EU Biodiversity Platform (EUBP) in 2022 (Register of Commission expert groups and other similar entities (europa.eu)). This platform brings together civil societies and interest groups (environmental NGOs, landowners and sector associations, with a total of ~28 stakeholders in 2024, as well as the European Environment Agency (EEA)), Member State ministries, as well as experts from the research community. These stakeholders meet every six months, enhancing knowledge exchange between them and updates on policy targets. This provides a real example of knowledge acceptance and integration, showing that environmental policymaking needs several sources of knowledge to solve complex issues that affects all societal actors at multiple scales. Within this framework, the Knowledge Centre for Biodiversity (KCBD) was established to connect science, policy and practice, while tracking and evaluating progress toward the BDS 2030 targets, promoting cooperation and partnerships, and supporting policy development. The scientific pillar of the KCBD is the Science Service for Biodiversity (SSBD), which is dedicated to provide decision makers with timely research-based options for policymaking on biodiversity, and inspired by other initiatives already acting as knowledge brokers for EU policymakers, such as BISE, Oppla or Eklipse. The SSBD is being developed by BioAgora and aims to boost the BDS 2030 by orchestrating science-policy interactions within the EU which can link scientific knowledge more efficiently with policy making and implementation.

1.4. The need for a framework to assess knowledge for the Science Service for Biodiversity

The aim of this deliverable is to analyse the state of knowledge to inform the BDS 2030, including the identification of recommendations and knowledge gaps. Communications with DG RTD and the KCBD underlined the necessity to synthesise the existing knowledge produced by the EC and identify current knowledge gaps encountered, which is critical to avoid misinformed political decisions. In addition to fulfilling this need, the SSBD is destined to become the main entry point for European biodiversity knowledge which policymakers' will activate when framing biodiversity relevant policy requests. This work is designed to align with these ambitions, to meet knowledge requirements of both policymakers and the expert community. Hence, we present and test a framework to assess knowledge and delineate its purpose, potential use and how it can be implemented.

The backbone of the framework to assess knowledge is built on classifying actionable information into distinct types, identifying their creators and how the knowledge flows towards implementation through policymaking. It is complemented with an example on how to apply this framework to Target 11 from BDS 2030, on the restoration of 25 000 km of European free-flowing rivers by 2030

(BioAgora Task 1.2, Freshwater DC). This contribution represents a step forward for BioAgora activities related to knowledge assessment and orchestration (BioAgora WP3), and especially for training the SSBD functions in the context of Demonstration Cases (BioAgora Tasks 1.2 and 1.3). However, the framework to assess knowledge is still a preliminary beta-version to be tested with the forthcoming Demonstration Cases, in order to be refined, updated and adapted to new application contexts.

Chapter 2 describes the methodological approach to set-up the framework, including a detailed overview of the actionable information types. Chapter 3 includes the main outcomes of testing the framework with two examples, the BDS 2020 assessment and the Freshwater DC. Chapter 4 discusses the contributions to the development of the functions of the SSBD, and the future perspectives to improve the framework for knowledge assessment.

2. Developing the framework to assess knowledge

The methodological approach is based on the analysis of the types of information used in key reports to inform targets of the BDS 2030. In biodiversity conservation, grey literature and agency reports are acknowledged to help capture diverse data sources and contribute to comprehensive analyses, which can lead to more accurate and unbiased conclusions (Krausman, 2024). Typologies of actionable information are defined here as generalizable categorizations of different forms of information that contribute to design, inform and assess conservation policies, each contributing uniquely to the decision-making process to enhance the effectiveness of conservation efforts (Figure 1). Moreover, information's typologies can help both knowledge producers and users to better envision the entire landscape of knowledge and its uses and can help to reduce the time and cost of the co-production of more "actionable" knowledge (Jagannathan et al., 2023b).

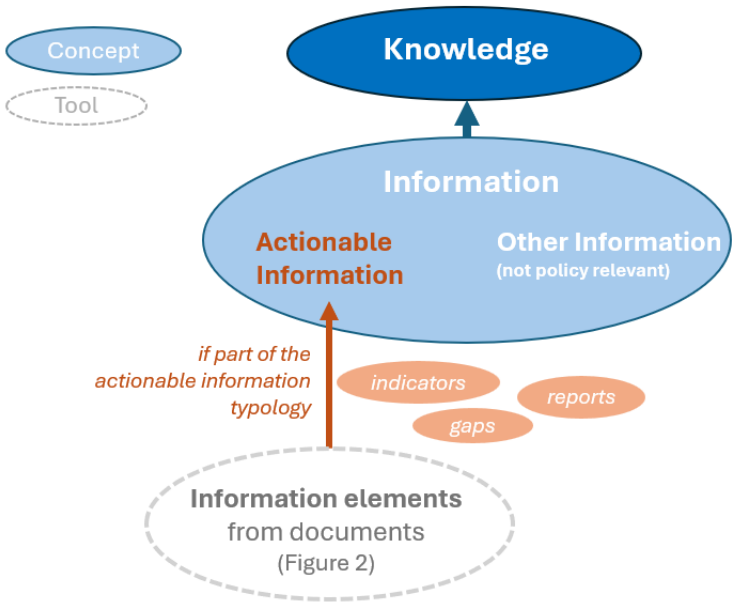

Figure 1. Linkages between knowledge, actionable information and information elements.

The assessment of knowledge and related information has used the following steps:

1. Define a protocol to identify and gather pieces of actionable information and key metadata from documents (here the BDS 2020 evaluation report): **section** Error! Reference source not found.,
2. Once framed, classify the actionable information's pieces into typologies (of information and use): **section 2.2**,
3. Set-up keywords to easily retrieve the piece of information per topic: **section 2.3**.

2.1. Identifying information elements (IE) and key metadata

To describe and assess the knowledge used to inform and evaluate BDS 2030 targets, we developed a stepwise approach to gather any piece of information referenced in relevant documents to be reviewed (Figure 2). The aim is to gather metadata related to textual segments that capture key biodiversity information within documents, hereafter called "information element" (IE) (Table 1). These metadata include bibliographic references, geographic and temporal scope, a classification of information elements in different typologies and related thematic keywords, as well as their contribution to the BDS 2030. This is intended to analyse the knowledge that has been applied by relevant policies to reveal best practices, gaps, and how knowledge is being used.

Key metadata identified is summarized in Table 1, and includes:

- **Identification of information elements:**
  Conceptualization of the information element by naming it (Figure 2). As a rule, the name given is the one used in the original source of information.

- **Keywords:**
  List of structured keywords to classify the information element by topic. It has been organized in four domains aiming to capture all kind of information and purposes. The list of keywords is organised hierarchically from general to specific key biodiversity issues aimed to complement the description of each information element, being also useful to identify potential gaps of knowledge related to the BDS 2030.

- **Geographical and temporal scope, and update frequency:**
  Spatial and temporal scope of the information elements, and update frequency (only if applicable). It can help identify knowledge limitations related with partial geographical or temporal availability of information for certain topics.

- **Bibliographic references:**
  Original references to trace back the sources from which information elements were extracted. It can include journal articles, reports, websites, etc.

- **Typology of actionable information (ANNEX 1, chap.2):**
  Classification of the different kinds of information elements and the output formats used to present it. To identify a policy-relevant typology of information, we first proceeded to review the evaluation report of the previous EU Biodiversity Strategy for 2020 (European Commission: Directorate-General for Environment, 2022). We considered that this report would provide a first comprehensive overview of policy-relevant knowledge for biodiversity, where we identified 15 actionable information types: ***Data and platforms***, ***Frameworks***, ***Funds***, ***Gaps - Capacity***, ***Gaps – Knowledge***, ***Indicators***, ***Initiatives***, ***Networks***, ***Policy Documents***, ***Projects***, ***Recommendations***, ***Reports***, ***Scenarios***, ***Variables and Essential Variables***. Further information types were identified

later on by the review of other documents and the mapping exercise described in section 2.2.1, such as ***Drivers of change***, ***Management Practices, Innovations, Polls, Public consultations*** *and* ***EU Citizen's initiatives*** as well as eight ***Policy instruments***. The different categories of information were first defined based on definitions from the IPBES glossary (e.g. Indicators, Scenarios, Reports etc.) enlarged with complementary types found in the reviewed documents but not defined in the glossary of the IPBES (e.g. Funds, Projects, Networks, etc). Table A2 shows the list of information typologies their relationship with information elements (examples provided).

- **Contribution to the BDS 2030 and other relevant EU policy instruments:**
  Stated or potential contribution of the information element to the Pillars and Actions of the BDS 2030, and to other EU biodiversity policy instruments (e.g. Habitats Directive, Birds Directive, EU Invasive Alien Species Regulation, etc).

A guideline document on how to collect information relevant to the BDS 2030 has been compiled in ANNEX 2. We used Google Forms and Sheets to implement and test the ANNEX 2 guidelines (ANNEX 3). Initially, each information entry is linked to its studied document through a unique ID. This ID can be used in other BioAgora database, like the one designed by T3.2. on EU projects impact. Additionally, the guideline document includes a column entry indicating whether the document is associated with an EU project (including the project name) (ANNEX 3).

What is an information element?

An information element is a piece of information used in documents to inform and assess topics related to the BDS 2030 and other National, EU or Global biodiversity commitments. This piece of information can be classified within our identified typology, e.g. as an indicator, report, database, scenario, etc.

How is it identified?

An information element is a piece of text, graphic reference, quantitative or qualitative information or statement identified via the review of documents. Those documents can be synthesis reports, deliverables from EU projects, reports from public or private institutions (EEA, JCR, etc.) or anything identified as relevant by the SSBD topical network. Generally, an information element should always be accompanied by a reference, even though the document can be the reference itself when it is the original source of information (see below).

How can it be used?

Once identified and conceptualised, this information can be associated with keywords, biodiversity objectives, EU policies, and linked to an information type. This information can thus be easily mobilized by experts and used by DGs when a specific policy request arises.

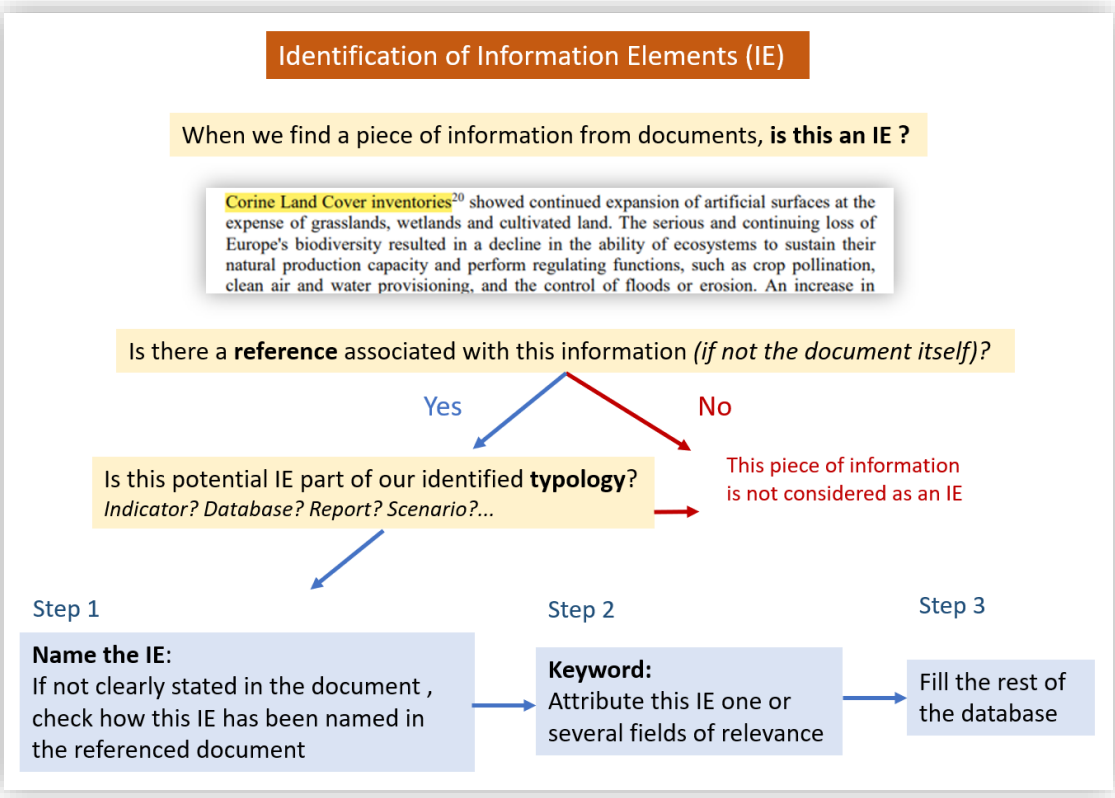

Figure 2. Definition and identification of information elements

Table 1. Data gathered with the protocol to assess knowledge used to inform BDS 2030. Entries in bold are being further explained in a specific section of the deliverable.

Entries	**Description**
Reviewed document	Reference of the document reviewed
Information element (section 2.1)	Textual segments that capture key information within documents (Figure 2). Name of the information element used in the document or as being referred at the highest possible reference level
Keywords (section 2.3)	To classify the information element by topics. Keywords are organised in a hierarchical manner, with main topics in capital letters and sub-topics in minuscule
Geographical scope	Spatial scope of the information element, defined in four categories: Global, EU, Member states and Regional
Temporal scope	Temporal scope of the information element, defined by the starting and ending year of the knowledge validity
Update frequency	Update frequency of the information element, only when it is updated over time
Bibliographic reference	Reference of the journal article, document, website, etc., from which the knowledge was extracted
Typology of actionable information (ANNEX 1, chap. 2) (preliminary)	Classification of the information element based on the format (output) it is presented (e.g. Graph, Descriptive text, etc) and the class of knowledge (e.g. Indicator, Scenario, Report, Funds, Gaps, etc.)
Update on identified gaps	Shows identified gaps and whether they have been filled or not
Contribution to BDS 2030	Stated or potential contribution to BDS 2030 Pillars and Actions

The guidelines from ANNEX 2 were trained and refined by analysing the knowledge used in the Evaluation of the EU Biodiversity Strategy to 2020 (European Commission, 2022) (hereafter, BDS 2020 evaluation). This BDS 2020 evaluation report is the most relevant and comprehensive information synthesis initiative for the evaluation of EU biodiversity policies to date, examining the performance of the BDS 2020 and providing key lessons to improve the implementation of BDS 2030. The BDS 2020 evaluation report provides a comprehensive overview of the knowledge used to implement the previous biodiversity strategy, as well as the challenges and gaps encountered. Thus, it represents a perfect starting point for the identification of actionable information elements and potential typologies. To analyse the potential contribution of the BDS 2020 evaluation to the BDS 2030, we cross-tabulated the goals and actions of the BDS 2020 with the pillars and actions of the BDS 2030 (ANNEX 4).

Table A2. Information typologies and examples of linked information elements

Information typology	Information elements (examples)
Data and Platforms	Biodiversity Information System for Europe (BISE), Ecologically or Biologically Significant Marine Areas (EBSA), European Citizen Science Platform
Variables	Species Phenology (Essential Biodiversity Variable), Zooplankton biomass and diversity (Essential Ocean Variable)
Indicators	European grassland butterfly indicator Pesticides in rivers, lakes and groundwater in Europe
Drivers of change	Direct and indirect impacts of barriers on fish, Impacts of river construction on ecosystem properties
Scenarios	BioMonitor Reference Scenario (BRS), Go-it-Alone, Hand-in-hand
Project	Wozep ecological programme, PoshBee
Knowledge gaps	"Knowledge to enable restoration planning": *information element taken from the BDS 2020 review that mentions "In relation to Target 2, factors of failure mentioned by stakeholders include knowledge to enable restoration planning (national and regional authorities and experts)".*
Spatial planning tool	Barrier assessment tool to prioritise barrier removal
Policy briefs	AMBER Policy Brief IPBES Global Assessment, summary for policy makers
Research synthesis and papers	Corporate emissions targets and the neglect of future innovators (Science)
Research synthesis	The positive impact of conservation action (Science) Synthesis reveals approximately balanced biotic differentiation and homogenization (Science Advances)
Reports	Commission Report on the State of Nature in the EU 2020, EEA Report on the State of the Environment and Outlook
Policy documents	EU Forest Strategy for 2030, EU Pollinators Initiative
Management practices	Green supply chain management, Eco-efficiency
Recommendations	Better mapping and monitoring of barrier numbers is needed, particularly of low head structures, as these are the most abundant and the main cause of fragmentation.
Initiatives	Leave no-one behind (from WWF),

	GeoNature-citizen (nature-occitanie)
Frameworks	Data protocol - Marine Information and Data Centre
Networks	LTER-Europe network, AlterNet, GEO BON
Innovations	Biodegradable materials from mycelium: Ecovative, Biodegradable polymers: Novomer
Funds	EU funding for Green infrastructure, The European Maritime and Fisheries Fund (EMFF)
Compensation payments and offsets	Verified Carbon Standard , Climate Action Reserve
Regulations and standards	Environmental quality objectives, Impact regulations, Legislation
Rights based and customary norms	European court of human right
Subsidies and incentives	Ecological fiscal transfers (ETF), Emissions cap and allowances
Taxes and charges	Taxes, charges and fees, Green Taxation
Tradable permits	EU Emission Trading System (ETS)
Capacity and implementation gaps	"Human resources for restoration": *information element taken from the BDS 2020 review that mentions "In relation to Target 2, factors of failures mentioned by stakeholders include human and financial resources for restoration, lacking in particular outside of protected areas and often deprioritised for biodiversity in the context for budget cuts."*

To test the protocol from ANNEX 2 on its ability to retrieve policy-relevant knowledge, we examined Target 11 of the BDS 2030, that states that at least 25,000 km of free-flowing rivers are restored. The analysis was based on two synthesis reports provided by the topical network on freshwater, the Freshwater Demonstration Case (DC) of BioAgora (Task 1.2). One report was related to river continuity restoration (Schmidt and Fokkens, 2023) while the other one focused on dam removal experiences from different European countries (WWF Deutschland, 2021). The main outcomes from these two examples, the BDS 2020 evaluation and the analysis of knowledge regarding Target 11 of the BDS 2030, are presented in **Chapter 3**.

2.2. Building information typologies

Biodiversity conservation policies are informed by different knowledge systems coming from different actors. Each knowledge source contributes to unique insights and perspectives to the formulation, implementation and evaluation of effective conservation strategies (Sténs et al., 2019). Scientific knowledge, which includes empirical monitoring data and theoretical insights, forms the backbone of biodiversity conservation efforts, providing evidence of biodiversity loss and the effectiveness of conservation actions (Borzée & Button, 2023). However, the translation of this scientific knowledge into pressing policy contexts often requires the integration of other knowledge types, such as professional knowledge or knowledge from local and indigenous communities, which can offer practical insights and enhance the relevance and acceptance of conservation measures (Pullin *et al.*, 2016; Sténs *et al.*, 2019). Overall, the synthesis of different types of knowledge and the iterative co-design of conservation strategies with stakeholders are essential for developing robust and effective biodiversity conservation policies that can address the multifaceted challenges of biodiversity loss and ecosystem degradation (Sutherland *et al.*, 2014; Korhonen-Kurki *et al.*, 2022).

In scientific literature, there is a wide range of approaches of knowledge use, for instance, for improving understanding of how science can be mobilized to inform decision-making (Jagannathan *et al.*, 2023b), for informing and conflict solving related to natural resources management (Salomaa *et al.*, 2016; Stepanova *et al.*, 2020), for developing indicators for knowledge integration (Karrasch *et al.*, 2022) or for identifying climate metrics and indicators (Vincent *et al.*, 2020).

In this chapter, we first identified key knowledge holders relevant to European policy and evaluated the actionable information each can provide, along with how it flows into EU policy. For each actor, we examined the information that is currently monitored by the EC or will be in the near future. Secondly, we applied the study of Jagannathan et al. (2023b) for assessing the various types of climate information that can be deemed as usable by different stakeholders, and the different ways in which they may be utilized in decision-making. Jagannathan et al. (2023b) have demonstrated the potential of this framework for mapping the landscape of climate information and examining its applications to elucidate how complex climate science gets used by institutions and in different decisions contexts. Because we are particularly focused on the use of knowledge in a hot topic which is similar to climate, this framework of actionable information typologies aligns perfectly with the goals of our study.

2.2.1. Mapping the landscape of knowledge holders and the information flow towards the EC

In this section, we aimed to map the actors based on how their knowledge and information output can help inform European policymaking. This exercise serves to ensure we do not omit information that should or does feed into policymaking. Indeed, while some information might already flow into European policy, much of it does not, due to inadequate coordination between actors, lack of financial or human capacity, or confidentiality requirements (Conejo *et al.*, 2020). The outcome of this work supports ANNEX 1, which lists all actionable information types considered. This section presents the effort made on how we got there.

Through the review of applied studies (Table 3), we identified six main branches of actors involved in producing knowledge for environmental policymaking: governments, non-profit organizations, businesses, research institutions, local communities and citizens, at national, regional, and local scales. To ensure all types of knowledge are being represented and to determine to which extent, we classified the previous six actors along the three knowledge domains described by Stepanova et al. (2014) (Figure 3). Unlike Stepanova et al. (2020, 2014), we considered that civil societies should be part of all knowledge domains, as they can be involved in science production (e.g. citizens science), provide reports or assessments for governments and foster local communities and knowledge exchange. As indigenous and local communities can produce professional knowledge through their practical experience in traditional resource extraction (e.g. fishermen and farmers), we oriented them towards "professional knowledge".

These actors generate knowledge driven by diverse motivations or necessities, forming the basis of our classification (Figure 4). We are aware that from a broad perspective and in an ideal world, all actors should aim to act for the common good. We considered here that acting for the common good is perceived through different priorities (which can be taken over by divergent interests), affecting the way knowledge is produced.

Mapping the landscape of the main actors of knowledge production (Figure 4) allowed us to uncover missing information typologies that were absent from the review of the evaluation report of the EU Biodiversity Strategy 2020 (European Commission: Directorate-General for Environment, 2022). We highlighted five additional sources: ***Management Practices, Innovations, Polls, Public consultations*** *and* ***EU Citizen's initiatives*** as missing typologies, as well as eight ***Policy instruments*** categories (see ANNEX 1). We linked those information types to the different actors in Table 4.

In order to better understand the utilization of different information types from raw data to implementation, we classified them within the knowledge generation framework in Figure 4. An example of this conceptual framework is provided in section 3, "Testing the Framework". It should be noted that only traceable knowledge that flows towards the European Commission has been considered here. This disregards all knowledge gained through expert consultations and oral exchanges, which also represent a significant knowledge gain from the Commission staff and can also influence the redaction of policy documents. The types of information considered are further described in Annex 1.

Table 3. Grouping of actors identified in applied studies

ACTORS	Sutherland et al. (2017)	Butler et al. (2015)	Lukomska et al. (2015)	Turnpenny et al. (2005)
Businesses	"Farms", "Input supplier"	"Wildlife tourism operator"	"Businesses"	"Business and industries"
Governmental agencies	"Formal advisor such as the Agricultural Municipal Services and National	"Scottish government"	"The government of Poland", "Regional government", "Local government"	"Government agencies", "Administrative regional / local authorities"

	Agricultural Advisory Service"			
Civil societies	"Farming organization"	"Salmon NetFishing association"	"National NGOs", "Local NGOs"	"NGOs"
Citizens	"Family", "Friends"	-	"Citizens"	-
Local communities	"Local agronomists"	"Inshore fishermen"	-	-
Scientific bodies	"Research institute"	"Research program"	-	"Hadley Centre for Climate Prediction and Research"

Table 4. Generation of information type by different knowledge holders.

Knowledge holders / Information types	Businesses	Governmental agencies	Civil societies	Citizens	Local communities	Scientific bodies
Data and platforms	x	x	x			x
Drivers of change			x			x
EU citizens initiatives			x	x		
Frameworks	x	x	x		x	x
Gaps - capacity		x	x			x
Gaps - knowledge		x	x			x
Indicators and variables			x			x
Initiatives			x *(campaigns)*	x	x	x *(petitions)*
Innovations	x		x		x	x
Management practices	x	x	x		x	

Networks	x	x	x		x
Policy documents		x			
Policy briefs			x	x *(Saami people)*	x *(via IPBES, EU Project)*
Polls		x			
Public consultations		x	x	x	x *(via surveys)*
Projects			x	x	x
Recommendations	x	x (*across scales*)	x	x	x *(via ipbes)*
Reports	x	x	x	x *(Saami people)*	x
Research papers					x
Research synthesis					x
Scenarios					x
Spatial planning tools	x	x	x	x	x
Policy instruments		x			

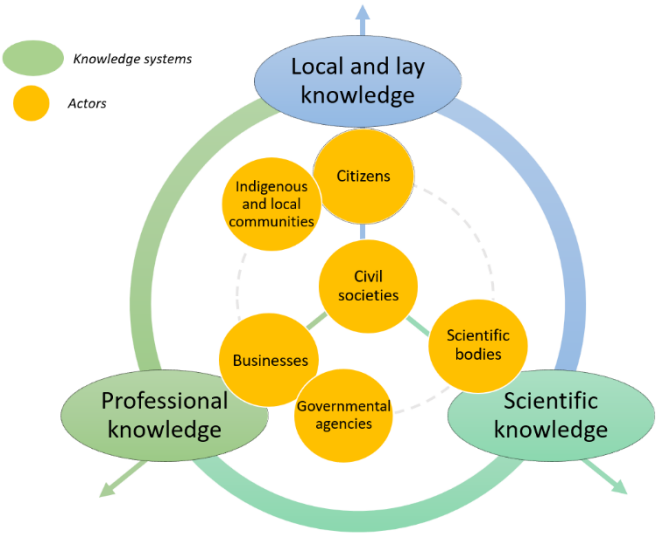

Figure 2. Knowledge producers' actors along the three knowledge systems described by Stepanova et. al (2020, 2014)

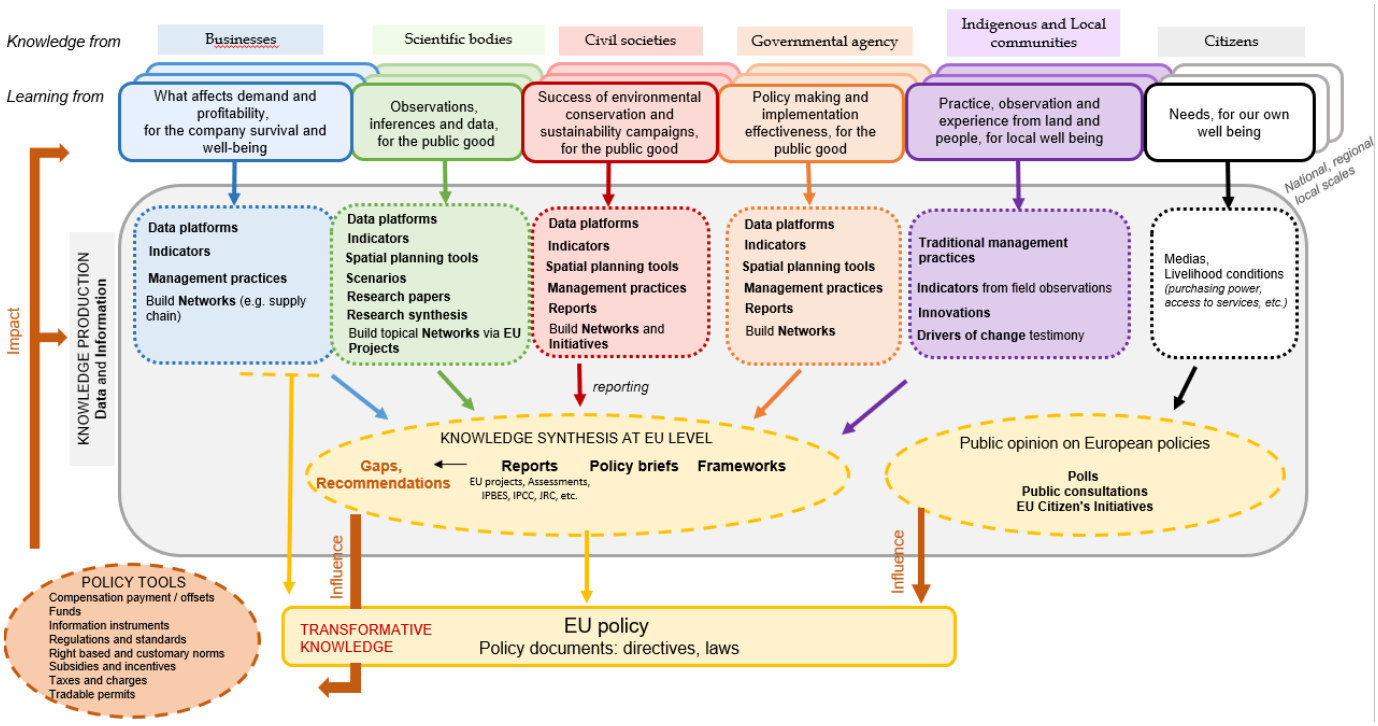

Figure 3. The landscape of policy-relevant biodiversity knowledge. Only written formal knowledge that can be traceable through documents has been considered.

1. Businesses knowledge

The main motivation of this category is to learn from what affects demand to sustain or optimize profit for the company´s survival, and potentially maximize shareholder value and corporate wealth (Sundaram & Inkpen, 2001; Keay, 2008). Corporate wealth induces the balance of economic goals and social responsibilities, which aims at ensuring the long-term sustainability of the company. Business models present diverse degrees of environmental sustainability. In some, environmental issues or social values can take over on profitability goals (Certo & Miller, 2008), while others prioritize high production rates, efficiency, and output at the expense of environmental conservation, worker welfare, and product quality (Bocken & Short, 2021). The private sector gains knowledge from both external sources and internal research and development. External sources encompass knowledge-intensive business services, universities, technology centres, public research organizations, innovation intermediaries, and public administration bodies (Pinto *et al.*, 2023). To achieve a robust understanding of the role of knowledge in firms, one needs to consider the different environments, economic sectors, type, and size of firms (Pinto *et al.*, 2023). Each company has its own expertise, management practices and governance model, which makes it a complex ecosystem, stirring up a tremendous amount of information which remains mostly internal. To ensure companies can comply to the Green Deal and the BDS 2030, the EC needs to improve transparency of environmental information and practices of firms. Several regulations and directives have been produced to achieve this goal and improve the knowledge flow from companies to policymaking.

Unlock data sharing: The Data Act

When the private sector uses or collects environmental information, it is usually with the goal to improve their management efficiency or reduce the environmental impact of their product line (Wible *et al.*, 2014). For instance, the implementation of green accounting practices, such as identifying and allocating costs for environmental management, can lead to improved eco-efficiency and competitive advantage in sectors vulnerable to environmental issues like the agro-industry (Ardiana *et al.*, 2023). Companies can use environmental data to save money through energy or water saving, improve their image, comply regulations, adapt to climate impact through informed decisions on investment. With the raise of Big Data, the use of such environmental information increases (Hellweg & Milà i Canals, 2014; Wolfert *et al.*, 2017). Yet, the EC estimated that 80% of industrial data remained unused, including environmental data (Data Act: measures for a fair and innovative data economy (europa.eu)). To remedy to this problem, the European Commission launched the Data Act in 2022, which advocates for centralized access to publicly available information. The Data Act designed a set of rules to regulate how data is accessed and used within the EU by granting companies certain data rights, establishing data sharing obligations, and formulating rules for data intermediaries ("Data Act," 2022). From an environmental point of view, the Data Act could foster efficiency gains through data-driven decision making by incentivizing or regulating the sharing of data related to energy use or resource consumption. This data could be used to optimize processes, potentially leading to reduced energy consumption and resource waste.

Sustainable finance: The European Sustainability Reporting Standards (ESRS)

A recent World Bank study shows that by 2030, even a partial collapse of a few ecosystem services (wild pollination, timber from native forests, etc.) could already greatly impact the global economy (GDP) with an annual cost of $2.7 trillion (2.3% loss) (Johnson *et al.*, 2021). Indeed, the loss of biodiversity and ecosystem services poses numerous risks to businesses which stem from both (1) the physical impacts of climate change on production or supply chains via extreme weather events, and (2) the transition risks associated with the shift towards a low-carbon economy (obsolete investments, shift in consumer behaviour, changes in regulation, etc.) (Förster *et al.*, 2022). Companies as well as institutional investors are becoming increasingly aware of these risks and are demanding more transparency about the impact of biodiversity loss and the potentially significant investment risks this loss entails. A study released by the JRC revealed that around 11% of European investors' portfolios are exposed to climate-transition risks, with the least regulated financial institutions hitting 18% of risk exposure (Alessi & Battiston, 2023). To mitigate financial risks and assist investors, civil societies and consumers in evaluating corporate sustainability and viability, the European Commission mandates the disclosure of non-financial information, starting for the fiscal years 2024 or 2025, depending on the company's size and status (Corporate Sustainability Reporting Directive 2022). In total, this will affect around 50,000 companies in the European Union (Förster *et al.*, 2022). The evaluation covers the full range of environmental, social, and governance issues (ESG), including climate change, biodiversity and human rights. This reporting will consider how the ESG factors can influence a company's performance (what it depends on), and how its activity can impact the environment and society in return[ii]. In summer 2027, the EC is expected to launch the European

Single Access Point (ESAP), a centralized web platform where public financial and sustainability-related information about EU companies and EU investment products can be retrieved ("Easy access to corporate information for investors," 2023) . This includes the previous information, making it easier for stakeholders to access and analyse sustainability-related information. As a common data space, the ESAP will be a fundamental enabler of the EU's Digital Strategy and the Digital Finance Strategy.

Centralizing agricultural monitoring data: the Agri Sustainability Compass

To help to fill the environmental monitoring gap, the EC engaged with the agriculture industry to convert the Farm Accountancy Data Network (FADN) which was monitoring more than 80 000 EU farms' income and business activities, into the Farm Sustainability Data Network (FSDN) that adds environmental data monitoring (Commission proposes to collect environmental and social data in European farms - European Commission (europa.eu)). The data collection methodology of the new FSDN will be aligned with the current FADN, with the addition of environmental indicators and the integration of data sharing features. The Commission plan to set up a harmonised methodology for Member States to collect data at farm-level, with the farmer's consent, paying attention to data protection issues. Member States will have the possibility to set incentives for farmers' participation in the data network, such as financial contribution, feedback on the farm performance with a focus on improving sustainable farming practices, or targeted advice based on data collected by the FSDN. This will provide additional information for advisory services and feedback to farmers with the aim of improving farms sustainability. This initiative has been supported by the launch of the Agri Sustainability Compass (Agri Sustainability Compass (europa.eu)), which brings key indicators to monitor water, soil, air quality and biodiversity, among other. All data bases are managed by Eurostat which co-ordinate statistical activities across the Commission (Co-ordination role - Eurostat (europa.eu)).

In the last years, several actions have been implemented by the EU to support businesses in complying with the BDS 2030 and facilitating the green transition. These measures primarily target data sharing facilitation, transparency in financial reporting, and indicator monitoring in the farming industry. They highlight the importance of sharing datasets collected by firms for the monitoring of environmental indicators and sustainability indices. This practice can lead to the revision of businesses environmental management practices and reinforce their long-term competitiveness and attractiveness to investors. Therefore, we considered that data platforms (incl. datasets), indicators (including the information collected by the Agri Sustainability Compass and the ESAP, when available), management practices and networks (incl. supply chain) are primer information to be shared with the EU by businesses to help rachet up the BDS 2030 (Figure 3, Annex 1).

2. Scientific bodies knowledge

The main purpose of this category is to analyse a system via observations, inferences and data (Yin et al. 2022). Data and observations are utilized to solve questions, generate concepts or innovations (McCain, 2015). Most of the knowledge is supported by public investment (governmental agencies, foundations), which aims to advance not only science itself but also broader public interest (Thelwall

et al., 2023). The actors considered here encompass research institutes from universities, state research centres from the public side as well as private institutes and field experts.

Several instruments produced by researchers can be used to inform policy makers, such as variables, indicators, or scenarios (Störmer *et al.*, 2020; Wright *et al.*, 2020; Lehmann *et al.*, 2022). Other input from social science through conceptualization and empirical testing of policy solutions contribute to the support of scientific knowledge to policy making (Coglianese & Starobin, 2020), including citizen science. Those can either be used in scientific publications or be stored in Data Platforms to directly inform policy makers (EC staff, Member States, etc.), scientists, or the general public (e.g. Indicators | European Environment Agency's home page (europa.eu), Biodiversity Information System for Europe (europa.eu)). Scientists use information derived from data and scientific literature to draft reports (EU projects deliverable), policy briefs or frameworks for implementation (guidelines). As those documents have a clear policy target, we grouped them within "knowledge synthesis at the EU level" (Figure 3). However, there is always a risk of knowledge misuse. For instance, scientific output can be used to justify or legitimize a preexisting position (Ledermann, 2012). This can be detrimental when research quality or a research consensus on a topic has been disregarded.

3. *Environmental civil societies' knowledge*

Environmental civil societies, including non-governmental organizations (NGOs), involve individuals, groups, and organizations outside of government structures who work collectively for the common good, promoting environmental conservation and sustainability (Lewis, 2010). They play a key role in information collection (knowledge broker) and dissemination, policy development consultation, compliance monitoring of MS to EU regulations, policy implementation, assessment and monitoring of policy progress or data collection, as well as lobbying with advocacy for environment justice, education, research, and community engagement (Andonova and Tuta 2014, Make a complaint | European Union, Gemmill-Herren and Bamidele-Izu 2002). NGOs play a crucial role in shaping environmental EU policy through various mechanisms such as public consultations, civil society dialogues, and participation in legislative proceedings. NGOs involved in environmental issues are highly diverse with various missions (e.g. conservation, sustainable development, poverty alleviation, animal welfare, etc.) and can operate at multiple scales, with local, national, regional, and international groups. Moreover, international and local NGOs engage increasingly with local communities in the management of environmental resources and development priorities (Andonova & Tuta, 2014). This engagement provides them a multiscale perspective on environmental issues that other actors might struggle to capture. To make their voice stronger, the European Environmental Bureau (EEB), a non/profit organization, works as an "umbrella organization", through the development of an extensive network of environmental organizations and EU institutions. With the support of this communication channel, the EEB monitor and respond to emerging EU environmental policies (Wachholz, 2020). In general, environmental NGOs are seen as important actors reinforcing the democratic debate, capable of keeping an eye on policy development and reflecting the voice of citizens. They enjoy special procedural rights within EU law to help achieve the public interest of a sound environment, stepping in when governments fall short in environmental protection tasks, playing a role of "Watch dogs" (Peeters, 2018).

As part of the Europe 2020 Strategy, the European Commission has made a priority to establish and strengthen partnerships between EU institutions, national and regional governments and European

stakeholders, including civil society. Thus, specific Commission DGs work closely with NGOs through activities such as bi-annual meetings where NGOs are invited to discuss current matters with other stakeholders (DG ENV and the EUBP meetings or DG EMPL, under the framework of the European Platform against Poverty and Social Exclusion, NGOs: What, why and where? - European Union). Overall, knowledge transfer from NGO to EU institutions in mostly informal with advisory committees, business test panels, exchange platforms (EUBP) and ad hoc consultations, but also has formal compounds via Communications, EU consultation, White or Green Papers (including policy briefs) THE RELATIONSHIP BETWEEN THE EU AND NGOs | Association of Accredited Public Policy Advocates to the European Union (aalep.eu)). It is this last aspect that we are interested in.

Some non-profit organizations such as Bird Life International or Butterfly Conservation - which are focused on birds and butterfly protection, respectively -, are using scientific expertise to set up conservation priorities, inform action and shape policy and advocacy. Through they work, they reinforce data collection and harmonization with, for instance, citizen science programs. Those programs also play a role of environmental education, with the development of species recognition Apps such as iNaturalist, reaching a large range of citizens, on top of the volunteers trained on the field. They also participate in indicators development, such as the EU grassland butterfly indicator from Butterfly Conservation Europe, a widespread indicator commonly used by the EEA and in EC reports. Their work can be of big help to scientists, allowing them to study some taxonomic groups at scale and resolution that can be otherwise hard to achieve, reinforce the robustness of their studies, making available Atlas, global and regional databases. Those organizations, as well as others such as WWF also published regular reports on the state of biodiversity, set-up topical campaigns to get the support they need to reach EU policymakers. The combination of evidence and citizen support can be an effective tool to raise policymaker's interest.

Thus, non-profit organisations generate different types of information, from data collection to knowledge synthesis. We considered that civil societies are dealing with a large array of information among the ones we identified, such as data, indicators, spatial planning tools, etc. (Table 4).

4. Governmental agencies' knowledge

Government agencies are permanent or semi-permanent organization within a national or state government. They are responsible for oversight or administration of a specific sector, field, or area of study. Most government agencies are meant to be non-political, but the direction and intention of their work may change depending on which political party makes up the majority of elected officials. Thus, this group learns from policy making and implementation, to make better informed decisions, for the public good. Many governments have recently recognised the strategic importance of data, information and knowledge. They use and collect a wide range of data to inform policy making so that an adapted response to environmental or societal issues can be framed (Laihonen *et al.*, 2023). For instance, Member States and local governmental agencies likely utilizes social science data on demographics, economic trends, and public sentiment (Berinsky, 2017), scientific data to inform policy on health, environment, and infrastructure, legal information to ensure adherence to laws and regulations (*Communication from the Commission to the Council and the European Parliament - Forest Law Enforcement, Governance and Trade (FLEGT) - Proposal for an EU Action Plan*, 2003; "Communication from the Commission – Enforcing EU law for a Europe that delivers - European Commission," 2022), as well as input from stakeholders including citizens, businesses, and interest group.

Diverse environmental themes are under the responsibility of government agencies, such as forest and water management or public transport and infrastructures. Forest and water management are both framed by European directives, such as the Water Framework Directive and the Forest Law Enforcement Governance and Trade which aims to halt illegal logging in Europe (*Communication from the Commission to the Council and the European Parliament - Forest Law Enforcement, Governance and Trade (FLEGT) - Proposal for an EU Action Plan*, 2003). Europe also invested 30 billion to fund transport, energy and digital projects to better connect Member States under a sustainable plan (European Parliament, 2021).

The Water Framework directive set-up water quality thresholds to ensure the good chemical and ecological status of water bodies in Europe by 2027 ("Water Framework Directive - European Commission," 2024). This directive has provided a strong push to Member States to implement a water monitoring system that tracks the chemical and ecological status of water bodies, measures the effectiveness of planned measures, and identifies necessary updates of the monitoring system as new techniques and products emerge. Thus, technical and scientific institutes are closely involved in this monitoring framework. The results published by those institutes can influence water management, which governance generally includes several actors, such as elected officials, local authorities (municipalities, regions), representatives of water users (industries, farmers, environmental protection associations, fishing associations, consumer groups, etc.) as well as states representatives ("Gestion de l'eau en France," 2023).

Thus, the information produced by those actors includes data generation, the development of monitoring platforms, the review of management practices (e.g. forest management), reporting, etc. (Table 4).

5. Local and Indigenous communities' knowledge

Actors involved in local communities here include citizens living in a specific locality, private land managers and indigenous peoples. Those actors share a so called local knowledge, which plays a crucial role in various aspects of life, such as agriculture, caregiving (Lestari *et al.*, 2023), fishing, address challenges such as natural hazard (Setten & Lein, 2019), and maintain traditions. Local knowledge is often a blend of traditional wisdom and contemporary influences, adapting to changing circumstances while preserving cultural identity and community cohesion, when not lost (Aswani *et al.*, 2018). This type of knowledge is essential for sustainable resource management, social support systems, and the transmission of cultural heritage within diverse communities worldwide.

In Europe, local ecological knowledge encompasses the understanding and perceptions of local communities regarding ecosystem services, invasive species impact, landscape changes, as well as human-nature relationships in protected areas, emphasizing the importance of including local knowledge systems in conservation efforts (Cebrián-Piqueras *et al.*, 2020). Local ecological knowledge is recognized as complementary to scientific knowledge, with both types of knowledge being essential for conservation strategies and ecological modelling, especially when dealing with methodological challenges and interdisciplinary approaches (Bélisle *et al.*, 2018). For instance, in the Adriatic Sea, local ecological knowledge provided by fishers offered valuable insights into the abundance trends of megabenthic species, an indicator highlighting the decline of certain invertebrate populations, supplementing scientific data in monitoring environmental changes (Bastari *et al.*, 2017). Thus, the combination of small-scale fishers' knowledge and scientific

knowledge can improve policy recommendations for fisheries optimization and marine resource conservation (Piñeiro-Corbeira *et al.*, 2022).

This knowledge updates and maintains itself through interactions between people and their ecosystems, but also between people within and outside the community. Field observations and dialogue within a community are critical, so that they can learn from experience and adapt their resource management. For instance, the Saami, the last indigenous people in the EU located in the Scandinavian countries, are impacted by climate change which threatened their cultural way of life (Jaakkola *et al.*, 2018). A big part of their culture relies on reindeer husbandry, which depends on climate-dependant variables such as vegetation distribution, temperature, wind, snow cover and freezing of rivers (Rees *et al.*, 2008). Thus, they adapted their reindeer herding through flexible use of pasture land, but also work on climate change mitigation via intensive grazing, protecting the tundra biome from shrubification, increasing the surface albedo and thus, delaying snowmelt (Jaakkola *et al.*, 2018).

Understanding and incorporating local knowledge into various fields can lead to more effective policies, improved practices, and better outcomes by bridging the gap between traditional wisdom and modern approaches (Tengö *et al.*, 2014; Bennett, 2016).

At the EU scale, local communities have been incorporated through the integration of European Landowners' Organisation and the Saami Council in the EUBP meetings. The Saami council developed an EU Unit in 2019, which aims to inform decision-making through their participation in EU networks and forum, improve their visibility and raise awareness of Sámi issues within the EU. The Saami also aim to reduce EU knowledge gap by including their needs and experience within EU policy through EU projects and the release of policy reports ('Sámi Lens Evaluation on the European Green Deal Policy', 2024). On another hand, the European Landowners' Organisation (ELO) is a federation of national association representing the interests of landowners, land managers and rural entrepreneurs. They place those communities as central players to deal with issues on land management, agriculture, forestry, hunting, land access, and property rights supporting biodiversity and a sustainable food system ("Manifesto - European Elections 2024," 2024). They release regular position papers on those topics (i.e. ("Another push for a forest-based bioeconomy that considers forest owners and managers," 2024).

6. Citizens' opinion and knowledge

Citizens' opinion on European policies is influenced by a complex interplay of factors impacting life satisfaction, general well-being, and trust in government efficacy in fulfilling one´s needs (Dijkstra *et al.*, 2020). Various sources of knowledge influence citizens opinion on environmental issues, ranging from the education system to media consumption (Jerit *et al.*, 2006). Self-interest in specific topics further influences opinion and depth of acquired knowledge. It is in the interest of the EC to understand public opinion to better tailor regulations. Indeed, as regulations require the Parliament and the Council approval, the EC should ensure a certain degree of alignment with public concerns to avoid strong rejection (e.g. as one interviewee for BioAgora Task1.1 highlighted, the Green New Deal of the previous Commission was partly inspired by the strengthening voice of grassroot youth movements, such as Fridays4Future). Therefore, the EC – as other EU bodies- utilizes the Eurobarometer to monitor public opinion in EU-related issues and attitudes towards political or social matters. This tool informs EU policy discussions and priorities, while national governments also consider public opinion through polls when formulating their positions on EU policies (Vries,

2020). In addition to influencing EU policy indirectly, citizens can actively express their opinions via voting, EU consultations, Citizen Initiatives, protests, petitions, public debates through social or conventional medias. The EC also envision reinforcing citizens' participation to EU decision making by the creation of a citizens 'panel (Future of Europe: citizens' panel proposals on democracy and EU reform - European Parliament (europa.eu), Launch of new centre to design policies with citizens, for citizens - European Commission (europa.eu)). However, there are limitations to citizen influence. EU policymaking involves complex negotiations between Member States, the Commission, and Parliament, making it difficult to translate public opinion into concrete policy changes. Public consultations with citizens can be time- and resource-intensive, especially if they apply a participatory or deliberative approach. Misinformation and biased media coverage can also distort public understanding of EU policies, making policymakers question the robustness of citizen-derived information (as interviews in BioAgora Task1.1 and Task4.1 underlined).

7. Knowledge synthesis at the EU level

Business, scientific, governmental, local communities and citizen knowledge, all flaw into EU decision-making through reporting or data sharing, often acknowledging the knowledge gaps they encounter. Currently, the EU is implementing strategies to cover those gaps to improve decision-making performance (e.g. cover monitoring gaps via the Agri Sustainability Compass). Knowledge synthesis allows experts and knowledge brokers to draw guidelines and recommendations in forms of frameworks, policy briefs and reports. Through this work, knowledge and capacity gaps can be identified, which inform on the next priorities to tackle. Thus, recommendations and knowledge synthesis are affecting the way European laws, directives and other policy documents are drafted by the EC (Topp *et al.*, 2018). Also, they influence the design and parametrization of policy tools, such as funding allocation, subsidies and incentives, tax and charges as well as the re-evaluation of resources extraction thresholds such as fishing quotas. Those policy tools will then impact the quality of information gathered from the different knowledge sources. For instance, corporation environmental regulations influence their internal and external management, budget for monitoring affect scientific results as well as decision making from local governments.

Even though knowledge syntheses and research prioritisation have high transformative potential, it should also be noted that the currently prevailing interest groups across different sectors from academia to politics steer the directions of knowledge synthesis and recommendations for research priorities. Such politics of knowledge does not necessarily always lead to syntheses and recommendations which are optimal for a given policy goal. Methods for knowledge synthesis and research prioritisation should thus be examined with scrutiny. Interdisciplinary knowledge synthesis mechanisms which are independent of external influence should be promoted.

Many sources of knowledge are already covered by the EC, yet the Commission still needs to improve the management of the amount of information collected. Moreover, with the rise of Big Data, the amount of information is foreseen to increase tremendously (Hampton *et al.*, 2013; Bingham *et al.*, 2017; Wolfert *et al.*, 2017). It plays a major role in gathering and centralizing private sector, scientific and governmental agencies information. Projects, networks and initiatives are

playing an active role in shaping and mixing knowledge communities, bringing similar stakeholders together through cooperations, European projects or organizations.

2.2.2. Typologies of actionable information and its use

We adapted the framework of typologies developed by Jagannathan et al. (2023b) which maps the landscape of climate information, distinguishing between two typologies, one on actionable information and one on information use. Types (and sub-types) of actionable information are threefold and include: (1) detailed data and results (drivers and processes, decision-relevant events, and changes in decision-relevant metrics), (2) broad trends and patterns, and (3) data improvements and guidance (models and data-scale improvements and data credibility and uncertainty). In addition to this typology of actionable climate information, Jagannathan et al. (2023b) defined a typology of use of this information with six main types based on previous classifications and empirical work, including (1) Understanding, (2) Motivation/Communication, (3) Informing, (4) Planning, (5) Funding and (6) Taking action. These two typologies offer a valuable starting point for knowledge producers and users to assess the use of knowledge in science-policy interfaces. Jagannathan et al. (2023b) encourage other scholars and practitioners from different contexts to adapt, expand, refine, or critique these typologies, or to develop new ones.

Based on this framework, we reclassified our typology of actionable biodiversity information to match the two typologies described by Jagannathan et al. (2023b) (Table 5). Despite the usefulness of their classification, their definitions of typology use are not adapted to our case, as principally addressed to the climate stakeholders who are used to deal with data-driven information. As the biodiversity community is broader, with the inclusion of diverse knowledge actors including the climate ones, the typologies developed here also need to be more generic. Thus, we redefined the terms they used to our case in “Typology of use – definition” (Table 5), and we discarded the “(2) Motivation/Communication”, which relates to improve communication skills and capacity building, and is not about formal knowledge transfer. As the aim of this work is also to highlight knowledge and capacity gaps, we added a category “Observe” that refers to existing database and observations (e.g. from practitioners) to assess what is available and identify the existing gaps in this category. Indeed, robust information depends on the quality of data or observations, particularly their spatial and temporal resolution and scale. When a policy question arises, it is important to ensure that the indicators or other information serving to “Understand” the system are available, which relies on data availability. As we consider that gaps can be present in all steps of information use, we did not include knowledge and capacity gaps in Table 4, which would relate to the “Model and data improvements*” sub-type from Jagannathan et al. (2023b). Same applied to “networks”, as being considered as a category of actors that can interfere at any step of information use. As pointed out in their study, different types of actionable information and their use overlap, or influence each other (e.g. detailed data and results can help to examine “broad trends and patterns”). We also encountered this issue when matching actionable biodiversity information typologies with their use. Indeed, some reports or scenarios can be used to inform, but also to plan. We assigned the information use to its primary use (reports are first used to “Understand” before “Planning”), and the closest typology of actionable biodiversity information with the “Typology of actionable climate information” when there was some degree of overlap with definitions.

Among the 25 types of biodiversity actionable information (excluding gaps and actors as mentioned above), six matched with the typology of use "Understand", as well as all the types and sub-types identified by Jagannathan et al. (2023b): *Data platforms*, *Variables*, *Indicators*, *Drivers of change*, *Scenarios* and *Knowledge gaps* (Table 5). The remaining 19 environmental actionable information types were distributed among the other typologies of use.

To show the potential of this theorical framework in answering policy requests, the actionable information cycle developed in Figure 5 has been further tested in Section 3.2 with the Freshwater DC.

Table 5. Relation of typology of actionable biodiversity information identified through the protocol and typologies of actionable climate information and typologies of use. Where possible, Subtypes of actionable information are indicated (marked with an asterisk).

Typology of actionable biodiversity information	**Typology of actionable climate information** *(Types and sub-types) Jagannathan et al. (2023b)*	**Typology of use of actionable information** *inspired from Jagannathan et al. (2023b)*	**Typology of use definitions**
Data and Platforms	Decision relevant events*	Observe	Published database, data-platform or any qualitative observation made by the knowledge actors, that can be then analysed.
Polls			
Variables	Changes in decision-relevant metrics*	Understand	Processed data and observations that can allow us to better understand the system.
Indicators			
Drivers of change	Drivers and processes*		
Scenarios	Broad trends and patterns		
Policy briefs		Inform	Knowledge synthesis with the use of the information provided by "Understand" to inform practitioners and decision makers.
Public consultation			
Projects			
EU citizens´initiative			
Research synthesis and papers			
Reports			
Recommendations			
Frameworks		Plan	The information produced until this step can be used to develop planning reports or undertake future
Spatial planning tools			

			implementation plans *(vulnerability assessments, resource availability plans, infrastructure design plans, best management practices, etc.)*
Funds		Fund	Funding is unlocked based on previous information and give room for implementation.
Policy documents Management practices Innovations Compensation payments and offsets Regulations and standards Rights based and customary norms Subsidies and incentives Taxes and charges Tradable permits		Implement	Policymakers and practitioners are taking action and implement diverse policies, scale-up innovations or new management practices to create a change towards sustainability.

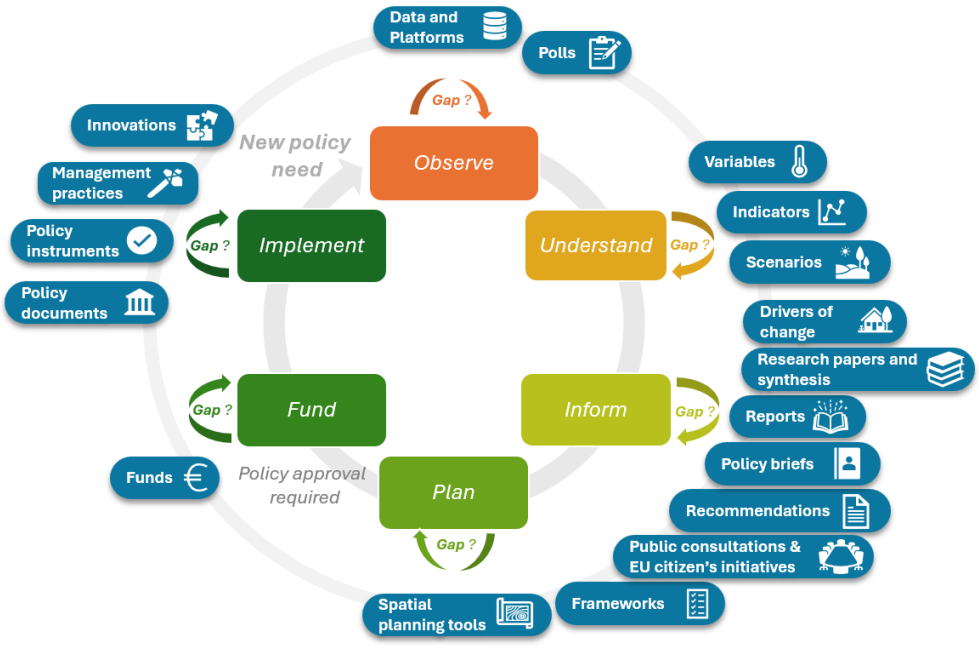

Figure 4. Actionable information cycle and use.

2.3. Keywords

To classify information elements by policy-relevant topic, we identified keywords through the review of the Biodiversity Strategy 2030 document (ANNEX 5). The idea is that information elements can be easily retrieved when needed. Those keywords where classified in four main groups (Figure 6), by:

1. **Ecosystem types** for information elements that refer to ecosystems. For example, the information element "potential water retention from forests" is a *variable* that refers to the "forest" ecosystem. A list of keywords referring to ecosystems have been generated (see Figure 6). This encompasses **air, agroecosystems, desert, forest, freshwater, grassland, marine, mountains, soil, urban** ecosystems. Ideally, those keywords could be combined, for instance if we need knowledge about "Urban air" quality, or "Mountain soil" diversity. If an IE can be applied to several or all ecosystems, it should be linked to them. **This category is needed to make a search by environmental topic**.

2. **Biodiversity topics** for information elements that refer to diverse ecological themes. For instance, the information element "Seafloor integrity status" is an *indicator* that can be found under the keyword "Habitat status and trends" (Figure 6). As this information element is about "Seafloor", it could be found under the cumulation of the "Marine" from "Ecosystem types" keywords and the "Habitat status and trends" biodiversity topic keywords. **This category is pertinent to refine the search and combine it with other keywords.**

3. **Driver of pressures** for information elements that refer to impact on biodiversity, ecosystems and human well-being. For example, the information element "Continuity and aggravation of overexploitation, pollution, habitat loss, climate change and invasion by alien species" is a *scenario* that considers factors of pressures, without considering specific habitat types or biodiversity goals. In this example, this information element would fit different drivers of pressure, such as "pollution", "climate change impact", "land use change" and "invasive alien species impact". **This category is important for impact assessments or related policy question**.

4. **Solutions** for information elements that refer to ways to prevent biodiversity loss and benefit to human well-being. It includes policy instruments which would permit to easily retrieve evidence regarding their relevance or impact, via assessment reports or scientific publications. Some of those drivers of change can overlap with Biodiversity goals, as they push towards solutions. Solutions refers to the identification of processes to go towards a sustainable society, by the identification of sustainable behaviours, consumption patterns or education / communication that foster change towards the reduction of biodiversity loss. For instance, the information element "coordination to support consumption and production policies in making a tangible difference for biodiversity" is a recommendation extracted from the review of the BDS 2020 (European Commission: Directorate-General for Environment, 2022) that would fall under the keyword "organic products consumption". **This category is of high relevance as a source of inspiration** to highlight solutions found and can be linked by topic (e.g. nature base solution).

This classification of information elements by keywords aims to facilitate the search of knowledge to answer a request or identify topical knowledge gaps. However, the search by keywords can be tricky if information elements are being mislabelled, or when highly specific information is targeted. Thus, in addition of predefined keywords, one could make a search bar that quickly find relevant information elements where the keyword is mentioned in the raw (e.g. in reference name, description of the information element, etc.), like it is implemented in the IPBES knowledge gaps database (see the "search by keyword" entry).

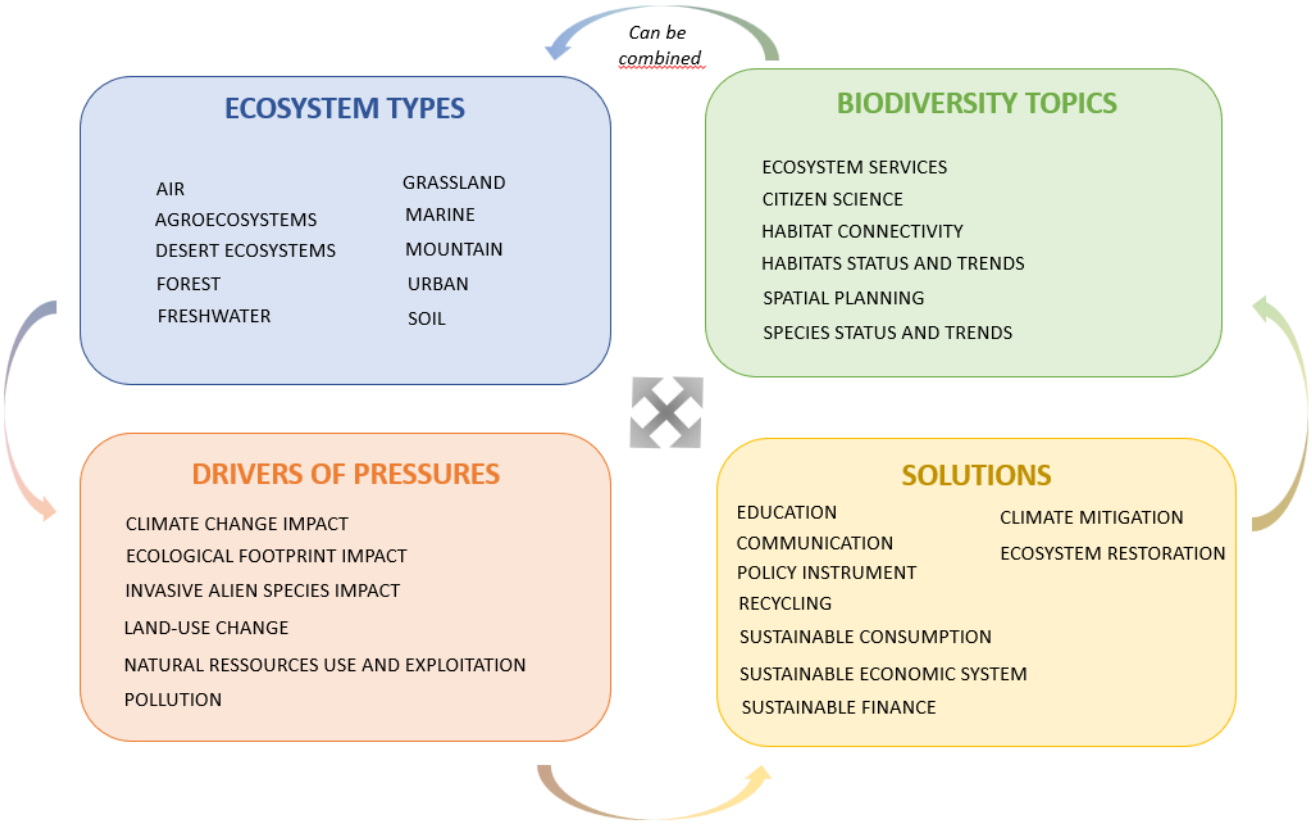

Figure 5. Example of main keywords per policy relevant topic (see ANNEX 5 for a more exhaustive list).

3. Testing the framework to assess knowledge

3.1. Knowledge used for the BDS 2020 evaluation

METHOD

The BDS 2020 evaluation (European Commission, 2022) was used to train and refine the framework to assess actionable information, aimed analyse the information elements associated with the implementation and evaluation of the BDS 2020, and potentially linked with BDS 2030. This report was reviewed in depth by the authors following the protocol in ANNEX 2, and all the information elements identified were gathered in a standard data collection form implemented in Google Forms. Once the review was completed, the resulting dataset was cross-checked to avoid duplicates and harmonise criteria for the definition of information types, and to improve and refine the protocol.

MAIN RESULTS (SEE ANNEX 6 FOR MORE DETAILED RESULTS)

From this review, we identified 15 information types that could be policy-relevant (see section 2.1).

The analysis of the types of actionable information used to assess the EU Biodiversity Strategy to 2020 (BDS 2020) in relation to the implementation of the BDS 2030 strategy has drawn the following conclusions:

- The "Implement" type of use was predominantly used in assessing the BDS 2020 Targets (35%, Table 6), indicating a focus on practical implementation over other stages like planning or funding. This suggests that considerable effort was directed towards putting plans into action.
- The evaluation of the BDS 2020 revealed nearly 20% of knowledge gaps as well as implementation and capacity gaps across all targets (Table 6), indicating that despite the emphasis on implementation, there were challenges in both knowledge base and capacity to execute the strategy effectively.
- Pillar 2 of the BDS 2030, focusing on nature restoration, has the most comprehensive representation of different actionable information types, suggesting that this pillar builds upon a more robust foundation of existing knowledge and implementation experience compared to other pillars (Figure 8).
- All Pillars of the BDS 2030 showed significant missing information in the "Plan," and "Fund" typologies (Table 7). This can imply that either many financial and planning information were not mentioned in the BDS 2020 review document, or that they require further attention. The

lack of information elements within those two categories regarding Pillars 3 and 4 can also relfect the novelty of these themes and the need for further development in these areas.

Table 6. Total number of information elements grouped by typology of actionable information and typologies of use of actionable information (shaded rows), from the Evaluation of the EU Biodiversity Strategy to 2020 (European Commission, 2022).

Typology of actionable information	Numer of information elements	Percentage of information elements
Observe	***1***	***0,5%***
Data Platforms	1	0,5%
Understand	***52***	***24,1%***
Variables	13	6%
Indicators	26	12%
Drivers of change	1	0,5%
Scenarios	12	5,6%
Knowledge gaps	***15***	***7%***
Knowledge gaps	15	7%
Inform	***32***	***14,9%***
Reports	32	14,9%
Plan	***5***	***2,3%***
Frameworks	5	2,3%
Fund	***7***	***3,3%***
Funds	7	3,3%
Implement	***76***	***35,3%***
Policy documents	29	13,5%
Recommendations	42	19,4%
Initiatives	4	1,9%
Regulations and standards	1	0,5%
Implementation and capacity gaps	***27***	***12,6%***
Capacity gaps	3	1,4%
Implementation gaps	24	11,2%
Total of actionable information types	**215**	**100%**

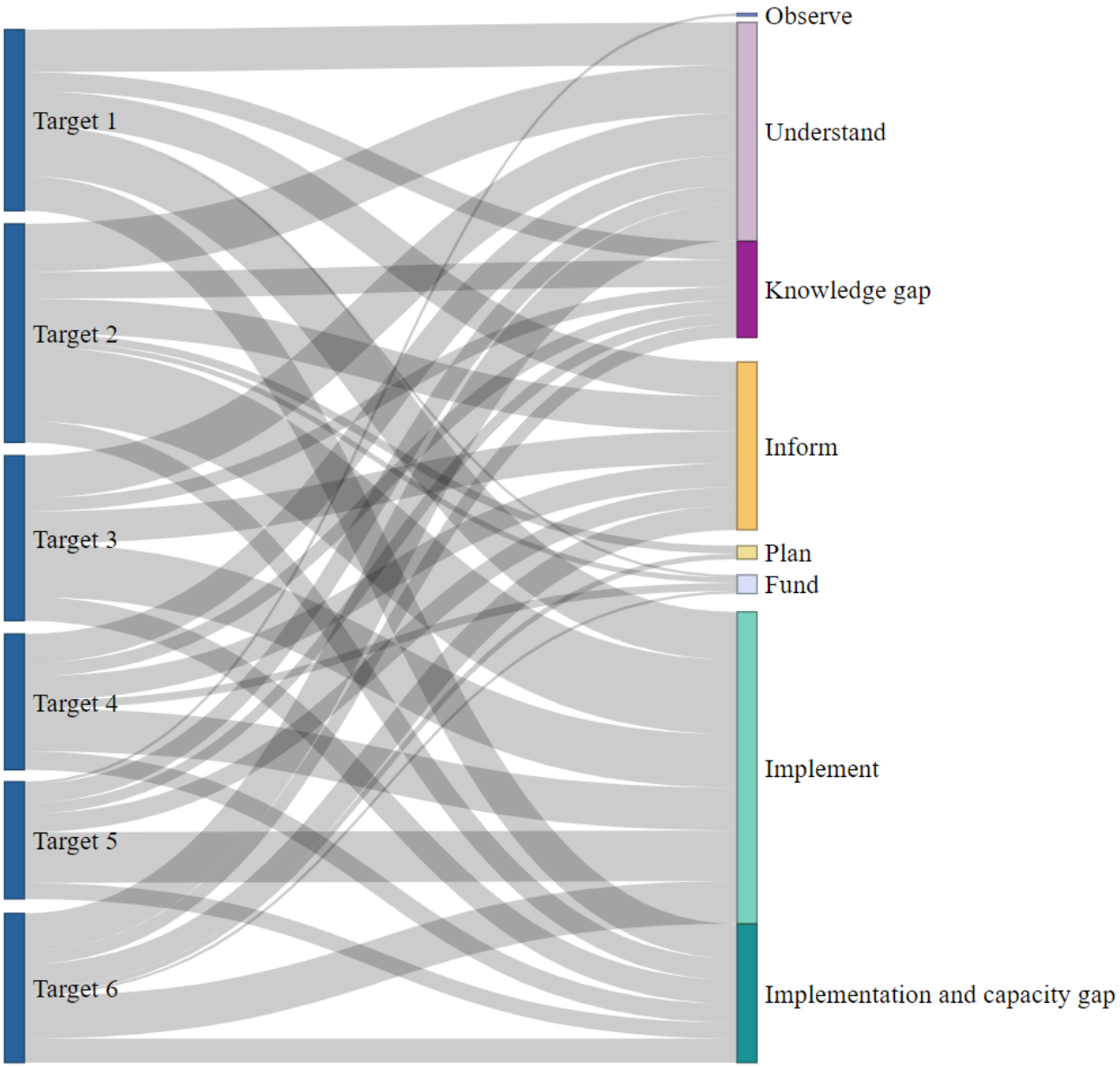

Figure 6. Typologies of actionable information used to evaluate the Targets of the BDS 2020 (European Commission, 2022).

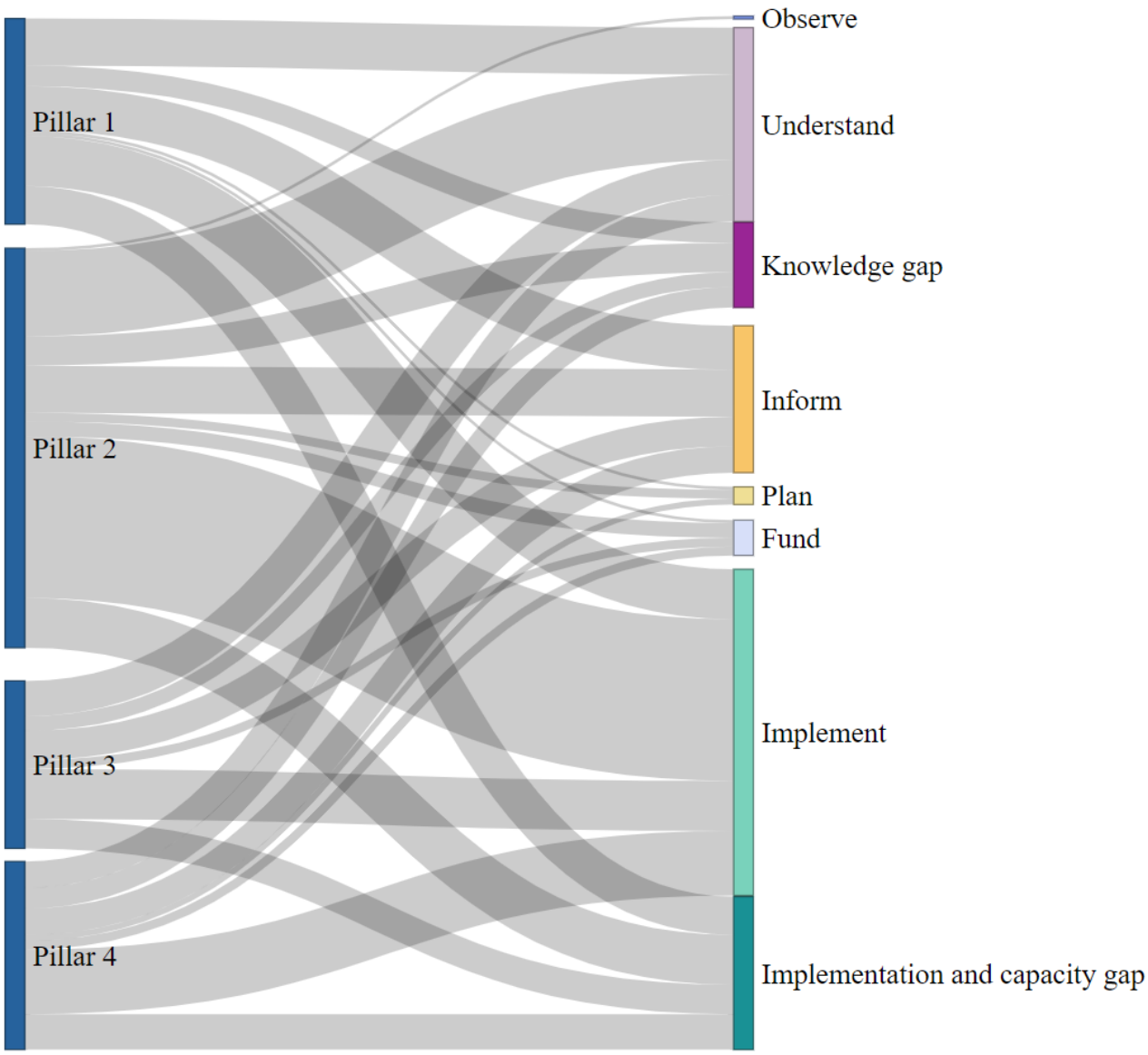

Figure 7. Contribution to assess the Pillars of the BDS 2030 from the actionable information used in the BDS 2020 evaluation (European Commission, 2022).

Table 7. Frequency of use of types of actionable information across BDS 2030 Pillars, from the Evaluation of the EU Biodiversity Strategy to 2020 (European Commission, 2022). Percentages are not equal to Table 6 as some information elements are either not related to any BDS 2030 Pillar, or may be related to more than one Pillar.

BDS 2030 Pillars	Types of use of actionable information						Total by Target
	Observe	Understand	Inform	Plan	Fund	Implement	
Pillar 1	-	6,5%	6,1%	0,4%	0,4%	6,9%	**20,3%**
Pillar 2	0,4%	11,8%	6,5%	1,2%	2%	22,4%	**44,3%**
Pillar 3	-	4,9%	4,1%	-	1,2%	6,9%	**17,1%**
Pillar 4	-	3,7%	3,7%	0,8%	1,2%	8,9%	**18,3%**
Total by Type of use	**0,4%**	[1] **26,9%**	**20,4%**	**2,4%**	**4,8%**	**45,1%**	**100%**

3.2. The *Freshwater DC – using the framework to tackle the BDS Action 42*

QUESTION

As an initial exercise to test our framework, we **evaluated its ability to address the first action** of Target 11, which aims to restore 25,000 km of European free-flowing rivers by 2030. This primary **Action 42** involves providing a technical **guidance document** and support to the Member States to **identify obsolete barriers** for removal (e.g. dam). As this action has been fulfilled, the guidance document is now published and could serve as a reference to test the relevance of our framework (Directorate-General for Environment (European Commission, 2022)).

METHOD

To gather the knowledge needed to answer this action, we reviewed two documents recommended by the Freshwater DC, relevant to Target 11: a policy review on European national river restoration from the European Centre for River Restoration - **ECRR** (Schmidt & Fokkens, 2023), and a report of a four days seminar on dam removal in the Alps held by **WWF** in 2021, which regrouped more than 900 experts from 60 countries (WWF Deutschland, 2021).

Action 42 has two requirements: (1) the **recognition of barriers that can be feasibly removed** (starting by obsolete barriers), and (2) the **identification of funding for restoration** at the sites identified.

Three weeks were allocated to review the documents provided by the Freshwater DC, proceeding to the identification and classification of information elements within the typology of actionable

information (ANNEX 1 - indicators, data-platforms, knowledge gaps, etc.). In total 96 information elements were identified and classified within a Google sheet: 56 from the WWF report and 40 from the ECRR policy review.

Once the Google sheet was filled (ANNEX 3, T31_Freshwater_DC_Google Sheets), we used different filters to get the information relevant to the Action 42 of the BDS 2030. We selected "freshwater" from the Keyword column, and we filtered for the "Information elements" related to "barrier" and "dam" via the search function (Figure 9). From this filtering exercise, 24 information elements were identified (Table A3 in ANNEX 6).

We integrated those information elements along the knowledge generation framework from Figure 5 (Section 2.2), to know which knowledge is relevant at which step, from raw data to implementation. As a **guideline document** has been requested by Action 42, only the steps "**Observe**", "**Understand**", "**Inform**" and "**Plan**" applies to answer the Action (Figure 10). This guideline document should unlock the following steps of "**Fund**" and "**Implement**" at a later stage.

PROCESS

Understand - Processed data

To answer Action 42, one can wonder what kind of information is available which can help to identify the barriers that can possibly be removed. The "Type of IE" column allows us to easily filter and identify all processed data such as variables, indicators and scenarios. Four **variables** were identified: "*Number of artificial barriers less than 0.5 m in height*", "*Number of barriers in European rivers*", "*Number of barriers lower than 2 m high*", and "*Percentage of obsolete barriers in Europe*". Those variables already inform us on the facts that obsolete barriers were already identified, some barriers have been already removed (on which criteria?), barriers lower than 2 and 0.5 meters high have been counted (what is their location?). That information can be easily found when digging into the references of the information element (columns displayed in ANNEX 3) and trigger other questions. Maybe this information is not available at the desired temporal or spatial scale. For instance, the variables which provides the "*Number of artificial barriers less than 0.5 m in height*" is just available at the Member State scale (see ANNEX 6). If this information is needed at the EU scale, then a knowledge gap needs to be filled.

Observe - Data collection

If the data lack the necessary resolution to support a BDS 2030 Action, a data collection and harmonization effort is needed. This can involve launching a new monitoring program or contacting various actors who may hold the data. For example, in regard to the freshwater case, Europe faced a gap in **data** harmonization and collection on barriers a few years ago. To face this gap, a new EU Horizon 2020 AMBER project has been created. This project centralized all data held by Member States and diverse institutions into one Atlas on European stream barriers (European Barrier Atlas). Once the data gap has been fulfilled, all necessary variables and indicators could be developed to feed guidelines and recommendations.

Inform

Through existing variables, indicators or scenarios we can comprehend the state and evolution of a system and the problematics to be solved. Changes in an ecosystem can be quantified, pressures estimated, and drivers of change can be identified. Recommendations and guidelines can be drafted from those results, including sometimes citizens sentiments and stakeholders needs. Several types of information can be of relevance at this stage: **driver of changes**, **management practices**, **reports**, and **recommendations**. From the fourteen information elements that corresponded to the mentioned types, three seemed to be of relevance to identify barriers to remove from the analysed documents: "*Prioritisation criteria of barrier restoration projects*", "*Prioritisation of barrier removal*" and "*Remove barriers that do not serve a purpose or meet regulations*". Those information elements are linked to descriptions informing on the strategy to adopt for barrier removal (Table A4 in ANNEX 6). Based on these descriptions, we should **prioritize removing barriers that meet the following criteria**: (1) **barriers that do not serve a purpose**, (2) **barriers where threatened fish species live**, (3) **barriers located in water bodies sensitive to climate change**, (4) **barriers located in protected areas**, (5) **barriers whose removal would maximize river length**, and (6) **barriers whose removal is accepted by the local community and landowners**. Even though many of those points should be better specified to guide implementation, it gives clear directions on what prioritization can be based on. In addition, to avoid knowledge gaps before implementation, one can wonder if all actors or parameters have been included, and if the barriers to implementation have been identified.

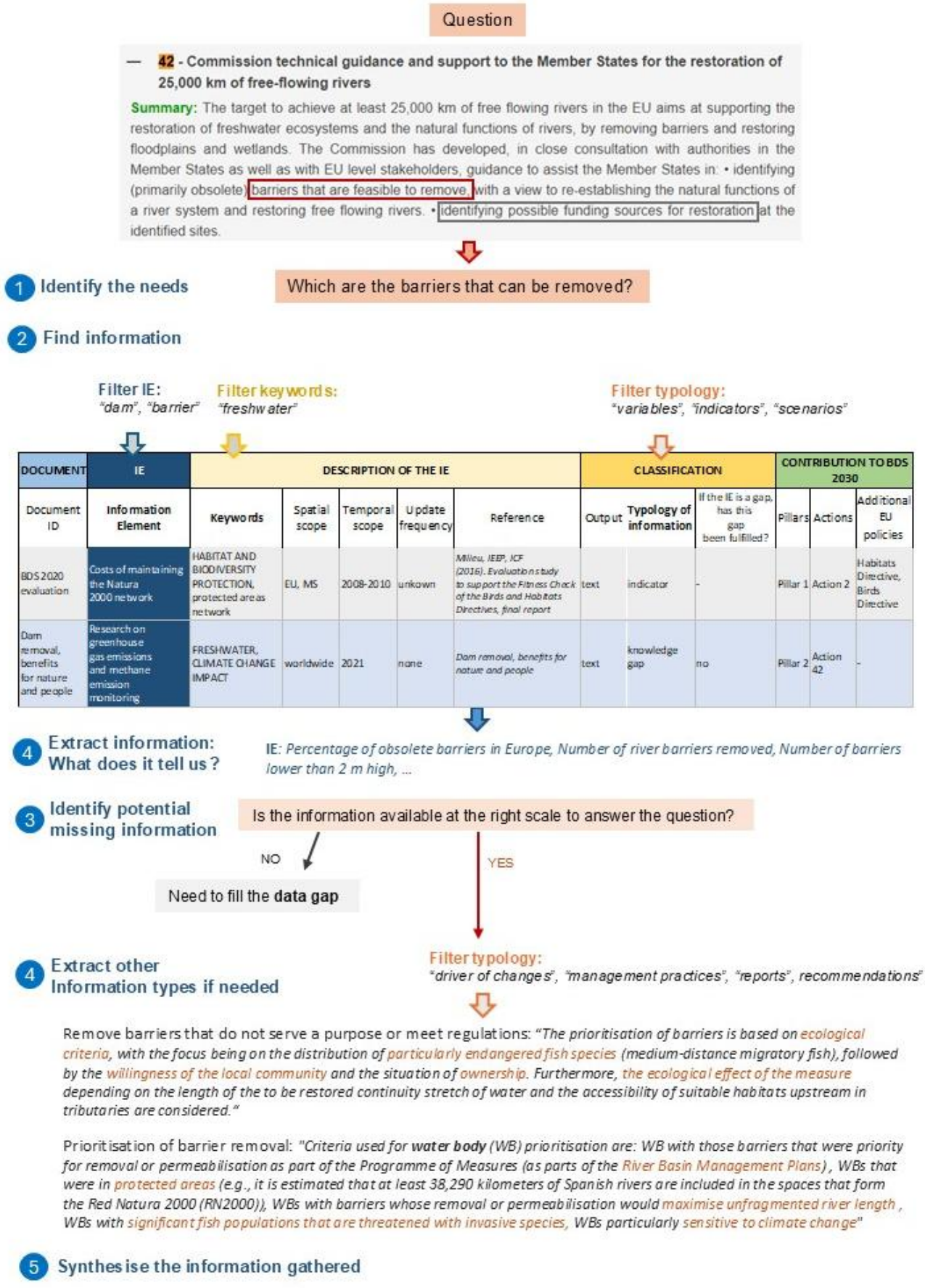

Figure 8. Flowchart illustrating the process to get the information needed to answer Action 42.

Plan

Once the guidelines are clearly framed, it is time to dig into real case studies: what have been done already, what are the lessons learned and best practices? This kind of information can be found in Frameworks, Management practices, Innovations, Policy instruments (i.e. subsidies use) and Recommendations. There is one information element from Table A3 in ANNEX 6 that can inform us, the element "*Evacuation of endangered species when a barrier is removed".* A **recommendation** relating a success story that occurred in the Windach Bavarian river, where the removal of a barrier might demolish a habitat of the common river mussel, a protected FFH (fauna/flora/habitat) species which colonised the mill channel (drying out after the removal). Markus Brandtner (Water Management Authority) reported that, when the barrier was removed on this channel, the mussel population was evacuated and brought to an appropriate location within the river. The mussel population is now considered to be stable in its new environment (WWF Deutchland, 2021).

This is just one practical example, and many others might be found in documents. Also, more information might be available to apply guidance, mobilize resources for implementation, use innovative solutions and technologies. Moreover, it is equally important at this stage to double check for capacity or knowledge gaps: are the recommendations made being realistic (financially, etc)? Is the network of actors in place? Are the changes needed being broadly accepted by the community? These can require extra work of preparation before Implementation.

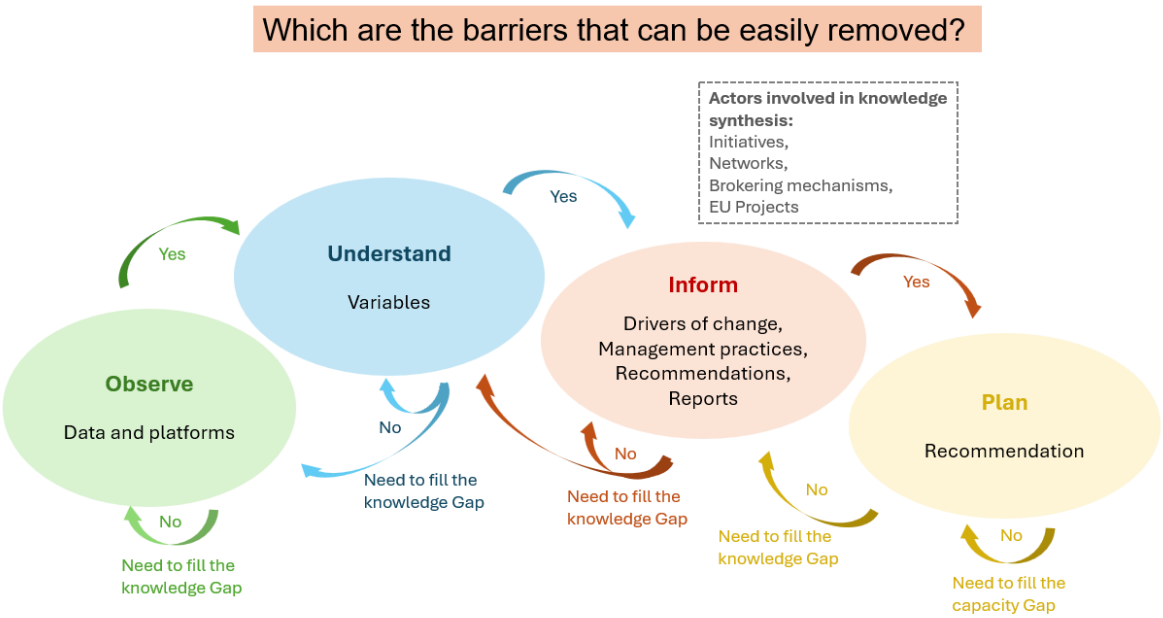

Figure 9. The information use process – actionable information and their application to answer the Action 42.

RESULTS

Based on the example of the Action 42 of the BDS 2030, the Freshwater DC exercise permitted to illustrate how the information can be easily mobilized to answer policy requests, once it has been collected and organized. By having harvested information of only two documents, we could already have similar recommendation outcomes than the ones provided in the final guideline document (see Box 1, ANNEX 6). Overall, **the process to get the information needed** to answer the Action 42 **could be measured in minutes** instead of weeks of work when it comes to mobilize expert knowledge. It is the work behind to collect relevant information that was laborious. Based on this experience, we suggest to set-up an **automatized process** that collects policy relevant information through "text extraction and classification" processes. A **machine learning algorithm** could identify information elements based on their **typology**. This exercise allows us to better understand which information can be best suitable for the knowledge generation process (from observe to implement) and identify related gaps.

4. Limitations

The framework to assess knowledge is still a preliminary beta-version to be tested with the forthcoming Demonstration Cases, to be refined, updated and adapted to new application contexts. Exploration work in this direction could be performed at the next consortium meeting in Cambridge in November 2024.

The first limitation of this work is its inability to capture informal knowledge (workshops, meetings, oral knowledge), which is the primary source of knowledge that feeds policymaking. However, formal knowledge present in documents can already provide solid evidence for the SSBD community.

4.1. Typology of actionable information

We adopted an inclusive approach to the proposed typology of information, ensuring that no policy-relevant knowledge was overlooked. Consequently, we compiled an extensive list of information types, though not all may hold equal relevance for policy requests. On another hand, we may have missed some other information types. To address this, a **survey** distributed to SSBD stakeholders could identify which information they find relevant and highlight any missing type. The typologies of actionable information and its use needs to be tested and refined with a wider range of stakeholders, such as politicians and local communities. This can help determine their generalizability and identify where they might need adaptation or expansion to suit different user needs, and ensure that the typologies remain relevant and useful across various applications (Jagannathan *et al.*, 2023a). In addition, stakeholders could directly provide suggestions of "information elements" that should be integrated in the framework.

Another challenge is the determination of the quality of certain typologies, especially the ones relation to literature such as 'Research papers' or 'Reports.' We need a method to ensure quality in selecting which papers to include. While we recommend prioritizing papers from Q1 journals, additional criteria should be developed.

4.2. Typology of use

Through this work, we mapped the different actors outsourcing knowledge that have the potential of being pertinent for the future SSBD. Along with this mapping exercise, we identified different categories of policy-relevant information generated or used by the different actors. We organized them along a gradient of actionability, from "observe" to "implement". The ultimate purpose of this work is to establish a foundation as inspiration for creating an operational web platform.

4.3. Documents to review

In section 6.1, we provide some suggestions regarding documents to review and extract the knowledge from. These suggestions still need to be better refined, with a prioritization process. Our current position is to let the experts from the DCs decide what are the most relevant documents to examine.

5. Contribution to the Science Service for Biodiversity

Identifying and making biodiversity knowledge usable for policymaking is crucial for promoting evidence-based decision-making, addressing complex environmental challenges, enhancing policy effectiveness, promoting sustainable development, and fostering stakeholder engagement in the policy process. In this framework, we set-up requirements to identify knowledge that could be actionable, in a way that this knowledge can be easily mobilised to serve different purposes. Given that AI technologies are evolving fast, we present a framework for knowledge collection that can serve as a foundation for future applications including potentially AI, especially for the web-platform.

The Science Service is intended to run different functions to aid the EC shifting towards a sustainable path. Our framework can serve to support four of those functions (Figure 11): (1) building up evidence and knowledge base on topic, (2) answering requests, (3) link up with biodiversity commitment and (4) horizon scanning and research prioritization functions. We then explore the contribution of the web platform set up by T4.4 in the implementation of our framework.

DOCUMENT	**IE**	**DESCRIPTION OF THE IE**					**CLASSIFICATION**			**CONTRIBUTION TO BDS 2030**		
Document ID	**Information Element**	**Keywords**	Spatial scope	Temporal scope	Update frequency	Reference	Output	**Typology of information**	If the IE is a gap, has this gap been fulfilled?	Pillars	Actions	Additional EU policies
BDS 2020 evaluation	Costs of maintaining the Natura 2000 network	HABITAT AND BIODIVERSITY PROTECTION, protected areas network	EU, MS	2008-2010	unkown	*Milieu, IEEP, ICF (2016). Evaluation study to support the Fitness Check of the Birds and Habitats Directives, final report*	text	indicator	-	Pillar 1	Action 2	Habitats Directive, Birds Directive
Dam removal, benefits for nature and people	Research on greenhouse gas emissions and methane emission monitoring	FRESHWATER, CLIMATE CHANGE IMPACT	worldwide	2021	none	*Dam removal, benefits for nature and people*	text	knowledge gap	no	Pillar 2	Action 42	-

Figure 10. Main entries suggested for gathering information in the context of the BDS 2030. Entries in bold are being addressed in specific sections of the deliverable. Coloured lines reflect the relevance of different entries of the SSBD functions. The blue line reflects relevance for the building up evidence and knowledge base on topic function, the red line is relevant to the answering request's function, the yellow line is relevant to the establish research prioritization function, the green line is relevant to the linking up with biodiversity commitment's function.

5.1. Building up evidence and knowledge base on topic

The mission of this function is to make existing knowledge easily accessible and actionable through innovative mechanisms for knowledge gathering and synthesis supported by AI engines, to avoid the knowledge to get lost, avoid duplication, identify needs for updates (as currently defined by T4.2

on “setting up the functions of the science service”). Being able to easily retrieve existing knowledge would facilitate to answer urgent requests in a timely manner. This is the main function we are working with, which is closely intertwined with three other functions: (1) the answering request function, as it provides the knowledge base for it, (2) “research prioritization” function, as knowledge gaps present in documents are being uncovered, and (3) “linking up with biodiversity policy and strategies” function which links knowledge to EU policies, including the different actions of the BDS 2030. The tremendous and challenging effort to integrate and synthetise such amount of knowledge requires AI use to ensure a broad and robust overview of the knowledge used to evaluate biodiversity policies. Therefore, we provide some suggestions on their potential use in the section 6, on the centralized web-platform.

5.2. Answering requests

In addition to fulfilling internal knowledge synthesis requirements, the SSBD will be asked to handle requests from the EC and other societal actors. The aim of the answering request support function is to implement a request submission system that will accessible to the EC staff. Through tested knowledge synthesis methods and protocols for balancing requests’ prioritization, the SSBD will provide consolidated knowledge on the specific topics addressed in the requests, making use of scientific and non-scientific sources, such as traditional, local, practitioners’, technical, and transdisciplinary knowledge systems (as currently defined by T4.2). This work would help speeding up the process and align with the EC timeline to be policy-relevant, especially for answering urgent request. Overall, **the final product of this framework is the facilitation of the process of answering urgent requests**.

To facilitate the answering request process, we inform about:

- **the display of the information (Output)**: is it available as a graphic? A table? A text? This would help experts know how the information is currently communicated or documented, so they can update or improve it accordingly.
- **the type of information**: what kind of policy-relevant knowledge do we deal with? Is it a database? An indicator? A scenario?
- **gaps**: does the information element addresses a knowledge or capacity gap? If so, does that gap has been filled? If so a reference as a proof will be needed. As gaps may become outdated over time, this can be a precious information to avoid duplication.
- **the type of use of this information**: when can this information be relevant? For which purpose?
- **keywords**: they provide a direct access to a repository of information relevant to an area of interest. Keywords and filters speed up information retrieval and make navigating the future knowledge database easier.

The use of our work in the answering request process:

1. **before submitting a request**: use of a ***large language model*** like ClimateQ&A or Consensus trained on relevant database (see section 6.1). This AI could summarize existing knowledge on a question formulated by a SSBD user.

2. **the scoping phase:** the ***knowledge database*** could permit a quick retrieval of relevant documents to assess if the request has been addressed in the past. This can be done by screening existing projects, policy briefs, reports, and research papers present in the database, using keywords to filter the information needed.

3. **knowledge overview and knowledge synthesis:** like in section 4.2., the ***knowledge database*** could be used to retrieve information types relevant to the request (e.g. knowledge gaps, recommendations, etc.). This will help having an overview of the existing information on the topic and speed up the knowledge synthesis.

We showed here and in section 3.2 how the *knowledge database* could act as a tool to retrieve biodiversity information. In addition to help answer a request, the *knowledge database* could work as an incentive to the different stakeholders to be part of the SSBD (if available to them). Moreover, this could help in diminishing experts bias regarding knowledge use (Bennett *et al.*, 2023).

5.3. Link up with Biodiversity Commitments

The mission of this function is to ensure that efforts on different fronts at the SPSIs contribute directly and indirectly to implementing existing policy frameworks around biodiversity, including the EU BDS2030, the Nature Restoration Law, Farm2Fork, the Kunming-Montreal Global Biodiversity Framework, and upcoming version of them. It is hence understood as an overarching mission of the SSBD, which delineates biodiversity-related topical areas to which the rest of SSBD functions contribute, e.g., topical networks, answering requests (02_Notes 1st T1.2-Consortium workshop on SSBD framework_20.11.2023_version 3.docx (sharepoint.com)).

This protocol links formal knowledge to different EU biodiversity policies and commitments to better inform decision on implementation.

The Science Service is also committed to support the formulation and implementation of biodiversity commitments. In the context of the BDS 2030, this approach could effectively complement the Action Tracker by evaluating the fulfilment of commitments.

5.4. Horizon scanning and research prioritisation

Aas currently defined by T4.2, horizon scanning is the systematic search for, and examination of, potentially significant medium- to long-term threats and opportunities that are not well recognized within a particular field.

The identification of knowledge gap from written documents can help determine future research needs and thus contribute to research prioritization (see the actionable information type “gap – knowledge” in ANNEX 1, Figure 11).

6. Future perspectives and the web platform

6.1. Integration of AI tools and the knowledge database within the web platform

One of the objectives of the future Science Service is to be the main entry point for biodiversity knowledge for the EC. This framework aims to provide tools to establish a web platform capable of effectively deliver on this commitment and serve several **users** of the SSBD.

The services provided by the web-platform could be:

1) An AI assistant supported by a **large language model** trained on different libraries such as Cordis, Scopus, Patents from Patstat, that could **provide a summary** and **answers** based on the search on **hundreds of documents** related to the topic (potential use of our identified keywords). Although it should make clear that the AI cannot replace professional expertise when required. As a base for inspiration, several AI tools trained on scientific literature already exist: ClimateQ&A, https://scispace.com/, Scite or https://consensus.app/search/.

2) A **knowledge database** with entries inspired from Figure 11 (see ANNEX 2 and ANNEX 6), to facilitate the work of experts to tackle urgent requests. It could enable the EC staff and knowledge brokers to easily access biodiversity information relevant for each Action of the BDS 2030 (reports, indicators, etc.). It would provide access to raw information needed for each step of the implementation process described in sections 2.2.2. and 3.2, with **clear gaps** and **recommendations** identified per topic and BDS Action. The users could have directly access to lists of reports, data platforms, indicators, scenarios, gaps and recommendations from analysed documents. Thus, this could complement a large language model, increase reliability with direct access to the mentioned paragraph and link to web-databases, speeding-up the knowledge synthesis process. As source of inspiration, IPBES already have implemented a knowledge gap database: Knowledge gaps | IPBES secretariat. However, the use of "piece of information" as described in section **Error! Reference source not found.** seems more pertinent, as it can be quickly spotted. To implement this "knowledge database", we need tools to extract information elements from documents and automatically classify them in the information typologies mentioned above. Different AI platforms such as Medallia, Google cloud AI or Watsonx could be used. Through these platforms, machine learning techniques can be used for text extraction and classification. They require training on targeted documents, which we can perform with the assistance of T1.2 and T1.4.

The "knowledge database" could be a tool for:

a. **the EC staff and governmental agencies**. It could inspire them to set the next priorities for policy by providing an overview of knowledge and capacity gaps, as well as being aware of existing solutions to potentially support their development, such as innovations, sustainable management practices in the private sector, among others.

b. **the scientific community:** Get an overview of policy-relevant knowledge that has been produced by the scientific community: e.g. essential variables, indicators, scenarios, and monitoring platforms. This overview is of importance for scientists to be aware of the last advancement in their field related to policy, as well as discovering open database they might not be aware of. It can also help being aware of knowledge gaps to better orient their work.

c. **the NGOs and knowledge brokers**: It could facilitate synthesis work with pre-processed knowledge available from reports, research papers synthesis, etc. (see section **Error! Reference source not found.**). Also, NGOs and knowledge brokers could actively populate the database with their latest reports.

d. **businesses and practitioners**: it could provide them inspiration for sustainable solutions for businesses (e.g. sustainable management practices for their field), innovations as well as innovative financing for climate action, existing payment for ecosystem services, etc.

3) A **visualization tool** such as Figure 7 and 8 in 3.1 that could highlight knowledge gaps acknowledged by the literature or other policy-relevant knowledge displayed in a figure, like Figure 7. By filling up some queries, such as specifying keywords, an information type as well as a BDS 2030 action, a graph displaying potential knowledge gaps or other kind of knowledge from our identified typology could be generated. This tool requires the implementation of the knowledge database.

Table 8. Utility of a large language model versus a knowledge database.

large language model		**knowledge database**	
Generate text on request and can draft answers to questions (Chat GPT like).		Humans need to search for the information needed.	
Advantage	Caution	Advantage	Caution
Get fast answer on specific questions supported by references.	Take care about the accuracy of the large language model.	Useful when experts want to have a specific list of information on a topic (e.g. reports).	Need to ensure the performance of search within the database.
		Useful to link information produced to specific policy. For	

		instance, if the EC needs to update a policy document, they can have all indicators, reports, etc. that might be of relevance for this document.	
Can report and summarize some gaps, but might not provide an exhaustive list and details on data availability for instance.		Efficient tool to assess **gaps and bottlenecks**, as information can be filtered and gaps in knowledge, capacity or in data availability can be easily assessed.	

Suggested documents to train the AI:

Large language models or machine learning algorithms could be trained on scientific literature on environmental topics relevant for policy making from existing databases (e.g. Semantic scholar), from papers emerging from European projects, IPBES and IPCC documents, reports from the JRC, the EEA (European Environmental Agency), reports from NGOs (e.g. Saami council) and other knowledge brokering mechanisms identified by T3.4. Documents produced by the EU could be incorporated such as documents from the European Commission, stored in the Register of Commission documents, documents from the Public Register of Documents of the European Parliament, and from the Public register of Council documents from the European Council. They encompass proposals, impact assessments, communications, delegated and implementing acts and other Commission decisions, agendas and minutes of meetings held by the College of Commissioners, among other.

Conclusion

As highlighted in Table 8, the use of a **large language model and a knowledge database is complementary** as they provide different services. Thus**, we recommend the establishment of both methodologies** for the future SSBD.

6.2. Challenges and next steps

Short term:

- Assess the **relevance to the different SSBD users** of the suggested typology of actionable information via a **survey**. The survey can be used by the demonstration cases (DCs) of BioAgora to identify additional knowledge needs in their field of expertise.

- Develop a controlled vocabularies to be understandable by machines. A workflow to answer requests could integrate a knowledge base that can be read by machines.
- Certain information type will need to be better framed in terms of quality regarding what to harvest, such as EU reports or scientific papers. A **quality assessment** should be made to better filter information.
- Make a test with DCs to **train a machine learning algorithm** for text extraction and classification.
- Identify **what can be automated and what cannot** to assess how realistic the set-up of the "knowledge database" can be.
- **Contact AI experts** (e.g. Ekimetrics) to see how they could support us.
- **Test our framework for a database with other DCs (Landscape DC, monitoring DC).** Suggestion from the Landscape DC to set-up a Shiny App to streamline the text extraction process.

Long term:

- The implementation of an AI will require **unlocking funds** to work with AI experts and develop a large language model or a knowledge database.
- Another main challenge is **maintenance**, with regular update to ensure up-to-date available information. Outputs from new EU projects could be easily identified and integrated, along with reports that could be regularly provided by the Science Service network. The network could be asked to report on new insights that are being generated, enabling the integration of newly generated information into the database. Also, storage capacity should be ensured to store the database. Updates and data storage needs should be integrated in the **SSDB business plan** to make the Science Service run smoothly.

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8. Annexes

8.1. Annex 1 – Actionable information typology - description

1 Introduction

In order to easily identify what kind of policy-relevant biodiversity knowledge is out there, we group information elements under a same class, or "type".

Those information types should be either 1) policy-relevant, meaning usable by the EC staff or policymakers, or 2) relevant for knowledge synthesis, to gather information for the EC staff when answering policy-requests, and 3) systematically collected from written documents which are "quality proved" (e.g. peer reviewed, or from trusted libraries / institutions / organizations).

The final use of this typology will be to define what information to collect within the *knowledge database*, that would serve the different users of the SSBD (see Section 4.2.5 of D1.3).

2 Methodological approach to define a typology of actionable information

To identify policy-relevant information types, we proceeded to a review of the evaluation report of the previous EU Biodiversity Strategy for 2020 (Denksatt et al. 2022). We considered that this report would provide a first comprehensive overview of policy-relevant information for biodiversity, where we identified 15 types: ***Data and Platforms, Frameworks, Funds, Gaps - Capacity, Gaps – Knowledge, Indicators, Initiatives, Networks, Policy Documents, Projects, Quotas, Recommendations, Reports, Scenarios, Variables and Essential Variables***.

To uncover missing types that were absent from the evaluation report, we mapped the main actors of knowledge production (Figure 2 of the main document) and the type of information they might produce. We highlighted ***Management Practices*** and ***Innovations*** as missing types as well as many ***Policy instruments*** in additions to funds and quotas that we classified in eight categories (see B. Policy Instruments). We chose to include policy instruments in the typology, as providing an overview on all EU instruments and their use could help the different SSBD stakeholders.

We used both the policy instruments classifications from IPCC and IPBES to design these categories (IPBES 2018) (Table A1). We chose to keep ***Subsidies and incentives***, as well as ***Taxes and charges*** separated and created a new category for ***Compensation payment and Offsets***. This choice was based on the purpose of these policy instruments. *Subsidies and incentives* are a form of reward which pushes for good environmental behaviours, while *Taxes and charges* can be seen as sanctions, as polluters must pay for environmental damages. *Compensation payment and Offsets*, in principle, encourage environmental neutrality.

To complete the identification process of typologies, we asked feedback from the BioAgora community, the knowledge broker Eklipse[1] and from the DCs (freshwater, marine and NBS). The Freshwater DC communicated us relevant documents to go through to train our typology (Posnjak, WWF Germany, 2021, Schmidt, 2023). Through this review, we identified a missing information type: ***Drivers of change***.

The **list of all information typologies** is disclosed below with their **description**, potential **synonyms**, related **examples**, their **policy or knowledge synthesis relevance** as well as **potential overlaps** with other typologies. A list of identified overlaps is provided in the section 4. Typologies overlap.

This knowledge list encompasses the typologies that have been originally sent via our survey, as well as the ones that have been added after our survey.

Next steps

To assess the utility of our typology, we designed a **survey** to be sent to BioAgora and the expert communities as well as the EC staff with the identified typologies.

Both experts and EC staff will be asked to rate the relevance of the information types below on a scale from 1 to 5, regarding the aptitude of the information types to reinforce the science-policy aspect of their work, as well as to speed-up of the answering request process (for experts only). They will be also asked to provide us with more examples of information elements that are the most relevant to them (not mandatory) and suggest any information typology we might have overlooked.

3 Description of actionable information types

A. Actionable information

1. Data and Platforms

Description:
Information management tool linked to databases, designed to visually track or map key indicators and metrics, providing a comprehensive overview of a targeted ecosystem or set of species for both experts and non-expert users such as policy makers.

Synonyms: Database, Monitoring dashboard, platforms or systems.

Examples:
Biodiversity Information System for Europe (BISE),
Forest Information System for Europe (FISE) (europa.eu),
Ecologically or Biologically Significant Marine Areas (EBSA)

Policy or knowledge synthesis relevance:
Tools that are designed to be used by both experts and non-experts (incl. policymakers).

2. Drivers of change

Description:
Drivers of change refer to external factors that cause change in nature, anthropogenic assets, nature's benefits to people and a good quality of life. As a consequence, drivers of change also affect the supply of nature's contributions to people. The IPBES conceptual framework includes drivers of change as two of its main elements: indirect drivers, which are all anthropogenic, and direct drivers, both natural and anthropogenic (IPBES glossary, drivers of change).

Examples:
"Direct and indirect impacts of barriers on fish"
information element taken from a report review that mentions: *"Barriers detain fish from reaching their spawning grounds and turbines in barriers can result in direct mortality (Drouineau et al., 2018).".*

"Impacts of river construction on ecosystem properties"
information element taken from a report review that mentions: "Obstructing a river can vastly alter ecosystem properties such as water depth, flow regimes, channel morphology, sediment loads, chemical proper ties, and thermal conditions (Dynesius & Nilsson, 1994).".

Policy or knowledge synthesis relevance:
Highlight factors that are driving positive or negative changes, and their potential impact on biodiversity, ecosystem services and human health. This knowledge can help orienting policy and quickly find information for knowledge synthesis.

3. European Citizens' Initiative

Description:
The European Citizens' Initiative (ECI) is an important instrument of participatory democracy in the EU, allowing one million citizens residing in one quarter of the Member States to invite the Commission to submit a proposal for a legal act to implement the EU Treaties. Since the application of a 2011 Regulation establishing detailed procedures for the ECI, ten initiatives have been successfully submitted to the Commission, out of 111 initiatives registered.

Example:
"Right2Water", "Ban Glyphosate", "Save bees and farmers".

Policy or knowledge synthesis relevance:
Keeping track of those initiatives allows EU policymakers to be aware of the biggest citizens 'concerns. Allows citizens to interact with European policies and increase their democratic power. It can be interesting to check the impact of those initiatives, especially for transformative change.

4. Frameworks

Description:
Guidance toolkits which assist scholars, practitioners and other stakeholders in the design or implementation of sustainable solutions (e.g. standardization protocols, taxonomies, other kinds of protocols).

Examples:
"Knowledge Innovation Project on ecosystem services and Natural Capital Accounting (KIP INCA)"
"Data protocol - Marine Information and Data Centre (informatiehuismarien.nl)"
EUNIS Habitat types and Species lists

Policy or knowledge synthesis relevance:
Guide scholars, practitioners and other stakeholders in the implementation of sustainable solutions.

Potential overlaps with other typology: Reports (see 3. Typologies overlap)

5. Gaps – Knowledge

Description:

Knowledge gap in a policy context refers to areas lacking sufficient information for effective decision-making. It outlines insufficient research capacity on a topic (Pita et al., 2020).

Examples:

"Knowledge to enable restoration planning", information element taken from the BDS 2020 review that mentions "In relation to Target 2, factors of failure mentioned by stakeholders include knowledge to enable restoration planning (national and regional authorities and experts)".

Please, keep in mind that each information element will be linked to an Action of the strategy, and will be accompanied with its reference document and quote from where it has been extracted.

Policy or knowledge synthesis relevance:

Identifying knowledge gap is of outermost important to prioritize fundings and next research programs.

6. Gaps – Capacity and implementation

Description:

Capacity gaps in implementing environmental policies refer to limitations in resources, and enforcement capabilities hindering effective policy implementation. These gaps can stem from various factors such as weak administrative capabilities, and inadequate enforcement practices.

Examples:

"Human resources for restoration", information element taken from the BDS 2020 review that mentions "In relation to Target 2, factors of failures mentioned by stakeholders include human and financial resources for restoration, lacking in particular outside of protected areas and often deprioritised for biodiversity in the context for budget cuts."

Please, keep in mind that each information element will be linked to an Action of the strategy, and will be accompanied with its reference document and quote from where it has been extracted.

Policy or knowledge synthesis relevance:

Highlight gaps in funding, administrative capabilities or work capacity that needs to be fulfilled to achieve sustainable objectives. This information is relevant to properly allocate fundings and effort.

7. Indicators

Description:

Indicators reflect or evaluate the trends, state and pressures of the environment and monitor the progress made in realising environmental policy targets (Heink and Kowarik 2010).

Examples:

European grassland butterfly indicator — European Environment Agency (europa.eu) (state indicator)

Pesticides in rivers, lakes and groundwater in Europe (Indicator) (europa.eu) (pressure indicator)

Marine protected areas in Europe's seas (europa.eu) (used to monitor the BDS 2030 Target 1 progress)

Policy or knowledge synthesis relevance:

Indicators are of prime importance to convey messages to policymakers, showcasing trends or facts supported by scientific evidence. This type can permit the identification of previously overlooked indicators that could be used to assessing progress towards biodiversity goals, therefore enhancing their implementation.

8. Initiatives

Description:

Proactive approach taken by an individual or a group of individuals to bring about a change or improvement in a particular area. It involves taking the lead to identify a problem, develop a plan of action, and implement it without being prompted or directed by anyone else. The key characteristic of an initiative is that it is driven by a sense of purpose and a desire to make a difference, e.g. actions taken by non-profit organisations or citizens to tackle a specific issue.

Difference between initiative and project: while an initiative might introduce a new policy or approach in an organization or community, a project usually has a narrower focus, targeting specific deliverables and results. Thus, one can see an Initiative as a broader concept, whereas a Project is often a component within that broader concept.

Synonym: Campaign

> **Examples:** GeoNature-citizen (nature-occitanie.org): this is a citizen´s science initiative which pushes the members of the organization to report their species observations, “Leave no-one behind” (from WWF): this is a campaign launched by WWF.

Policy or knowledge synthesis relevance:

Provides an overview of the effort in place and expertise available to address a certain topic. Facilitates contact to reach specific stakeholders if needed.

Potential overlaps with other typologies: Data platforms, Networks, Projects (see 3. Typologies overlap)

9. Innovations

Description:

A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. Product innovations can utilise new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies. The term 'product' is used to cover both goods and services. Only innovations that go towards the ecological transitions are accountable.

Examples:

Biodegradable materials from mycelium: Ecovative,

Biodegradable polymers: Novomer,

Efficient solar solutions: Solarus,

Electricity from sea waves: BPS energy,

Microplastic, PFAs, pollutants, water filtering methods: under-sink reverse osmosis system, under-sink two-stage filters, under-sink single-stage filters, faucet filters, whole-house granular activated carbon (Frizzlife, Alb filter, Tappwater, etc.)

Gravity powers batteries for renewable energy: Energy Vault, Gravitricity, Gravity Power,

Wood-burning stoves without smoke: The Rocket Stove,

Sustainability monitoring, tracks crops, ecosystems, risks and supply chain assets: Satelligence

Policy or knowledge synthesis relevance:

Being aware of all existing innovations as ecological solutions is essential to activate a political push for the transition. It could foster the development of some of them, identify further research needs, and scale them up through political support and funding.

10. Management practices - Sustainable

Description:

Practices used by businesses, agriculture, and communities with the goal of lowering emissions and energy use, reducing environmental impacts in their day-to-day operations, ensuring the availability of resources for future generations. Examples may include life cycle analysis, environmental management services (EMS), industrial ecology, and energy management (Lounsbury 1999).

Examples:

In the case of businesses, environmental management practices can help:

1) the organizational processes of firms to lower environmental impacts: Life cycle environmental assessment (LCEA), Green supply chain management, Eco-efficiency, Environmental performance frameworks, Energy Waste Air and Water management.

2) company's products to be more environmentally friendly: Eco-label, eco-design, Cleaner production, Green chemistry (Lounsbury 1999).

Policy or knowledge synthesis relevance:

The EC staff should be aware of existing sustainable management practices to better orient their policy (CAP, business policies).

Potential overlaps with other typologies: Policy instruments, Recommendations (see 3. Typologies overlap)

11. Networks

Description:
In the context of institutions, research, and projects, a network refers to a group of two or more entities (such as universities, companies, or individuals) that are interconnected for the purpose of exchanging information, collaborating, and sharing resources. Networks foster interactions of a group of individuals or legal entities who are working on a common topic or objective.

Examples:
"LTER-Europe network",
"AlterNet",
"GEO BON Group on Earth Observations Biodiversity Observation Network"

Policy or knowledge synthesis relevance:
Being aware of existing networks attached to a topic is critical to mobilize relevant experts and stakeholders when a policy request arise and establish a linkage with EC policymaking.

12. Polls

Description:

Systematic method of collecting data on public opinion or behavior through structured questions directed at a sample of individuals. (Dillman, D. A. (2000). *Mail and Internet Surveys: The Tailored Design Method*. Wiley.)

Examples:

EU Challenges and Priorities from the Eurobarometer

Attitudes of Europeans towards the environment from the Eurobarometer

Policy or knowledge synthesis relevance:

Surveys focus on the one hand on citizens' perceptions and expectations towards EU action, and the main challenges the Union is facing. The EC is interested in those tools to better frame policy documents submitted to the Parliament.

Potential overlap: data and platforms

13. Policy Documents

Description:

It encompasses documents which are written by the European Commission[2], the European Council[3] and the European Parliament (see list from "Document type"), as well as similar documents written by national and subnational governments.

Examples:

"EU Forest Strategy for 2030",
"EU Pollinators Initiative"

Policy or knowledge synthesis relevance:

Can help the expert community and other stakeholders keep up to date with the most recent policy move or change.

Allow the EC staff as well as JRC, EEA staff to have a good overview on interactions between the EC, the Parliament and the Council, as well as internal communication.

14. Policy briefs / Summary for policy makers

Description:

A policy brief is a short document that uses graphics and text to summarize the key elements of one or multiple researches and provides a succinct explanation of a policy issue or problem, together with options and specific recommendations for addressing that issue or problem. It is analytic in nature and aims to remain objective and fact-based. Their resolve can be placed on a continuum going from "neutral", meaning objective and nuanced information, to "interventionist", which puts forwards solutions to the stated problem. (Arnautu and Dagenais 2021; Dagenais and Ridde 2018; Arcury et al. 2017; Wong et al. 2017; Keepnews 2016). IPBES describes a "summary for policy makers" as a component of any report, providing a policy-relevant but not policy prescriptive summary of that report. (summary for policymakers | IPBES secretariat).

Difference between policy brief and reports: A policy brief and a report are both important documents in the realm of policy-making, but they serve different purposes and are structured differently.

A policy brief is a concise document that outlines the rationale for choosing a particular policy alternative or course of action in a current policy debate. It is typically short, often only a few pages long, and is focused on conveying the most important aspects of a policy issue to non-experts. Policy briefs are designed to be accessible to a broader audience, including policymakers, stakeholders, and the public, and aim to influence or inform policy decisions. On the other hand, a report is usually a more detailed and comprehensive document. It can include extensive research findings, data analysis, and a thorough examination of the subject matter. Reports are often longer than policy briefs and provide a deeper level of detail. They are used to present information on complex issues and may be targeted towards specialists or individuals with a deeper understanding of the topic.

Examples:

AMBER-Policy-Brief-2.pdf

IPBES Global Assessment, summary for policy makers

Policy or knowledge synthesis relevance:

Critical for policymakers and EC staff. The objective of a policy brief is to make research output accessible to different stakeholders, inform policymakers' decisions or motivate action. (Arnautu and Dagenais 2021; Wong et al. 2017; Keepnews 2016).

15. Projects

Description:

A project is a series of activities aimed at bringing about clearly specified objectives within a defined timeframe and with a specific budget. A project includes: (1) Clearly identified stakeholders, including the primary target group and the final beneficiaries, (2) Clearly defined coordination, management and financing arrangements, (3) A monitoring system to oversee and follow implementation and to support project management. (Managing a project, EC)

Examples:

Research projects:

Wozep ecological programme - Noordzeeloket UK

PoshBee

Biodiversity and Ecosystem Services in Territories of European overseas (BEST)

Policy or knowledge synthesis relevance:

EU commanded projects are of high relevance as they are designed to directly answer policy needs. Other kinds of project also might deliver interesting outcomes by (1) identifying and addressing environmental issues (highlight new or emerging environmental problems that require policy attention), (2) helping to ensure that policies remain relevant and effective over time by monitoring environmental changes and the impacts of policy interventions, (3) promoting the integration of environmental considerations into other policy areas, such as economic development, agriculture, and transportation, among others.

On a larger scale, environmental projects can influence the architecture of global environmental governance, potentially leading to the creation of new institutions or the strengthening of existing ones.

16. Public consultations

Description:

Citizens and businesses can share their views on new EU policies and existing laws via the Have your say portal. The Commission analyses and sums up the feedback and contributions received. Reports become available under some consultations.

Examples:

Sustainable agreements in agriculture – consultation on draft guidelines on antitrust exclusion,

GreenData4All – updated rules on geospatial environmental data and access to environmental information,

Protecting the marine environment – review of EU rules

Policy or knowledge synthesis relevance:

Focus on stakeholders' perceptions and expectations towards EU decision making and the main challenges the Union is facing. The EC is interested in those tools to better frame policy documents submitted to the Parliament.

17. Recommendations

Description:

Policy advice or suggestion for policy makers of action needed to be taken, backed by scientific facts. Provides solutions to fill knowledge or capacity gaps.

Examples:

“River surveys and citizen science to document barrier numbers and locations “, from “To fill barrier data gaps we emphasize the value of ground truthing via river surveys, and the contribution that citizen scientists can make for validating and augmenting barrier numbers and locations” (ref, p8, AMBER Consortium (2020). AMBER Policy Brief No 1., 11 pp. https://amber.international/policy-briefs/)

Policy or knowledge synthesis relevance:
Advice policy into actions to be taken.

Potential overlaps with other typologies: Gaps – Knowledge, Gaps – Capacity, Management practices, Spatial planning tools (see 3. Typologies overlap)

18. Reports

Description:
published output of scientific, technical and socioeconomic issue that take into account different approaches, visions and knowledge systems to describe the process, progress, or results of technical or scientific research or the state of the art of a research problem (assessment reports), or the integration of the outcomes drawing from other reports (synthesis reports) to address policy relevant questions. (IPBES glossary)

Examples:

"CAP impacts on biodiversity: Evaluation of the impacts of the CAP on biodiversity, soil and water (natural resources) (SWD/2021/424 final). ",

"Commission Report on the State of Nature in the EU 2020",

"EEA Report on the State of the Environment and Outlook"

Policy or knowledge synthesis relevance:

Reports summarise existing knowledge, describe the state of the art and often provide policy recommendations. Thus, they are of prime importance for the EC staff and knowledge synthesis work.

19. Research papers – high impact factors

Description:

Peer reviewed research paper published in a Q1 journal that is specifically relevant to a topic.

Examples:

Corporate emissions targets and the neglect of future innovators | Science

Policy or knowledge synthesis relevance:

Might help when doing the knowledge synthesis to answer a request to have access to a list of the most recent and pertinent research papers in the field. Connecting research papers to the BDS 2030 targets can provide the EC staff with a clearer understanding of significant research related to these targets. However, it is important to recognize

that comprehending a research paper is not always straightforward, especially since the intended audience is mainly other researchers.

20. Research synthesis

Description:

Systematic reviews and meta-analyses which present results by combining and analysing data from different studies conducted on similar research topics. Meta-analyses either (1) assess the evidence for the effectiveness of specific interventions for a particular problem or hypothesized causal associations for a condition, or (2) reach broad generalizations across larger numbers of study outcomes (dozens to hundreds) to provide a more comprehensive picture than can be attained from an individual primary study. (Meta-analysis and the science of research synthesis | Nature).

Synonyms: Research meta-analysis, research papers synthesis

Examples:

The positive impact of conservation action | Science

Synthesis reveals approximately balanced biotic differentiation and homogenization | Science Advances

Policy or knowledge synthesis relevance:

Both meta-analysis and meta-synthesis contribute to evidence-based policy-making by synthesizing research findings, identifying gaps, and informing decision-makers. They enhance the rigor of existing approaches and promote informed choices based on scientific evidence. Leveraging Research Synthesis Methods to Support Evidence-Based Policy- and Decision-Making | Prevention Science (springer.com) Meta-analysis provides a more powerful and less biased means for clarifying, quantifying and disproving (or confirming) assumed wisdom than do conventional approaches, including narrative reviews and flawed quantitative methods such as 'vote counts'. Meta-analytic methods have resolved apparently inconclusive data to arrive at a clearer picture, often more rapidly than other approaches. (Synthesizing evidence: shifting the focus from individual studies to the body of evidence - PubMed (nih.gov) , Meta-analysis and the science of research synthesis | Nature)

21. Scenarios

Description:

Representations of different possible futures from a defined starting point, aimed to explore consequences of drivers of change over a specified time frame. They enable decision-makers to anticipate potential changes and develop timely responses. (IPBES glossary, scenarios)

Examples:

Scenarios often consist of (a set of) qualitative descriptions, or narratives, of the future, as well as quantitative outcomes, or projections, that result from each of the narratives. A common scenario is the baseline, or reference scenario, which is built to contrast with other alternative scenarios.

The Special Report on Emission Scenarios includes four major scenario families: A1, A2, B1, and B2. They describe divergent futures covering key characteristics such as demographic change, economic development, and technological change.

A1: The A1 scenarios describe global tendencies toward economic development. Within each series, the 1-series scenarios depict a more globalized world.

A2: The A2 scenarios depict a less globalized and more heterogenous world. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

B1: The B1 scenarios describe a convergent world, with rapid changes toward a service and information economy, with the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives

B2: The B2 scenarios describe a world focused on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines.

The EU Horizon 2020 project BioMonitor developed a set of five scenarios to explore the future of the EU Bioeconomy: a baseline scenario (BioMonitor Reference Scenario - BRS), and four alternative scenarios – 'Go-it-Alone', 'Hand-in-hand', 'Bio-Eco Resilience', and 'Drill baby drill'.

BioMonitor Reference Scenario (BRS): assumes a continuation of current policies, regulations and market trends on the future situation of the bioeconomy production, usage and trade until 2030 with projections to 2050. It serves as reference for measuring the impacts of alternative scenarios for bioeconomy futures.

'Go-it-Alone': assumes that the EU pursues its vision of the sustainable bioeconomy to boost the efficient use of resources by moving to a clean, circular economy and to safeguard biodiversity and cut pollution, without waiting for international commitments.

'Hand-in-hand': assumes that the EU is not acting alone, and instead many of the initiatives in the 'Go-it-alone' scenario are implemented globally.

'Bio-Eco Resilience': assumes that all key nations participate in seeking to achieve the 'two degree' target from the Paris Agreement through major reforms of the energy markets and relevant climate policies, thus affording opportunities to the bioeconomy.

'Drill baby drill': assumes the opposite to the 'Bio-Eco Resilience' scenario, with a fossil-centric world order, where all types of public policy support mechanisms of the bioeconomy development inherent within the BRS are removed.

Policy or knowledge synthesis relevance:

Reinforce the familiarity of policy makers, EC staff and other stakeholders to scenarios, which are powerful tools to understand the forthcoming challenges and the pathways that can help tackling them. It can also enable the research community to identify relevant tools, gaps and develop suitable ones for advancing specific biodiversity goals.

22. Spatial planning tools

Description:

Spatial planning is mostly recognized as a public sector function with the purpose of influencing future spatial distribution of activities. The aim is to create a more rational territorial organization of land use and the linkages between them, to balance demands for development with the need to protect the environment, and to achieve social and economic objectives (Wegener, 1998).

Spatial planning is an important tool to drive proactive, preventive adaptation of human settlements to the hazards caused or exacerbated by changes in climate patterns and extreme events (ADB, 2016; UN-HABITAT, 2014).

Spatial planning can be defined as the coordination of practices and policies affecting spatial organisation.

An activity concerned with reconciling competing land uses while protecting natural processes and significant cultural and natural resources. (IPBES glossary).

Examples:

Information element: "Barrier assessment tool to prioritise barrier removal"

Description of the IE: pg.26 "In the Flussfrei project, a barrier assessment tool to help prioritise barriers was developed. All barriers were taken into account and were first filtered according to catchment size, bed width and ecomorphology. A secondary filter was applied to selected barriers, depending on the length of reconnected river stretches. Selection of the barriers took into account the potential implications of a removal and the costs associated with the removal. Results were collected in two groups: barriers with high potential and low costs ('low hanging fruit') and barriers selected and highlighted by experts. Removal of the latter would ensure higher ecological potential, but might be complex and demanding in terms of technical feasibility and financial input."

Information element: "Prioritisation of barrier removal"

Description of the IE: pg. 22 "The prioritisation of barriers is based on ecological criteria, with the focus being on the distribution of particularly endangered fish species (medium-distance migratory fish), followed by the willingness of the local community and the situation of ownership. Furthermore, the ecological effect of the measure depending on the length to be restored, continuity stretch of water and the accessibility of suitable habitats upstream in tributaries are considered. "

Information element: "Habitat gains that can be achieved by dismantling transverse constructions"

Description of the IE: "pg.26: Another strategic approach adopted by the federal state of North-Rhine Westphalia in Germany uses GIS to determine the habitat gains that can be achieved by dismantling transverse constructions. The consortium of experts defined attributes for prioritisation based on type of barrier, backwater length, ecological status, target species, etc. Andreas Müller (chromgruen) explained that prioritisation was based on three main river basins and 26 sub-basins using a priority index calculation. Results were presented as fact sheets for each migration barrier and are used by local authorities to help in decision-making processes"

Another example:

Transport and Mobility Planning Models: help design efficient transportation networks by forecasting traffic patterns, public transit needs, and mobility trends. Integrating transport and spatial planning can optimize urban layouts and reduce congestion.

Policy or knowledge synthesis relevance:
Can help policymakers coordinate economic, environmental, and social objectives across MS.

23. Variables and Essential Variables

Description:

Parameters used to measure changes in biodiversity, ecosystem health, environment, etc. Variables represent specific aspects or environmental attributes that can be measured or quantified. This encompasses Essential

Variables that are standardized, measurable, and representative parameters that help scientists and policymakers to track and understand changes in biodiversity, ecosystems and climate and inform conservation and management efforts. (IPBES glossary, essential biodiversity variables)

Difference between variables and indicators: biodiversity indicators are derived from biodiversity variables and serve as summary metrics or indices. They condense complex biodiversity information into a more manageable form, allowing us to track changes over time or across different regions. Thus, unless they are used to build composite indicators (e.g. Human Footprint Index), some variables are directly used as indicators.

Examples:

Primary productivity (Essential Biodiversity Variable - EBV)

Ecosystem Vertical Profile (EBV)

Species Phenology (EBV)

Zooplankton biomass and diversity (Essential Ocean Variable - EOV)

Fish abundance and distribution (EOV)

Macroalgal canopy cover and composition (EOV)

Policy or knowledge synthesis relevance:

Variables and essential variables (EVs) provide critical information for assessing policy effectiveness, inform strategic policy planning by identifying priority areas for conservation and management and guide the implementation of policies related to biodiversity conservation and sustainable development goals. Essential variables can be used across scales, from local to global, and are essential for understanding and managing biodiversity. Thus, they appear in different reports: the Global Biodiversity Framework, Systems of Environmental Economic Accounting, Sustainable Development Goals, and the IPBES. A myriad of EVs were developed: the Essential Climate Variables (ECVs), the Essential Water Variables (EWVs), the Essential Ecosystem Services Variables (EESV), the Essential Land Cover Variables (CLC), etc.

Keeping track of all existing EVs and other relevant variables with information on their spatial and temporal coverage can help identifying gaps and associated data limitations. It could foster the reinforcement of some monitoring programs.

Potential overlaps with other typologies: Indicators (see 3. Typologies overlap)

B. Policy instruments

As many policy instruments for Biodiversity exist (IPBES 2018), we classified them into eight categories (Table A1):

1. Compensation payment and offsets,
2. Funds,
3. Legal and regulatory instruments,
4. Right based and customary norms,
5. Social and information-based instruments,
6. Subsidies and incentives,
7. Taxes and charges, and
8. Tradable permits.

24. Compensation payments and offsets

Offsets: Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant adverse biodiversity impacts arising from project development. These offsets aim to ensure at least no net loss of biodiversity and, where possible, a net gain. They are used predominantly by planning authorities and developers to compensate for biodiversity impacts associated with economic development through the planning process. (World Bank Document). However, the efficacy of offsetting has been highly criticized and needs to be improved Carbon offsets aren't helping the planet — four ways to fix them (nature.com) The meaning of net zero and how to get it right | Nature Climate Change .

25. Funds

Government funding and investment aimed at generating innovative approaches to solutions and/or the physical and social infrastructure to reduce biodiversity loss and environmental pressures.

Examples:
"EU funding for Green infrastructure",
"The European Maritime and Fisheries Fund (EMFF)"
"NextGenerationEU - European Union (europa.eu)"

26. Legal and regulatory instruments

Described in the IPBES regional report (2018), this category refers to "direct regulation" as environmental and technical standards as well as spatial planning. These instruments contribute to establishing, adjust, and implement standards aimed at preserving biodiversity and the contributions of nature to human well-being. Additionally, they facilitate the creation of protected areas to conserve ecological and societal benefits. They also can be applied to specify the technology standard or minimum requirements for pollution output (performance standard) that are necessary for reducing emissions (Gupta et al. 2007).

We present below five policy instruments that fall into this category: environmental quality objectives, impact regulations, legislation, standards and threshold values.

Environmental quality objectives: The European Union (EU) has set forth a comprehensive framework of environmental targets and objectives to guide its transition toward a 'green economy'. These objectives span the period from 2010 to 2050 and are crucial for promoting sustainable practices and safeguarding our environment. Here are some examples of the EU's environmental objectives:

1) Climate Change Mitigation (CCM): Focusing on reducing greenhouse gas emissions and combating climate change.
2) Climate Change Adaptation (CCA): Addressing the impacts of climate change and enhancing resilience.
3) Sustainable Use and Protection of Water and Marine Resources (WTR): Ensuring responsible water management and safeguarding marine ecosystems.
4) Transition to Circular Economy (CE): Promoting resource efficiency and minimizing waste.

5) Pollution Prevention and Control (PPC): Implementing measures to reduce pollution and protect human health.
6) Protection and Restoration of Biodiversity and Ecosystems (BIO): Preserving natural habitats, biodiversity, and ecosystem services.

Impact regulations: Evaluations assess the performance of an EU action. Impact assessments examine whether there is a need for an EU action and analyse the possible impacts of available solutions. (EC, DG HOME)

Legislation: Environmental legislation in the European Union (EU) is designed to protect the environment, human health, and to ensure the rational use of natural resources. It is based on several key principles:

Precaution: taking action to prevent environmental harm when there is scientific uncertainty.

Prevention: aiming to prevent environmental damage before it occurs.

Rectifying pollution at source: addressing environmental issues at their origin rather than dealing with the consequences.

Polluter pays, ensuring that those who cause environmental damage are responsible for covering the costs associated with it.

The EU's environmental policy addresses complex issues such as climate change, biodiversity loss, resource depletion, and pollution. It has evolved significantly since its inception, with major developments including the EU Climate Law, which sets a legally binding target of net-zero greenhouse gas emissions by 2050.
(https://www.europarl.europa.eu/factsheets/en/sheet/71/environment-policy-general-principles-and-basic-framework, Environment and green economy – EU action | European Union https://european-union.europa.eu/priorities-and-actions/actions-topic/environment_en, EU legislation on nature - European Environment Agency https://www.eea.europa.eu/signals-archived/signals-2021/articles/at-a-glance-eu-legislation, European Climate Law - European Commission - Climate Action https://climate.ec.europa.eu/eu-action/european-climate-law_en)

Standards: The primary objective of standardisation is the definition of voluntary technical or quality specifications with which current or future products, production processes or services may comply. Standardisation can cover various issues, such as standardisation of different grades or sizes of a particular product or technical specifications in product or services markets where compatibility and interoperability with other products or systems are essential. (Regulation (EU) No 1025/2012, 2023)

Threshold values: Quota on fishery, EU threshold values related to anthropogenic continuous noise in water (ref, Setting EU threshold values for continuous underwater sound - Publications Office of the EU (europa.eu)), etc.

27. Right based and customary norms

International and national human rights instruments: Synergizing rights and norms for the conservation and protection of systems of Mother Earth can foster complementarity with human well-being. International and national human rights instruments whether binding or non-binding can be creatively interpreted to fit socio-ecological systems and foster resilience. Strengthening of collective rights, customary norms and institutions of indigenous peoples and local communities, can promote adaptive governance including the equitable and fair management of natural resources. (IPBES 2018)

Example: European court of human right

Customary norms and institution of indigenous people and local communities: Indigenous and customary land tenure refers to the customs, norms, and associated practices developed or adopted by indigenous peoples or local communities. These regulate their activities and are considered binding. Customary norms and institutions of

indigenous people and local communities play a crucial role in shaping land tenure and resource management across diverse landscapes: Pasture right. (Indigenous customary law and community protocols – ICCA Consortium Meanings and Resources).

28. Social and information-based instruments

Required public disclosure of environmentally related information, generally by industry to consumers. These include labelling programs, rating and certification systems.

Certification and Ecolabelling: products and services that comply specific environmental and social criteria. Eco-labels guide consumer's purchasing decisions by providing information about the 'world' behind the product. For businesses, eco-labels are a means of measuring performance, communicating and marketing the environmental credentials of a given product. These tools encourage the behavioural change of producers and consumers towards long-term sustainability. (Eco-labelling | UNEP - UN Environment Programme)

Counselling

Education and Training: Education initiatives/capacity building can be promoted by e.g. companies through information-based instruments. It can include the training of harvesting operators, field workers, contractors and other employees to improve practices related to the sustainability of forestry operations, biodiversity, water and cultural values. (Frontiers | Private Governance of Biodiversity and Ecosystem Services: Findings From Nordic Forest Companies (frontiersin.org))

Voluntary Agreements: usually refers to an agreement between the European social partners that is largely the outcome of negotiations between representative social partner organisations rather than being the result of a political decision-making process conducted exclusively within the framework of the official EU institutions (the European Commission, Council of the European Union and European Parliament).
Since the 1990s, the EU has been developing a new regulatory policy, with an increasing emphasis on the use of alternative instruments that are complementary to traditional legislation. These instruments, which are of a less compelling or non-governmental nature, are often referred to as 'soft law', 'self-regulation' or 'co-regulation'. Voluntary agreements are a typical result of these alternative forms of multi-level governance. The aim of diversifying regulatory instruments is mainly to enhance the effectiveness, legitimacy and transparency of EU action and to follow the principles of conferred powers, subsidiarity and proportionality in the EU legislative process. (Voluntary agreement, europa.eu)

29. Subsidies and Incentives

Direct payments, tax reductions, price support or the equivalent, thereof from a government to an entity for implementing a practice or performing a specified action.

Ecological fiscal transfers (ETF): Ecological fiscal transfers (EFT) transfer public revenue between governments within a country, based on ecological indicators. EFT can compensate subnational governments for the costs of conserving ecosystems and in principle can incentivize greater ecological conservation by providing financial rewards based on ecological indicators. (Busch et al. 2021)

Emissions cap and allowances: The overall volume of greenhouse gases that can be emitted by power plants, industry factories and aviation sector covered by the EU Emissions Trading System (EU ETS) is limited by a 'cap' expressed in number of emission allowances, where one allowance gives the right to emit one tonne of CO2eq

(carbon dioxide equivalent, CO2 or other greenhouse gases). Within the cap, companies receive or buy emission allowances, which they can trade as needed. The cap decreases every year, ensuring that total emissions fall. Since the beginning of phase 3 of the EU ETS (2013-2020), the cap on emissions is set for the EU as a whole. (Emissions cap and allowances - European Commission (europa.eu))

Payment for Ecosystem Services (PES) schemes: Refers to a voluntary transaction between a service buyer (e.g. businesses) and a service seller (e.g. landowners) of ecosystem services. PES schemes typically pay for the amount of ecosystem service that is delivered, but "PES-like" schemes are also common, for example agri-environment programmes that pay farmers on the expected outcomes of their land management practices. (Le et al. 2024)

Subsidies: Environmental subsidies are payments by the government to corporations and households for environmental purposes, as defined in the system of environmental-economic accounting (SEEA). An example of an environmental subsidy is a government payment to promote the installation of solar panels on the roofs of buildings. (Environmental taxes and subsidies - Eurostat (europa.eu))

30. Taxes and Charges

Environmental taxes, charges or fees add extra costs to the use of products or services that reflect the environmental harm they cause.

Taxes, charges and fees: Environmental taxes, charges or fees add extra costs to the use of products or services that reflect the environmental harm they cause. Examples include taxes on carbon emissions, waste disposal fees, and charges for using natural resources. Environmental or green taxes include taxes on energy, transport, pollution and resources. The tax base can be a physical unit, for example litres of gasoline, or a proxy of a physical unit, for example taxes on nuclear power stations. The tax is always a monetary amount, such as euros. (Taxes, charges and fees - European Commission (europa.eu) , Green Taxation - European Commission (europa.eu), Environmental taxes and subsidies - Eurostat (europa.eu) , dfff60be-3c31-4fcb-93a6-fa6e2ea5f219_en (europa.eu))

31. Tradable Permits

Trade permit schemes set a cap or quota for pollution in a given area, and only allow actors in that area to pollute according to the quantity of permits they hold.

EU Emission Trading System (ETS): The EU ETS works on the 'cap and trade' principle. A cap is a limit set on the total amount of greenhouse gases that can be emitted by the installations and aircraft operators covered by the system. The cap is reduced annually in line with the EU's climate target, ensuring that emissions decrease overtime. Launched in 2005, the EU ETS operates in trading phases. The system is now in its fourth trading phase (2021-2030). Its legislative framework is spelled out in the ETS Directive. Over the years, it has undergone several revisions aligning the system with the overarching EU climate targets, helping bring down emissions from power and industry plants by 37%. (What is the EU ETS? - European Commission (europa.eu)).

Table A1. Comparison between IPBES, IPCC and the categories of policy instruments described in this document.

IPBES categories (IPBES 2018:672)	IPCC categories	Information type categories
Economic and financial instruments: price- or quantity-based mechanisms intended to change the behavior of public and private investors	**Research and Development (R&D):** Activities that involve direct government funding and investment aimed at generating innovative approaches to mitigation and/or the physical and social infrastructure to reduce emissions. Examples of these are prizes and incentives for technological advances. **Subsidies and Incentives**: Direct payments, tax reductions, price supports or the equivalent thereof from a government to an entity for implementing a practice or performing a specified action. **Taxes and Charges:** A levy imposed on each unit of undesirable activity by a source. **Tradable Permits**: These are also known as marketable permits or cap-and-trade systems. This instrument establishes a limit on aggregate emissions by specified sources, requires each source to hold permits equal to its actual emissions and allows permits to be traded among sources.	**Compensation payment and offsets** **Funds** (encompasses "Research and Development (R&D)" from IPCC) **Subsidies and Incentives** **Taxes and charges** **Tradable permits**
Legal and regulatory instruments: "command and control" measures usually applied to deal with environmental degradation	**Regulations and Standards**: These specify the abatement technologies (technology standard) or minimum requirements for pollution output (performance standard) that are necessary for reducing emissions.	**Legal and regulatory instruments**
Rights-based and customary norms instruments: measures that integrate indigenous and local community rights, norms, standards, and principles into policy, planning, and implementation	-	**Right based and customary norms**

Social and information-based instruments: information-, education-, and certification-based mechanisms that highlight the relevance of socio-cultural dynamics to environmental conservation	**Information Instruments:** Required public disclosure of environmentally related information, generally by industry to consumers. These include labelling programmes and rating and certification systems. **Voluntary Agreements**: An agreement between a government authority and one or more private parties with the aim of achieving environmental objectives or improving environmental performance beyond compliance to regulated obligations. Not all VAs are truly voluntary; some include rewards and/or penalties associated with participating in the agreement or achieving the commitments.	**Social and information-based instruments**

4. Typologies overlap

We identified 31 information types, some of which might overlap.

<u>As overlaps, we identified:</u>

Data and platforms vs **polls:** polls can be stored on a data platforms and are generating data.

Knowledge gaps vs **all other information types:** gap in reports, in scenarios, indicators, etc.

Overlapping gaps with other information types inform in which category the gap lies. For instance, we can easily see if there is a knowledge gap in “scenarios” from the freshwater keyword.

Recommendations are often **associated with a knowledge or capacity gap**, as it highlights future needs to fill those gaps. It can also be associated with **management practices** or **spatial planning tools**.

Reports vs **Policy Documents**

Examples: "CAP impacts on biodiversity: Evaluation of the impacts of the CAP on biodiversity, soil and water (natural resources) (SWD/2021/424 final). ", "Commission Report on the State of Nature in the EU 2020".

Those are reports written by the EC. Therefore, they fit our “policy document” class as well.

Reports vs **Frameworks**

Some Frameworks might be done under a report taxonomy. However, be careful that some reports are called "Framework", without providing clear guidance or methodology to achieve a specific objective.

Initiative vs **Data platforms**, **Networks**, **Projects**

Data platforms can result from an initiative, being it´s final product, and therefore could fit both typologies if they exist under a similar name. Networks can also be the product of an initiative to set it up, as well as projects. Full EU funded projects are not initiatives as they have a specific timeframe tailored for the EC needs, but it can happen that the EU funded projects become an initiative when their timeline is over.

Management practices - sustainable vs **Policy instruments**: several policy instruments can be used as sustainable management practices such as "information instruments": ecolabelling, eco-design, etc.

Variables and Essential Variables vs **Indicators:** those typologies can overlap, as it can happen that a variable can also serve as an indicator.

5. Hierarchy of information types

Some information types are embedded into each other (Table A2). For instance, "Polls" are a type of data, and thus, are part of the "Data and Platforms" information type. Similarly, "Data and Platforms" can be the result of "Initiatives" such as a monitoring activity. Therefore, as a rule, whenever an information element matches with a Type 2, this is the type that comes in priority to fill the "*knowledge database*" table. For instance, the result of the survey on the **Attitudes of Europeans towards the environment** should be categorized into "Polls", not "Data and Platforms".

Table A2. Hierarchy of information types

Type 1	Type 2
Data and Platforms	
	Polls
Drivers of change	
European citizens' initiative	
Indicators	
Initiatives	
	Data and Platforms (some of them)
	Networks
	Projects
Innovations	
Policy documents	
Policy instruments	
Policy briefs	
Recommendation	
	Gap – Implementation or Capacity
	Gap – Knowledge
	Management practices
	Spatial planning tool
Reports	
	Frameworks
Public consultation	

Research papers	
	Research synthesis
Scenarios	
Spatial planning tools	
Variables	
	Indicators (some of them)

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[1] Eklipse shared with us the insights gathered during their knowledge scoping phase of the EC deep request on the cumulative impact of offshore wind farms on biodiversity - no new information types were identified.

[2] Act, Administrative and budgetary matters, Agenda of Commission meeting, Amended proposal for a decision, Amended proposal for a regulation, Annex, Authentication note, Cabinets: competence distribution, Communication, Communication of the Commission on Council's position at 1st reading, Corrigendum, Day note of delegation procedures, Day note of empowerment procedures, Day note of written procedures, Decision, Delegated decision, Delegated directive, Delegated regulation, Directive, Document related to administrative/budgetary matter, Document related to a meeting with the constitutional bodies of European/third country governments, Document related to infringements control, Document related to the cabinets competence distribution, Draft decision, Evaluation, Executive summary of the evaluation, Executive summary of the fitness check, Fitness check, Green Paper, Impact assessment, Implementation plan, Implementing decision, Implementing directive, Implementing regulation, Incoming presidency, Infringements control, Joint communication, Joint impact assessment, Joint impact assessment summary, Joint proposal for a regulation, Joint report, Joint staff working document, Joint synopsis report of the public consultation, Joint text, List of administrative and budgetary matters, List of significant written procedures, List of the Members of the Commission on duty, Meetings with constitutional bodies of European/third country governement, Members of the Commission on duty, Minutes from a meeting with incoming presidency, Minutes of Commission meeting, Minutes of the Directors-General meeting, Non paper/supporting document, Note, Note of the Secretary-General, Opinion, Opinion on evaluation, Opinion on impact assessment, Proposal for a decision, Proposal for a directive, Proposal for an act, Proposal for an implementing decision, Proposal for an implementing regulation, Proposal for an opinion, Proposal for a recommendation, Proposal for a regulation, Provisional data, Recommendation, Recommendation for a decision, Recommendation for a recommendation, Regulation, Reply to national Parliaments' opinion, Report, Sensitive written procedures, Staff working document, State aid control, Summary of impact assessment, Synopsis report of the public consultation, Tentative agenda for forthcoming Commission meeting, Timetable of Commission meetings, Uncategorised, Viewpoint, White Paper.

[3] "A" item note, "I" item note, Accession documents, Conclusions, Contribution to the legal service, Cover note, Draft conclusions, Draft minutes, Draft statements of the Council's reasons, Draft summary conclusions, Information note, Legal acts, Legislative acts and other instruments, List of "A" items, Note, Notice of meeting and provisional agenda, Opinion of the legal service, Outcome of proceeding, Outcome of the council meeting, Press release, Proposal, Provisional agenda. Provisional list of "A" items, Reply to parliamentary question, Reply to parliamentary questions, Report, Statement of the council´s reason.

8.2. Annex 2- Guidance to collect actionable information and associated metadata to inform the BDS 2030

To link information elements (IEs) to information types and keywords, we assembled them in a table. We added other entries that serve different purposes as mentioned in Table A1.

This protocol should be further tested and may be subject to change.

Table A1. Table and data entries, with the purpose of each column entry and guidance to fill them. Column with an asterisk are the ones that are mandatory.

Information Element (IE) *	
Purpose	**Guidance to fill this column**
Collect potential actionable knowledge, to be used by experts or policy makers.	Naming the Information Element: as commonly used in policy documents or as being referred at the highest possible reference level (see reference entries). Before naming a IE, be sure it doesn´t already exist in the database, even under a slightly different name. While filling this column, please avoid putting acronyms (e.g. IAS for Invasive Alien Species). Acronyms allowed: - EU for European Union
Keywords *	
Purpose	**Guidance to fill this column**
To sort Information Element by topic. Useful for the "answering request function" or to identify knowledge gaps.	Keywords are organised by main keywords in capital letters, and sub-keywords which are more targeted in minuscule (see ANNEX 5). At least one main keyword should be identified by IE. If a IE fits with a sub-keyword, both main keyword and sub-keyword should be selected. If a IE is very general, several main keywords can be selected (e.g. “Nature Restauration Law”).
Spatial scope	
Purpose	**Guidance to fill this column**
Help identifying bottlenecks. For instance, if the IE is limited to certain member states but is necessary at the European level, it can pose a challenge: work	Four categories are provided to scale the IE, from high to low level: global, EU, member states and regional. The highest scaling level should be provided, as well as

will be needed to extend it. Conversely, if the IE is accessible only at the EU scale and cannot be downscaled, it may limit its utility.	the lowest level. For instance, the "total Allowable Catch (TAC) quotas" IE is accessible at the Regional, Member states, and EU levels. This implies that the data cover the entire EU area (highest level) but is also available per region (the lowest level) and individual countries. Consequently, if we seek information on the TAC in the Mediterranean Sea (regional level), these data are accessible. **Global:** knowledge that covers the planet (e.g. global assessment, satellite data, etc.) **EU**: covers EU 27, EU 28 and EU 28+ (EU 28 plus a couple of more countries) **Member states**: knowledge available in one of the few member states of the EU. **Regional:** knowledge produced within an EU region. It can be within a state or across states (e.g. the Mediterranean basin)
Temporal scope - Starting date	
Purpose Help identifying bottlenecks. In the case of outdated IE, or short time series that would need to be extended.	**Guidance to fill this column** In the case of a time series, the starting date should be reported here, like "2017". In the case of one date, it should be reported here. When reviewing a document, **what matters is the temporal scope covered by the content of the document**, not the publication date of the document. In the case there is no specific temporal scope mentioned, the publication date can be reported.
Temporal scope – Ending date	
Purpose Help identifying bottlenecks. In the case of outdated IE, or short time series that would need to be extended.	**Guidance to fill this column** In the case of a time series, the ending date should be reported here, like "2023". In the case of one date (one time event), "none" should be written here. The date will be reported in "starting date".

	If the work is not finished, “on-going” should be reported here. When reviewing a document, **what matters is the temporal scope covered by the content of the document**, not the publication date of the document
Update frequency	
Purpose	**Guidance to fill this column**
Help identifying bottlenecks, in the case that the time serie would not be updated often enough, or not regularly enough (e.g. to match with other data)	A few options are available here. **1 year**: yearly updated data or within a year **> 1 year**: data updated after a year (but before 5 years) **>= 5 years**: data updated every 5 years or more **“None”** means that no update has been done until now, but it might be updated in the future". **"Unknown"** means that current updated information was not found, but it might exist" (e.g. unavailable data).
Reference (the highest level, e.g. connected with data) *	
Purpose	**Guidance to fill this column**
To find back the data at the origin of the IE, or other document directly linked to it.	Write the reference of the document or DOI for the database. As online pages can change, the idea here is to avoid providing a website, that can be reported in the “reference (website)” entry below to facilitate its retrieval. Or state when the knowledge comes from an interview (available from a document): observations from Managers, Local communities, Indigenous communities. This column should never be empty.
Reference (website)	
Purpose	**Guidance to fill this column**
To facilitate finding data back.	Associated website linked to the highest reference level, when possible.
Reference additional information	

Purpose	Guidance to fill this column
Provides reference(s) that guide reviewers up to the highest reference level (as mentioned in the previous entry). The reference(s) entered here come from the reviewed document and may refer to another document, which could be at the highest level or not.	Write the reference of the document with the DOI when applicable, with an associated website link when possible.
Main outputs *	
Purpose	**Guidance to fill this column**
Inform on the way the KEs are displayed. This can be reused in reports or to answer urgent requests. For instance, some of the output like graphics or tables can be updated with new information.	Four categories were identified: document (report, policy document, etc.), graphic, table, descriptive text. An IE should be associated to one or several of those categories. For instance, if the IE is "EU ecosystem assessment" with the associated reference, this is a "document".
Type of IE *	
Purpose	**Guidance to fill this column**
Link IE to a typology. This categorization can help to easily access certain type of information (e.g. make a search by indicator).	29 IEs´ typologies were identified (see ANNEX 1). Each IE is associated to one information type. As an example, in the event where a **knowledge gap** was the main output in the previous column entry, it has been mentioned in the BDS 2020 review document that data available on "jobs provided by biodiversity and ecosystem services" do not allow for an analysis of the job creation and socio-economic impacts of the implementation of Target 2. Therefore, a report analysis should be done on the topic. The IE typology is then "Report", as well as "Recommendation" to signal that it is recommended a report should be done.
If the IE is a gap, has this gap been fulfilled?	
Purpose	**Guidance to fill this column**
To fill only when the main output has been a gap. This column ensures this gap is still to be solved.	Binary category, "Yes" or "No".
If the gap has been fulfilled, please provide a justification with a year	
Purpose	**Guidance to fill this column**
To keep track of what has been stated in the previous column entry.	To be filled only if the previous column entry had a "Yes" answer.

	Copy-paste a **piece of text with the reference that proves that this gap has been fulfilled.**
2030 Contribution (stated or potential) *	
Purpose	**Guidance to fill this column**
Add information regarding the link between the IE and its contribution.	If the contribution is "stated", that means the IE has been directly linked to Targets or Actions of one of the strategies (the link between both has been mentioned in a document). If the contribution is "potential", it means that reviewers assume that there is a link.
BDS 2030 Pillars *	
Purpose	**Guidance to fill this column**
Can be used to associate knowledge to the different pillars and potentially identify gaps.	Select the Pillar to which the IE has been associated with or could potentially be associated with (see previous column entry).
BDS 2030 Actions *	
Purpose	**Guidance to fill this column**
Can be used for to associate knowledge to the different actions and potentially identify gaps.	Select the Action to which the IE has been associated with or could potentially be associated with (see previous column entry).
Additional EU policies (potential)	
Purpose	**Guidance to fill this column**
Link the IE to other relevant policies where it could be of relevant contribution.	Select the EU policies that the IE could potentially be associated with.
Description of AKE *	
Purpose	**Guidance to fill this column**
Add the context of use of the IE or other information	Copy and paste part of the text where the IE was mentioned, or a few lines from the summary of a document.

8.3. Annex 3 – Google sheets and associated google forms

a. Freshwater Table: D3.1 Freshwater DC actionable information elements table

b. Freshwater Google form (linked to ANNEX 3.a.)

DESCRIPTION OF THE KNOWLEDGE ELEMENT

Description (facultative)

Knowledge element *

Réponse courte

Keywords

- [ ] SOIL
- [ ] Soil composition (organic matter)
- [ ] Soil status
- [ ] Soil fertility
- [ ] Soil erosion
- [ ] Soil pollution
- [ ] Soil restoration
- [ ] AIR
- [ ] Air quality / pollution
- [ ] FOREST
- [ ] Biodiversity-friendly afforestation
- [ ] Forest fires
- [ ] Forest pests/diseases emergence
- [ ] Forest management
- [ ] Illegal logging
- [ ] Reforestation
- [ ] AGROECOSYSTEMS
- [ ] Food security
- [ ] Pollination
- [ ] Farmland birds and insects
- [ ] Pesticide use (impact of)
- [ ] Genetic diversity of crops
- [ ] Sustainable agriculture
- [ ] Sustainable Common Agricultural Policy (CAP)
- [ ] Pollution (nitrogen, phosphorus, pesticides, etc.)
- [ ] Agriculture pests/diseases emergence
- [ ] FRESHWATER
- [ ] Restoration of freshwater connectivity (free-flowing)
- [ ] Restoration of floodplains and wetlands

- [ ] Freshwater status / quality (incl. nutrient pollution)
- [ ] Groundwater status / quality (incl. nutrient pollution)
- [ ] Flood protection (in all areas)
- [ ] Nursery habitat for fish
- [ ] MARINE ECOSYSTEMS
- [ ] Restoration of marine carbon-rich ecosystems (mangroves, tidal marshe
- [ ] Restoration of important fish spawning and nursery area
- [ ] Fish stock regulation
- [ ] Fishing gear/techniques impact
- [ ] Seafloor integrity / status
- [ ] Underwater noise
- [ ] URBAN AREAS
- [ ] Air, water and noise pollution in urban areas
- [ ] INVASIVE ALIEN SPECIES REGULATION
- [ ] Manage established invasive alien species
- [ ] CLIMATE CHANGE MITIGATION
- [ ] Carbon sequestration
- [ ] Renewable energy
- [ ] CLIMATE CHANGE IMPACT
- [ ] Droughts occurrence
- [ ] HABITAT AND BIODIVERSITY PROTECTION
- [ ] Protected areas network
- [ ] Carbon-rich ecosystems protection (peatlands, grasslands, wetlands, mangrove
- [ ] Carbon-rich ecosystems restoration
- [ ] Ecological corridors
- [ ] Genetic diversity
- [ ] Physical and mental wellbeing in urban areas
- [ ] Flooding protection in urban areas
- [ ] Drought and heat waves protection in urban areas
- [ ] Green infrastructures
- [ ] Nature-based solutions
- [ ] Green space management in urban area (incl. pesticide use)
- [ ] Connectivity between green space in urban area
- [ ] POLLUTION
- [ ] Plastic pollution
- [ ] INVASIVE ALIEN SPECIES IMPACT
- [ ] Introduction of alien species
- [ ] Establishment of alien species
- [ ] Species threatened by alien species
- [ ] Species migration
- [ ] ENABLING TRANSFORMATIVE CHANGE
- [ ] Enforcement of EU environmental legislation
- [ ] Business for biodiversity initiatives
- [ ] Measures to incentivize and eliminate barriers for the take-up of nature-based s
- [ ] Circular-economy
- [ ] Economic activities that substantially contribute to protecting and restoring bic
- [ ] Measuring the environmental footprint of products
- [ ] Measuring the environmental footprint of organizations
- [ ] Filling knowledge gaps
- [ ] Bridge between science, policy and practice
- [ ] Guidance for schools and teachers on how to cooperate and exchange experien
- [ ] Global biodiversity agenda

- [ ] EU support to governments and stakeholders across the globe
- [ ] Illegal wildlife trade
- [ ] Environmental crime
- [ ] Financial flows to developing countries for biodiversity
- [ ] ORGANIC PRODUCTS CONSUMPTION
- [ ] promotion campaign
- [ ] marketing rules for traditional crop varieties
- [ ] market access for traditional and locally adapted varieties
- [ ] MOUNTAIN ECOSYSTEMS
- [ ] ECOSYSTEM SERVICES
- [ ] Natural capital accounting
- [ ] ECOLOGICAL FOOTPRINT IMPACT
- [ ] Trade impact on biodiversity
- [ ] DESERT ECOSYSTEMS
- [ ] GRASSLAND ECOSYSTEMS
- [ ] URBAN ECOSYSTEMS
- [ ] ECOSYSTEMS RESTORATION
- [ ] LAND USE CHANGE
- [ ] NATURAL RESSOURCES AND EXPLOITATION
- [ ] SUSTAINABLE CONSUMPTION
- [ ] SUSTAINABLE FINANCE
- [ ] RECYCLING
- [ ] EDUCATION
- [ ] COMMUNICATION
- [ ] SUSTAINABLE ECONOMIC SYSTEM

Spatial scope

- [ ] Worldwide
- [ ] EU
- [ ] Member states
- [ ] Regional

Temporal scope (e.g. 2013-2018)

Réponse courte

Update frequency

1. 1 year
2. >1 year
3. >=5 years
4. Unknown
5. None

Reference (the highest level, e.g. connected with data)

Réponse longue

Reference (website)

Réponse longue

Reference additional information

Réponse longue

CLASSIFICATION OF THE KNOWLEDGE ELEMENT

Description (facultative)

Main outputs

- [ ] document
- [ ] graphic
- [ ] table
- [ ] other (descriptive text, etc.)
- [ ] gap

Type of KE *

1. Data Platform
2. Framework
3. Fund
4. Indicator
5. Initiative
6. Innovation
7. Recommendation
8. Management practices
9. Network
10. Policy document
11. Project
12. Quota
13. Report
14. Scenario
15. Spatial planning

16. Variable
17. Regulations and Standards
18. Taxes and Charges
19. Tradable Permits
20. Voluntary Agreements
21. Subsidies and Incentives
22. Information instruments
23. Drivers or pressures
24. Knowledge gap
25. Capacity gap

CONTRIBUTION TO EU BIODIVERSITY STRATEGY 2030

Description (facultative)

BDS 2030 Pillars

- [ ] Pillar 1: A coherent network of protected areas
- [ ] Pillar 2: EU nature restoration plan
- [ ] Pillar 3: Enabling transformative change
- [ ] Pillar 4: The European Union for an ambitious global biodiversity agenda

BDS 2030 Actions (102)

- [ ] Action 1: Commission guidance for identifying and designating additional protected areas, and appropriate ...
- [ ] Action 2: Complete the designation of Natura 2000 sites, including the necessary designations of marine sit...
- [ ] Action 3: Coordinate with Member States nature protection actions in the framework of the biogeographical...

- [ ] Action 4: Possible adjustment of the reporting format for nationally designated protected areas
- [ ] Action 5: Progress significantly in legally designing new protected areas and integrating ecological corridors
- [ ] Action 6: Commission assessment of progress to the 2030 targets on protected areas, and whether addition...
- [ ] Action 7: Commission guidance on defining, mapping and strictly protecting all primary and old-growth fore...
- [ ] Action 8: Promote and support investments in green and blue infrastructure and cooperation among Membe...
- [ ] Action 9: Protect and restore ecosystems in the EU´s Outermost Regions, and support biodiversity action in ...
- [ ] Action 10: Commission proposal for binding EU nature restauration targets
- [ ] Action 11: Commission guidance on the selection of species and habitats currently not in favourable conserv...
- [ ] Action 12: Restore 30% of habitats and species currently not in favorable conservation status
- [ ] Action 13: Commission guidance on an EU methodology to map, assess and achieve good condition of ecosy...
- [ ] Action 14: Fully implement the EU Pollinators initiative
- [ ] Action 15a: Commission report on the review of progress in the implementation of the EU Polinators Initiative
- [ ] Action 15b: Revise the EU Pollinators Initiative
- [ ] Action 16: implement measures to reduce by 50% the overall use of - and risk from - chemical pesticides
- [ ] Action 17: Commission proposal on revised Sustainable use of Pesticides Directive
- [ ] Action 18: Implement measures to ensure that at least 10% of agricultural area will be under high diversity la...
- [ ] Action 19: Constantly review progress on the target of 10% high-biodiversity landscape features and its poss...
- [ ] Action 20: EU action plan on organic farming
- [ ] Action 21: Take measures to ensure that Member States CAP´Strategic Plans set explicit national values for t...
- [ ] Action 22: Facilitate the registration of seed varieties for organic farming
- [ ] Action 23: Review marketing rules for traditional crop varieties in order to contribute to their conservation a...
- [ ] Action 24: Increase uptake of agroforestry support measures under rural development
- [ ] Action 25: EU Forest Strategy
- [ ] Action 26: Further develop the Forest Information System for Europe (FISE)

- [ ] Action 27: Work with Member States to ensure EU capacity to prevent and respond to major forest fires
- [ ] Action 28: Guidance on biodiversity-friendly afforestation and reforestation and closer-to-nature foresty
- [ ] Action 29: Commission Roadmap for planting at least 3 billion additional trees in the EU by 2030 in full respe...
- [ ] Action 30: Encourage sustainable soil management practices, including as part of the CAP
- [ ] Action 31: EU Soil Strategy
- [ ] Action 32: Identify contaminated soil sites, define conditions of good ecological status and improve monitor...
- [ ] Action 33: EU Stategy for a Sustainable Built Environment
- [ ] Action 34: Support development of solutions for restoring soil health and functions in the Horizon Europe mi...
- [ ] Action 35: Minimise the use of the whole trees and food and feed crops for energy production
- [ ] Action 36: Prioritise renewable energy solutions favourable to biodiversity
- [ ] Action 37: Regularly assess EU and global biomass supply and demand and related sustainability
- [ ] Action 38: Review and revise the level of ambition of the Renewable Energy Directive (RED), the Emission Tr...
- [ ] Action 39: Publish a study on the sustainability of the use of forest biomass for energy production
- [ ] Action 40: Commission operational guidance on the new sustainability criteria on forest biomass for energy
- [ ] Action 41: Review the data on biofuels with high indirect land-use change risk and set-up a strategy for their ...
- [ ] Action 42: Commission technical guidance to support Member States for the restoration of 25000 km of fre...
- [ ] Action 43: Remove or adjust barriers and restore floodplains
- [ ] Action 44: Provide technical support to Member States on their measures to review water abstraction and i...
- [ ] Action 45: Review water abstraction and impoundment permits to implement ecological flows and achieve g...
- [ ] Action 46: Step up the implementation of the European Invasive Alien Species (IAS) Regulation
- [ ] Action 47: Take actions to reduce nutrient losses and pollution from nitrogen and phosporus
- [ ] Action 48: Integrated Nutrient Management Action Plan
- [ ] Action 49: Zero Pollution Action Plan for Air, Water and Soil
- [ ] Action 50: EU Chemicals Strategy for Sustainability
- [ ] Action 51: Commission technical guidance on urban greening and assistance to mobilise funding and capaci...
- [ ] Action 52: EU Urban Greening Platform

- [ ] Action 53: Develop Urban Greening Plans
- [ ] Action 54: Implement measures to reduce or maintain fishing mortality at or under maximum sustainable yi...
- [ ] Action 55: New Action Plan to conserve fisheries resources and protect marine ecosystems
- [ ] Action 56: Ensure consistency of national maritime spatial plans with the objectives of the EU Biodiversity S...
- [ ] Action 57: Establish fisheries management measures in marine protected areas
- [ ] Action 58a: Establish seabed integrity threshold values
- [ ] Action 58b: Support the transition to more selective and less damaging fishing techniques through the Euro...
- [ ] Action 59: Ensure that Member States monito by-catch, set up data collection and take measures to elimina...
- [ ] Action 60: Put in place an EU biodiversity governance framework
- [ ] Action 61: Assess the effectiveness of the cooperation-based biodiversity governance framework, and the n...
- [ ] Action 62: Prioritise political support, financial and human resources to ensure full implementation and enfo...
- [ ] Action 63: Improve environmental compliance assurance
- [ ] Action 64: Revise the Aarhus Regulation

- [ ] Action 66: New sustainable corporate governance initiative addressing human rights, environmental duty of ...
- [ ] Action 67: Countiniously support the EU Business for Biodiversity movement
- [ ] Action 68: Review the reporting obligations of businesses under the Non-Financial Reporting Directive
- [ ] Action 69: Unlock at least 20 billion €/y for biodiversity and invest a significant proportion of the EU budget ...
- [ ] Action 70: Develop an EU-level Prioritised Action Framework
- [ ] Action 71: Develop a dedicated natural-capital and circular-economy initiative in the range of € 10 billion ove...
- [ ] Action 72: Strenghen the biodiversity proofing framework to ensure that EU funding supports biodiversity-f...
- [ ] Action 73: Propose a Delegated Act under the Taxonomy Regulation with technical screening criteria fulfillin...
- [ ] Action 74: Revise the Sustainable Finance Strategy
- [ ] Action 75: Promote and encourage tax shifts to reflect environmental costs
- [ ] Action 76: Develop methods, criteria and standards to better integrate biodiversity considerations into publi...
- [ ] Action 77: Promote an international Natural Capital Accounting Initiative
- [ ] Action 78: Revise criteria and monitoring to encourage Nature Based Solutions for Green Public Procurement

- [ ] Action 79: Establish a Knowledge Centre for Biodiversity
- [ ] Action 80: Enable research, innovation and knowledge exchange between science, policy and society on bio...
- [ ] Action 81: Establish a Biodiversity Partnership under Horizon Europe
- [ ] Action 82: Propose a council of recommendation on learning for environmental suistainability
- [ ] Action 83: Broker an agreement for an ambitious post-2020 biodiversity framework at CBD COP15
- [ ] Action 84: Launch or join High Ambition Coalitions
- [ ] Action 85: Broker an ambitious agreement on marine biological biodiversity of areas beyond national jurisdi...
- [ ] Action 86: Broker an agreement on three vast Marine Protected Areas in the Southern Ocean
- [ ] Action 87: Advocate that marine minerals in the international seabed area cannot be exploited before the eff...
- [ ] Action 88: Engage in WTO negociations towards a global agreement to ban harmful fisheries subsidies
- [ ] Action 89: Ensure full implementation and enforcement of biodiversity provisions in all trade agreements
- [ ] Action 90: Improve the assessment of the impact of trade agreements on biodiversity and strengthen the p...
- [ ] Action 91: Legislative proposal and measures to avoid or minimise the placing of products associated with d...
- [ ] Action 92: Revise the action plan against wildlife trafficking
- [ ] Action 93: Purpose a further tightening of the EU rules on the ivory trade
- [ ] Action 94: Consider strengthening the coordinating and investigative capacities for the biodiversity of the E...
- [ ] Action 95: Mobilise aid for trade to ensure that EU partner countries reap the benefits of biodiversity-friendl...
- [ ] Action 96: Increase support to partner countries for protection, ecosystem restoration and sustainable man...
- [ ] Action 97:- Support the Western Balkans and EU neighbourhood in their efforts to protect, sustainably use, r...
- [ ] Action 98: Implement NaturAfrica and other integrated regional and multi-country initiatives
- [ ] Action 99: Systematically strengthen links between biodiversity protection and sustainable socio-economic...
- [ ] Action 100: Support global efforts to apply the one health approach
- [ ] Action 101: Mainstream Biodiversity throughout bilateral and multilateral engagements
- [ ] Action 102: Assessment of progress in implementing the strategy
- [ ] ALL

DESCRIPTION OF KNOWLEDGE ELEMENTS

Description (facultative)

Description?

Réponse longue

c. Review of the BDS 2020 Table: D3.1 BDS2020 actionable information elements table

8.4. Annex 4 – Actions of the BDS 2020 vs BDS 2030

8.5. Annex 5 – Keywords

Keywords are divided into four groups: Ecosystem types, Biodiversity topics, Drivers of pressures and Solutions. Within those four groups, we identified the main keywords in bold, and related sub keywords. This list is not exhaustive and will need to be complemented but aims to have a better idea of how the information elements could be classified.

ECOSYSTEM TYPES

AGROECOSYSTEMS

Food security

Pollination

Farmland birds and insects

Pesticide use (impact of)

Genetic diversity of crops

Sustainable agriculture

Sustainable Common Agricultural Policy (CAP)

Pollution (nitrogen, phosphorus, pesticides, etc.)

Agriculture pests or diseases emergence

AIR

Air quality and pollution

FOREST

Biodiversity-friendly afforestation, Forest fires, Forest pests/diseases emergence, Forest management, Illegal logging, Reforestation

FRESHWATER

Restoration of freshwater connectivity (free-flowing), Restoration of floodplains and wetlands, Freshwater status / quality (incl. nutrient pollution), Groundwater status / quality (incl. nutrient pollution), Flood protection (in all areas), Nursery habitat for fish

MARINE ECOSYSTEMS

Restoration of marine carbon-rich ecosystems (mangroves, tidal marshes and seagrass meadows), Restoration of important fish spawning and nursery area, Fish stock regulation, Fishing gear/techniques impact, Seafloor integrity / status, Underwater noise

MOUNTAIN ECOSYSTEMS

URBAN ECOSYSTEMS

Air, water and noise pollution in urban areas, Physical and mental wellbeing in urban areas, Flooding protection in urban areas

Drought and heat waves protection in urban areas

Green infrastructures

Nature-based solutions

Green space management in urban area (incl. pesticide use)

Connectivity between green space in urban area

SOIL

Soil composition (organic matter), Soil status, Soil fertility, Soil erosion, Soil pollution, Soil restoration

DRIVERS OF PRESSURES

CLIMATE CHANGE IMPACT

GREENHOUSE GAS EMMISSION

ECOLOGICAL FOOTPRINT IMPACT

Trade impact on biodiversity

LAND USE CHANGE

NATURAL RESSOURCES AND EXPLOITATION

POLLUTION

Plastic pollution

INVASIVE ALIEN SPECIES IMPACT

Introduction of alien species

Establishment of alien species

Manage established invasive alien species

Species threatened by alien species

BIODIVERSITY TOPICS

ECOSYSTEM SERVICES

CITIZEN SCIENCE

HABITAT CONNECTIVITY

HABITAT STATUS AND TRENDS

SPATIAL PLANNING

SPECIES STATUS AND TRENDS

SOLUTIONS

CLIMATE REGULATION

Carbon sequestration

Renewable energy

HABITAT AND BIODIVERSITY PROTECTION

Protected areas network

Carbon-rich ecosystems protection (peatlands, grasslands, wetlands, mangroves and seagrass meadow)

Carbon-rich ecosystems restoration

Ecological corridors

Genetic diversity

Species migration

ENABLING TRANSFORMATIVE CHANGE

Enforcement of EU environmental legislation

Business for biodiversity initiatives

Measures to incentivize and eliminate barriers for the take-up of nature-based solutions

Circular-economy

Economic activities that substantially contribute to protecting and restoring biodiversity and ecosystem

Measuring the environmental footprint of products

Measuring the environmental footprint of organizations

Filling knowledge gaps (tools/methods)

Bridge between science, policy and practice

Guidance for schools and teachers on how to cooperate and exchange experiences across Member States on biodiversity teaching

Global biodiversity agenda

EU support to governments and stakeholders across the globe

Illegal wildlife trade

Environmental crime

Financial flows to developing countries for biodiversity

ORGANIC PRODUCTS CONSUMPTION

promotion campaign

marketing rules for traditional crop varieties

market access for traditional and locally adapted varieties

ECOSYSTEMS RESTORATION

ECOSYSTEM SERVICES

Natural capital accounting

COMMUNICATION

Knowledge integration into policy

EDUCATION

RECYCLING

SUSTAINABLE CONSUMPTION

SUSTAINABLE ECONOMIC SYSTEM

SUSTAINABLE FINANCE

8.6. Annex 6 – Testing the framework

KNOWLEDGE USED FOR THE BDS 2020 EVALUATION

Results of the information elements screening and their actionable typology

We obtained a dataset with 215 information elements, including 15 different information types. Table 7 summarizes the total number of information elements grouped by actionable information types. The most frequent type of information used were Recommendations (19,4%), followed by Reports (14,9%), Policy documents (13,5%), Indicators (12%) and Implementation gaps (11,2%). The rest of the types did not reach 10% frequency of use. It is worth noting that among the different information types, the identification of gaps occupies almost 20% of collected information elements, especially regarding implementation and capacity gaps (12,6%) and knowledge gaps (7%).

Results of typology of use

Overall, the analysis of the typologies of information related to the BDS 2020 Targets shows the priority use of actionable information typologies related firstly to the “Implement” type (35%) and secondly to the existing knowledge behind these Targets, either in the form of “Understand” (24%) or “Inform” (15%) types of actionable information. While these three typologies are well represented in all BDS 2020 Targets, information typologies “Observe” (0.5%), “Plan” (2.3%) and “Fund” (3.3%) appear almost anecdotally (Table 6) and are partially used to assess the BDS 2020 Targets (Figure 7 and Table 7). It is also worth noting that the two most common typologies, “Implement” and “Understand”, were also used to highlight implementation and capacity gaps as well as knowledge gaps. In addition to their quantitative importance, these information gaps are remarkably evenly distributed across the six BDS 2020 targets, reinforcing the robustness of the BDS 2020 evaluation (European Commission, 2022).

The asymmetries in the typologies of actionable information used to assess the main Targets of the BDS 2020 highlight a preferential use of “Implement” type, followed by “Understand” and “Inform”, while the other typologies of information are hardly used. In the case of the related take-action typologies (“Plan”, “Fund” and “Implement”), this suggests that only a small proportion of the measures corresponding to “Plan” and “Fund” typologies were not fully implemented. Otherwise, the same measures would have been reported as “Implement” information typologies. This argument is also valid for the actionable information types related to knowledge (“Observe”, “Understand” and “Inform”), where the under-representation of the “Observe” typology is justified by the existence of more elaborated and synthetized knowledge available to inform the BDS 2020 targets.

Identified gaps

Knowledge gaps, along with implementation and capacity gaps, were identified across all BDS 2020 Targets (Figure 7), collectively accounting for nearly 20% of the actionable information types (Table 6). The information elements used to evaluate the BDS 2020 show significant gaps for informing BDS 2030 Pillars based on the miss-match between the two strategies (Table 8 and Figure 8). Only Pillar 2, on nature restoration plan, has a broad and complete representation across different actionable information types with 44,3% of the information for BDS 2030 (Table 8). Within the information extracted from the BDS 2020 that can be relevant for the BDS 2030, the categories of "Plan" and "Fund" are notably scarce. In addition, the categories “Knowledge gap” and “Implementation and capacity gap” are quite prominent.

Lack of information types

For Pillar 1, which addresses the creation of "A Coherent Network of Protected Areas," there is a lower representation of the information elements analysed in BDS 2020. The BDS 2030 Pillar takes a step further by aiming to establish an integrated network of protected areas, rather than focusing solely on the Birds and Habitat Directives, as seen in Target 1 of BDS 2020. A significant portion of the information in this Pillar is associated with implementation and capacity gaps.

Pillars 3 and 4 focus on "Enabling Transformative Change" and "The European Union for an Ambitious Global Biodiversity Agenda," respectively. These are entirely new topics not addressed in BDS 2020, which explains the presence of significant information gaps. For Pillars 3 and 4, there is little to no information available for the categories "Observe," "Plan," and "Fund," while the "Understand" and "Inform" categories hold less than 5% of the available data. This discrepancy in information underscores that BDS 2030 tackles issues not previously covered by BDS 2020.

There is also a considerable percentage of the BDS 2020 elements representing information potentially related to the BDS 2030 Pillar 1 (Table 8). There is also significant missing information in relation to “Inform” and “Fund” typologies in Pillars 3 and 4, where the other typologies of actionable information are also missing.

Table 7. Frequency of use of types of actionable information across BDS 2020 Targets, from the Evaluation of the EU Biodiversity Strategy to 2020 (European Commission, 2022). Percentages are not equal to Table 6 as some information may be related to more than one BDS 2020 Targets.

BDS 2020 Targets	**Types of use of actionable information**						**Total by Target**
	Observe	**Understand**	**Inform**	**Plan**	**Fund**	**Implement**	
Target 1	-	5,8%	4,7%	-	0,4%	6,5%	**17,4%**
Target 2	-	6,5%	4,7%	1,1%	0,7%	10,2%	**23,2%**
Target 3	-	5,8%	4,4%	-	-	7,3%	**17,5%**
Target 4	-	4%	3,3%	-	1,1%	5,8%	**14,2%**
Target 5	0,5%	2,5%	2,5%	-	-	6,9%	**12,4%**
Target 6	-	5,1%	3,3%	0,7%	0,4%	5,8%	**15,3%**
Total by Type of use	**0,5%**	**29,7%**	**22,9%**	**1,8%**	**2,6%**	**42,5%**	**100%**

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Table A3. *Knowledge table after using "barrier", "dam" filtering on Information elements, as well as "Freshwater" filtering on Keywords. Some columns of the table have been removed to increase clarity, and some Descriptions have been shortened. See the complete table in ANNEX 6.*

Document	Information element (IE)	Keywords	Type of IE	Description
	search "**barrier**" +	"**freshwater**"		
ECRR2023	**Barrier** data base	**FRESHWATER**, HABITAT AND BIODIVERSITY PROTECTION	Data and Platform	pg. 28 "Today, the data base includes the estimation of the migratory phase connectivity and contains about 5.800 dams, the number of barriers is higher."
ECRR2023	**Barrier** database in Austria	**FRESHWATER**, HABITAT AND BIODIVERSITY PROTECTION	Data and Platform	pg. 22 "The data base entails the following attributes of a barrier: the location (coordinates), the type and function (hydropower, flood protection, etc.), the equipment (fish passability), and if it is a natural or artificial barrier. A total of 28,435 impassable artificial transverse structures, longitudinal elements and residual water stretches were surveyed in the watercourses […] (BMLRT, 2022)."
ECRR2023	Direct and indirect impacts of **barriers** on fish	**FRESHWATER**, NATURAL RESSOURCES AND EXPLOITATION	Drivers of change	pg. 7 "Barriers detain fish from reaching their spawning grounds and turbines in barriers can result in direct mortality (Drouineau et al., 2018). On top of that, many indirect impacts by barriers are mentioned by Drouineau et al. (2018), such as over-predation, overfishing, stress, diseases, and selective pressure."
ECRR2023	Ecosystem services provided by artificial **barriers** in rivers	**FRESHWATER**, ECOSYSTEM SERVICES, NATURAL RESSOURCES AND EXPLOITATION, SOIL, AGROECOSYSTEMS	Report	pg.7 "River barriers, including dams, weirs, culverts, fords, sluices, and ramps or bed sills, are artificial obstacles that are installed in rivers for specific, mostly provisional, ecosystem services such as flow regulation, hydropower generation, water level control or erosion reduction (AMBER Consortium, 2022) […]."
ECRR2023	French **barrier** data base	**FRESHWATER**, ENABLING TRANSFORMATIVE CHANGE	Data and Platform	pg. 38 "In 2010, a national inventory of longitudinal barriers in rivers was established by the OFB by harmonising and centralising existing data. The data base is constantly growing and contained 103 758 barriers in December 2021. Main attributes of entries to the data base are: Geographical position (X, Y coordinates), […]"
ECRR2023	Inventory of transversal **barriers**	**FRESHWATER**, ENABLING TRANSFORMATIVE CHANGE	Data and Platform	pg 66. "In total, more than 18,500 transversal barriers have been inventoried in the set of water bodies that form the channels of the inter-community basins"
ECRR2023	Main functions of migration **barriers**	**FRESHWATER**, CLIMATE CHANGE MITIGATION, HABITAT AND BIODIVERSITY PROTECTION, ECOSYSTEM SERVICES, NATURAL	Data and Platform	pg. 22 "The proportion of obstacles to migration caused by hydropower generation is 11%. There are also obstacles to migration due to fishing (1.4%) and agriculture and forestry (1.3%) (BMLRT, 2022). Leisure use/tourism as well as industry and commerce and other causes each make up less than 1% of all obstacles to migration (BMLRT, 2022). […]"

		RESSOURCES AND EXPLOITATION		
ECRR2023	Prioritisation criteria of **barrier** restoration projects	**FRESHWATER**, ENABLING TRANSFORMATIVE CHANGE	Management practices	pg. 66 "Criteria used for water body (WB) prioritisation are: •WB with those barriers that were priority for removal or permeabilisation as part of the Programme of Measures (as parts of the River Basin Management Plans) •WBs that were in protected areas (e.g., it is estimated that at least 38,290 kilometers of Spanish rivers are included in the spaces that form the Red Natura 2000 (RN2000)) […]"
ECRR2023	Prioritisation of **barrier** removal	**FRESHWATER**, ECOLOGICAL FOOTPRINT IMPACT, ECOSYSTEMS RESTORATION	Management practices	pg. 22 "The prioritisation of barriers is based on ecological criteria, with the focus being on the distribution of particularly endangered fish species (medium-distance migratory fish), followed by the willingness of the local community and the situation of ownership. […] "
ECRR2023	Rate of barriers removed per year	**FRESHWATER**, ENABLING TRANSFORMATIVE CHANGE, ECOSYSTEMS RESTORATION	Management practices	pg. 65 "In the Catalan River Basin District, barrier removals are currently being implemented at a rate of 2-3 demolitions of small structures per year"
ECRR2023	Threat of **barrier** construction on the values provided by rivers	**FRESHWATER**, ECOSYSTEM SERVICES	Drivers of change	pg. 7 "Barrier construction is identified as one of the factors that threaten the values provided by rivers (Brevé et al., 2014)."
WWF2021	Number of artificial **barriers** less than 0.5 m in height	**FRESHWATER**	Variable	pg.15: Armin Peter (FishConsulting) provided the example of Switzerland, where fragmentation is mostly caused by several hundred thousand artificial barriers less than 0.5 m in height, such as bed sills built to compensate for bed incision caused by channel straightening. […] “
WWF2021	Barrier assessment tool to prioritise **barrier** removal	**FRESHWATER**	Spatial planning tool	pg.26: In the Flussfrei project, a barrier assessment tool to help prioritise barriers was developed. All barriers were taken into account and were first filtered according to catchment size, bed width and ecomorphology. A secondary filter was applied to selected barriers, depending on the length of reconnected river stretches. […]”
WWF2021	Evacuation of endangered species when a **barrier** is removed	**FRESHWATER**	Recommendation	pg.35: Markus Brandtner (Water Management Authority, Weilheim) reported that, when the barrier was removed on the Windach river in Bavaria, the river mussel population, which colonised the mill channel (drying out after the removal) was evacuated and brought to an appropriate location within the river. […]”
WWF2021	Impact of small river **barriers**	**FRESHWATER**	Drivers of change	pg.13: While large dams get most of the attention, it is in fact the small ones that do most of the damage. Furthermore, when talking about dams, one instantly thinks about hydropower dams, but there are many varieties of barriers that negatively affect the integrity of the river: dams, ramps, fords, weirs, culverts and sluice gates (Figure 2).
WWF2021	Number of **barriers** in European rivers	**FRESHWATER**	Variable	pg. 3: Over 1.2 million barriers are blocking European rivers, which means an average density of 0.74 barriers per every kilometre of river.

WWF2021	Number of **barriers** lower than 2 m high	**FRESHWATER**	Variable	pg.13: Some 68 % of these barriers are lower than 2 m high, therefore hard to detect and poorly mapped.
WWF2021	Percentage of obsolete **barriers** in Europe	**FRESHWATER**	Variable	pg.15: Out of 4,614 barriers surveyed in detail within Europe, 13% have been identified as obsolete.
WWF2021	Remove **barriers** that do not serve a purpose or meet regulations	**FRESHWATER**	Recommendation	pg.22: In the Duero river basin, the authorities are actively removing barriers that do not serve a purpose or meet regulations. So far, 176 barriers have been removed and 225 by-passes have been constructed on the river basin's 4,000 barriers.
WWF2021	Removing migration **barriers** and improving habitat diversity increases the population's resilience to climate change.	**FRESHWATER**, CLIMATE CHANGE IMPACT	Recommendation	pg.17: Removing migration barriers and improving habitat diversity increases the population's resilience to climate change
	search "**dam**" +	"**freshwater**"		
WWF2021	Benefits of **dam** removal	**FRESHWATER**	Recommendation	pg.15: Results show that the benefits of removal differ widely across Europe, making the Scandinavian Peninsula and the Balkans hotspots for dam removal while the Alps score very low due to high fragmentation.
WWF2021	**Dam** removal positive effects	**FRESHWATER**	Drivers of change	pg.10: Following the dam's removal, the sediment was subject to the natural succession processes. Release of the sediment improved flood protection and the groundwater level went up by 1.5 m […]"
WWF2021	**Dam** removal helps to reduce greenhouse gas emissions	**FRESHWATER**, CLIMATE CHANGE MITIGATION	Report	pg.35: Methane is the second most important greenhouse gas, with a global warming potential of 28 to 35 times that of carbon dioxide (CO2). Its temporal dynamics (sources and sinks) are still poorly understood. Current estimates suggest that freshwater reservoirs account for between 2 and 8 % of global methane emissions (5 to 18 % of global anthropogenic emissions). […]"
WWF2021	The role of **dam** removal for restoring rivers	**FRESHWATER**	Drivers of change	pg.16: Dam removal is a very cost-effective way to restore river continuity.

Table A4. *Description of information element on barrier removal prioritization.*

Prioritisation criteria of barrier restoration projects	*Prioritisation of barrier removal*	*Remove barriers that do not serve a purpose or meet regulations*
ECRR report, pg. 22 "The prioritisation of barriers is based on ecological criteria, with the focus being on the distribution of particularly **endangered fish species** (medium-distance migratory fish), followed by the **willingness of the local community** and the situation of ownership. Furthermore, the ecological effect of the measure depending on the **length of the to be restored continuity** stretch of water and the accessibility of suitable habitats upstream in tributaries are considered. "	*ECRR report*, pg. 66 "Criteria used for water body (WB) prioritisation are: •WB with those barriers that were priority for removal or permeabilisation as part of the Programme of Measures (as parts of the River Basin Management Plans) •WBs that were in **protected areas** (e.g., it is estimated that at least 38,290 kilometers of Spanish rivers are included in the spaces that form the Red Natura 2000 (RN2000)) •WBs with barriers whose removal or permeabilisation would **maximise unfragmented river length** •WBs with significant **fish populations that are threatened** with invasive species •WBs particularly **sensitive to climate change"**	*WWF report, pg.22* "In the Duero river basin, the authorities are actively **removing barriers that do not serve a purpose** or meet regulations. So far, 176 barriers have been removed and 225 by-passes have been constructed on the river basin's 4,000 barriers."

Box 1. *Fack checks, comparison between the technical guidance published in 2021 that answered the Action 42 and the work done using the knowledge database*.

Fact checks: Guidelines from the European Commission

Technical guidance published in 2021 on "Barrier removal for river restoration" (Directorate-General for Environment (European Commission) 2022).

We focused on "Guidance on site selection for barrier removal – p.20-24":

The review of the guidance written by the Commission demonstrated that all the points previously identified in the ECRR and WWF documents related to barrier removal prioritization were considered (see below). This can serve as a first proof of the relevance and efficiency of our methodology as a facilitator for knowledge synthesis. However, many other points were not captured, which reveals that the reviewing effort done was not sufficient to capture all elements for prioritization. Those encompass (1) **migration routes** of migratory species, (2) the **existing uses** in a river basin, including inland navigation, flood defence, energy generation or agriculture, (3) the **collection of data** to mapping out the location of barriers to longitudinal and lateral connectivity, as well as (4) **gaps identification** in knowledge preventing the assessment of connectivity, (5) **river quality assessment** of the chemical and ecological status of the river basin including the hydromorphological quality, as well as (6) the inclusion for **futureproofing** (scenarios), as the impact of barriers often depends on river flow, it is important to consider predicted changes in river flows to future proof the benefits of barrier removal.

Considered by our review:	Cross checked by the EC document:
barriers whose removal would maximize river length	*"Three metrics could be used to assess the extent of fragmentation under the tenet that **the less fragmented a river is, the easier and more cost-effective it will be to restore continuity:** (1) estimated degree of fragmentation; (2) is fragmentation higher or lower than the regional average; and (3) river continuity conditions reported as part of River Basin Management Plans."*
barriers where threatened fish species live + **barriers located in protected areas**	*"**Biodiversity:** the status of the biological quality element fish - hydrological stressors tend to affect fish the most out of all biota, both in terms of intensity and sensitivity; and **whether the basin is in a protected Natura 2000 site and whether there are protected habitats or species that would benefit from the restoration.**"*
barriers whose removal is accepted by the local community and landowners	*"Governance and support: **Support from the local population and stakeholders is a key condition for the success of barrier removal** operations. It is an important aspect to be taken into account in barrier removal prioritisation. The benefits of intervention should be evaluated against other possible socio-economic services."*
barriers that do not serve a purpose	*"**Current impact of a barrier on** whole catchment connectivity. Relying on comprehensive evaluation of each aspect of connectivity e.g. ecological, sediment and hydrology. **Current use (in use, abandoned), Age (some barriers have passed their working life).**"*
barriers located in water bodies sensitive to climate change	*"It should also be considered whether removing barriers and enhancing the natural water retention of ecosystems **could mitigate the impact of floods in areas where more extreme rainfall events might occur as a result of a changing climate."***