

BIOFIN-EU-project.eu



PROTECTING AND RESTORING BIODIVERSITY USING MAINSTREAM FINANCE

D4.1: Initial Biodiversity Data for Financial Transactions

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Executive Summary

This document provides the initial version of the deliverable “Biodiversity data for financial transactions”. This document is the outcome of extensive consultation between partners in WP4 and the wider project consortium, as well as in-depth research and initial analysis of the BIOFIN-EU learning sites and how geographical and biodiversity data in the public domain can provide both valuable and necessary information for financial institutions funding Nature Based Solutions (NbS) and biodiversity initiatives in general.

This document first highlights the context and significance of biodiversity related data in enabling financial transactions towards NbS, both from an opportunity and risk perspective.

It describes the status of the methodology and framework this project will adopt for collecting and integrating biodiversity data into financial transactions. It details the work already carried out in the first 12 months of the BIOFIN-EU project with respect to researching available data and quantifying potential impacts and risks.

The main output of this document is a proposal and set of recommendations for the data sources and approach the BIOFIN-EU project will take to qualify and quantify biodiversity for financial institutions via the BIOFIN-EU dashboard.

Table of contents

1. Introduction	2
1.1. Relationship to other work packages and deliverables	2
1.2. Structure of this deliverable	3
2. Context	4
2.1. Background	4
2.2. Scope	4
2.3. Deliverable versions	5
3. Objectives	6
3.1. Biodiversity Classification for Sustainable Investments	6
3.1.1. Aligning investments with the EU Taxonomy	6
3.2. Appraisal: Evaluating Risks and Ecosystem Services	8
3.2.1. Risk Assessment	9
3.2.2. Valuation of Ecosystem services	9
3.3. Reporting and Regulatory Compliance	10
3.3.1. CSRD	11
3.3.2. TNFD	12
4. Methodology	14
4.1. The BIOFIN-EU MVP Prototype	14
4.2. Data Collection Strategy	14
4.2.1. Top-Down Approach	14
4.2.2. Bottom-Up Approach	15
5. Biodiversity data framework	17
5.1. Framework for Biodiversity Data Integration	17
5.1.1. Current Challenges and Framework Approach	17
5.1.2. Spatial-Temporal Integration and Multisource Data Fusion	18
5.1.3. Standardisation and Alignment with Indicators	19
6. Risk modelling biodiversity	20
6.1. Region and Geographical Categorization	20
6.2. Identification of Biodiversity Disturbances	21
6.3. Data Collection and Integration	21
6.4. Modelling and Machine Learning	22

6.5. Risk Assessment Approach	22
7. Recommendations and roadmap to version 2.....	24
7.1. Analysis of classification taxonomies and reporting frameworks.....	24
7.2. Scoping of use-cases for financial institutions.....	24
7.3. Development iterations of BIOFIN-EU dashboard.....	25
8. Challenges, Limitations and Risks	27
8.1. Data availability and completeness	27
8.2. Machine Learning Models (ML)	28
8.3. Dashboard use cases and MVP development.....	29
8.4. General limitations.....	30
9. References	31

List of Figures

Figure 1_EU Taxonomy Compass	7
Figure 2_The ENCORE Tool.....	10
Figure 3_Integrated Biodiversity Risk Assessment Framework for the BIOFIN-EU Project	20

Glossary of terms and abbreviations used

List of Abbreviations and Acronyms	
ES	Ecosystem Services
FAIR	Finable, Accessible, Interoperable, Reusable
NbS	Nature Based Solution(s)
MVP	Minimum Viable Product
DoA	Description of Action
ML	Machine Learning
CSRD	Corporate Sustainability Reporting Directive
TNFD	Taskforce on Nature-related Financial Disclosures
TCFD	Taskforce on Climate-related Financial Disclosures
ESG	Environment Social Governance

1. Introduction

BIOFIN-EU aims to unlock financial flows towards reversing biodiversity loss, in alignment with the European Green Deal priorities and in particular the EU Biodiversity Strategy for 2030 and the 2030 Climate Target Plan. The project will enhance the implementation of the sustainable finance taxonomy, thereby mainstreaming biodiversity and ecosystem services into society and the economy. The project will develop financial solutions to address societal challenges, including through innovative funding approaches for Nature-based Solutions (NbS).

At the core of the key objectives is the development of the BIOFIN-EU Dashboard, a digital software tool designed to help actors (including investors and NbS providers, financial and accounting experts, private and public beneficiaries, ecologists and data scientists) navigate large-scale financing challenges and to develop, replicate, scale out and strengthen NbS investment, creating a more sustainable, vibrant, resilient and healthy planet and supporting the EU's biodiversity restoration ambitions.

The dashboard will enable an NbS provider seeking full or partial financing for biodiversity initiatives (i.e. a specific NbS) to develop a business case using associated information and data with the explicit goal of attracting and connecting with potential funders (e.g. a bank or hedge fund manager). The dashboard will provide the funder with data, decision workflow tools, and analytics while enabling risk calculation and scenario analysis across one or more NbS.

To address the issue of transaction and reporting costs related to the financing of nature positive activity, the dashboard will support automation of investment reporting in line with relevant taxonomies and disclosure requirements. .

Fundamental to the dashboard and many of its features and functionalities will be biodiversity and environmental data, describing a specific NbS or enabling comparisons between two or more NbS and reducing prevalent obstacles to such comparisons due to fundamental differences between NbS locations, domains or objectives. To detail the requirements and use case for such data, this document takes forward the framework introduced in Deliverable 2.1 "Categorising Nature-based Solutions to support decision making for financial investments" by describing the methodology, framework and risk modelling approach with respect to how biodiversity data will be identified, collected, classified and utilised. It details the inherent challenges, limitations and risks in its use to attract financial transactions and flows towards nature positive investment and sets out recommendations and the roadmap for the next 12 months before submission of the final version of this deliverable in December 2025.

1.1. Relationship to other work packages and deliverables

The task allocation in the BIOFIN-EU proposal promotes strong collaboration between work packages 2 and 4, more specifically tasks 2.1 and 4.1, in the assessment, collection and monitoring of biodiversity and NbS for the requirements of financial investments.

Task 2.1 places its focus on NbS and biodiversity itself. It provides insight into how the entities involved in developing and implementing an NbS can efficiently collect reliable, high-quality data to build a business case

for their initiative, to assess their positive and negative biodiversity impacts, and to guide on the ground decision-making, using publicly available biodiversity data in combination with local monitoring approaches. Within this task, Deliverable 2.1 “Categorising Nature-based Solutions to support decision making for financial investments” outlines a “framework of typologies for NbS that will enable BIOFIN-EU to align and integrate NbS approaches with financial decision making” (Van Nieuwstadt, Biasin, Le Lann, & Masiero, 2024).

Task 4.1 acts as the bridge between Deliverable 2.1 and the financial sector, specifically the requirements potential investors and stakeholders involved in securing funding for a given NbS have in terms of the collection and use of biodiversity data. It will analyse the relevance and requirements of existing taxonomies (e.g. EU Taxonomy) and financial regulations (e.g. CSRD) and assess how publicly available data can enable analysis of NbS investments.

Work Packages 4, 5 and 6 work closely to identify and describe specific use cases for the BIOFIN-EU dashboard from the perspective of stakeholders in financial institutions. The use cases have the intended goal of identifying and classifying high-level requirements or “features” for the BIOFIN-EU dashboard that both support and enhance a given financial institution’s ability to perform investment appraisal across NbS by monitoring technical criteria and reducing the reporting requirement barriers that have prevented such investment in nature positive initiatives to date. This includes integrating external frameworks (i.e. taxonomies in the BIOFIN-EU dashboard).

1.2. Structure of this deliverable

Following the introduction, section 2 sets the context in terms of the background, significance and relevance of biodiversity data for attracting financial investment, the scope of this deliverable, and plans for its update. Section 3 introduces the core objectives for biodiversity data within this context, while section 4 is the methodology section for the BIOFIN-EU dashboard development, data collection, and analysis. Section 5 sets out the biodiversity data framework and given its significance as a separate task within this project (task 4.3), section 6 is dedicated to detailing the approach to risk modelling for biodiversity. Section 7 highlights the roadmap for research and development between this version of Deliverable 4.1 and the update due in M24 (December 2025). Finally, section 8 outlines the challenges, risks and limitations related to biodiversity data for financial transactions.

2. Context

2.1. Background

As described in the BIOFIN-EU proposal’s problem statement, “nature is essential for human existence and our quality of life and society is directly and indirectly dependent on the natural environment, its biodiversity and ecosystem services. We now know that the design of the globalised financial system, which seeks to optimise financial return irrespective of its secondary impacts, is contributing to large-scale biodiversity loss and bringing our biosphere closer to collapse”.

To encourage and support investment in environmentally sustainable projects, there are several biodiversity data related challenges to overcome, namely in how it is analysed, classified and reported. The parties involved in these challenges are primarily NbS providers and financial institutions. This document intends to give a clear description of the requirements, challenges, and potential solutions already under research within the BIOFIN-EU project, specifically concerning biodiversity data, the related frameworks, taxonomies and regulations, and how such data can be used by financial institutions to assess investment related risks and opportunities.

As stated in the introduction, the overall platform for biodiversity data collection and management within this project is the BIOFIN-EU dashboard, designed to enable NbS providers to promote biodiversity projects, and encourage nature-positive investment from financial institutions and support a reduction in transaction and reporting costs.

2.2. Scope

As described in the introduction, the purpose of this deliverable is to take forth the framework set out in deliverable 2.1 “Categorising Nature-based Solutions to support decision making for financial investments” and align it with requirements from financial institutions. In doing so, this deliverable will provide a set of recommendations and next steps to support the development of the BIOFIN-EU dashboard, more specifically the requirements including data models and standards which will sit at its core. For the avoidance of doubt, this deliverable’s scope does not include restating or describing the definitions and categories of biodiversity and NbS. It focuses on the relevance, framework and use of biodiversity data in the context of several high-level use cases from the perspective of financial institutions.

- For **classification**, the biodiversity related frameworks and criteria to support financial institutions to determine whether and how a specific investment in an NbS constitutes a sustainable economic activity.
- For investment **appraisal**, the biodiversity data required to support financial institutions and stakeholders (including monitors, certifiers, and auditors) to identify and support investment in nature-positive initiatives, including assessing risk and benefits.

- For **reporting** and adherence to regulations, the biodiversity data required to meet specific disclosure obligations under certain directives.

The objectives described in section 3 of this deliverable focus on these primary use cases by identifying and describing the specific classifications and requirements of financial institutions in the decision-making process of funding biodiversity and subsequent reporting needs.

2.3. Deliverable versions

This document is the first version of the “Biodiversity for Financial Transactions” deliverable, submitted in December 2024 (Month 12). As the framework and categorising of NbS, as well as the use-cases and research of governance and reporting requirements for financial institutions is still in progress, the content of this deliverable will be updated. The Description of Action (DoA) includes a second version of this deliverable to be completed by Month 24. Details of specific amendments and additions will be included in a new section of the updated version.

3. Objectives

The scope for this deliverable detailed in the previous section highlights several high-level use cases for biodiversity data in the context of financial transactions: classification, appraisal and reporting. This section introduces the individual scope, key considerations and examples within each requirement and makes clear the objectives for the BIOFIN-EU dashboard's biodiversity data framework, introduced in section 5.

3.1. Biodiversity Classification for Sustainable Investments

Classification involves categorising economic activities, specifically NbS, based on their biodiversity impact. This process enables financial institutions to evaluate one or more NbS initiatives and determine their potential to positively impact biodiversity and the environment in general, as well as their contribution to climate change mitigation. Accurate classification is critical for meeting reporting obligations and disclosure requirements. It ensures the application of appropriate terminology, criteria, and enables NbS providers, financial institutions, and other stakeholders to assess whether and how a specific NbS aligns with a particular taxonomy or framework. Biodiversity data provided through the BIOFIN-EU dashboard must therefore incorporate relevant taxonomies and frameworks.

This version in the following subsection 3.1.1 focuses on the EU Taxonomy given its clear relevance for this project and relationship to EU directives (i.e. CSRD). Future versions of this deliverable will provide an exhaustive list of the taxonomies and frameworks relevant for the BIOFIN-EU dashboard.

3.1.1. Aligning investments with the EU Taxonomy

The EU taxonomy is a European Union wide classification system for sustainable activities, intended as a market transparency tool. "It helps direct investments to the economic activities most needed for the transition, in line with the European Green Deal objectives. The taxonomy is a classification system that defines criteria for economic activities that are aligned with a net zero trajectory by 2050 and the broader environmental goals other than climate". (EU, EU taxonomy for sustainable activities, 2020)

The taxonomy addresses EU climate and energy targets by providing a common language and unified definition of sustainability to guide investments.

"The EU taxonomy allows financial and non-financial companies to share a common definition of economic activities that can be considered environmentally sustainable. In this way, it plays an important role in helping the EU scale up sustainable investment, by creating security for investors, protecting private investors from greenwashing, helping companies become more climate-friendly and mitigating market fragmentation." (EU, EU taxonomy for sustainable activities, 2020)

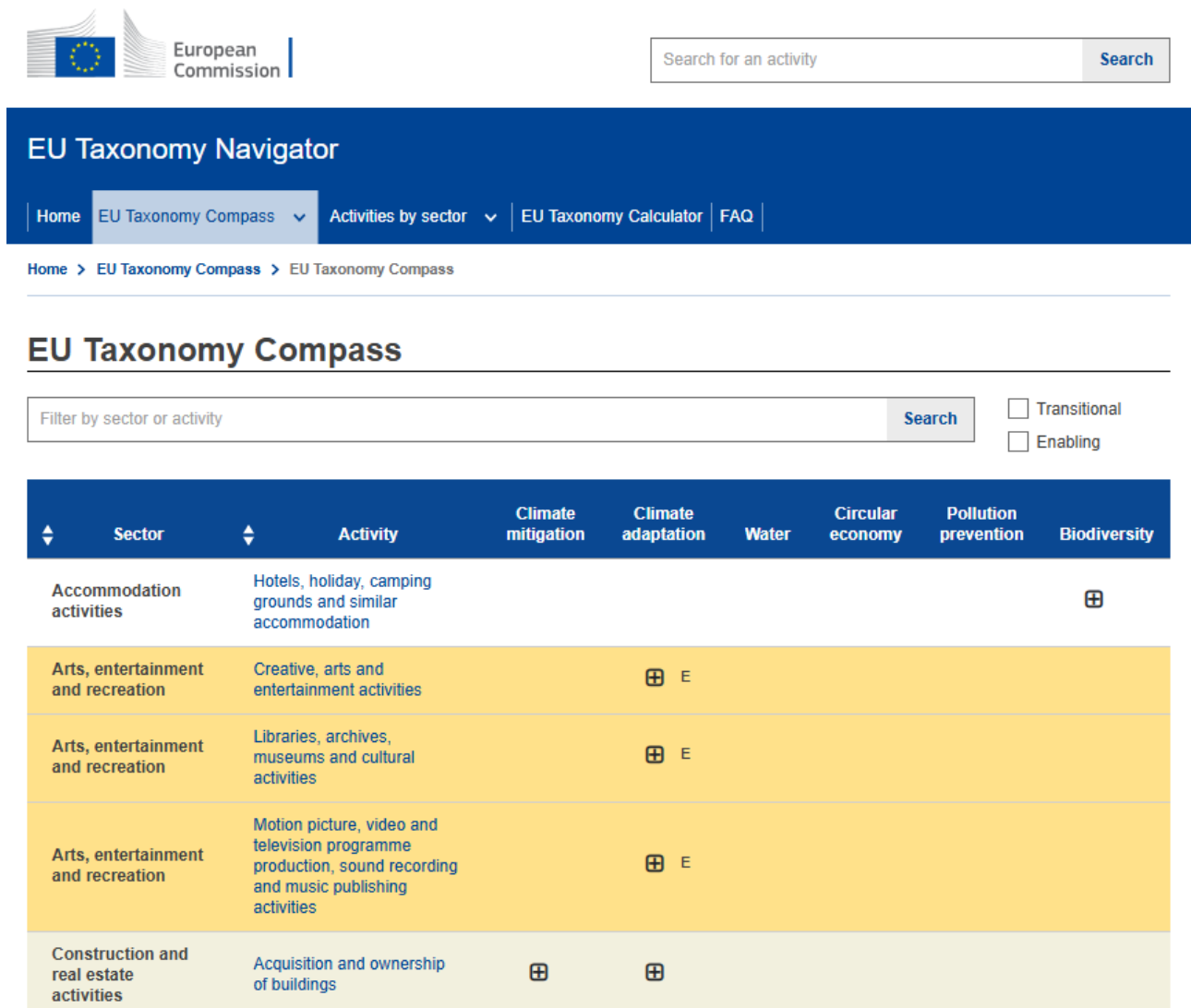
The taxonomy establishes six climate and environmental objectives.

1. Climate change mitigation
2. Climate change adaptation

3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

The BIOFIN-EU project is concerned with the sixth objective: “The protection and restoration of biodiversity and ecosystems” and NbS within its scope must Do No Significant Harm (EU, Do No Significant Harm, 2021) to objectives 1 to 5.

To navigate the EU taxonomy, and relevant to the BIOFIN-EU dashboard, the European Commission offers a set of tools including the EU Taxonomy Compass, which provides “a visual representation of sectors, activities and criteria included in the EU Taxonomy delegated acts”. (EU, EU taxonomy for sustainable activities, 2020).



The screenshot shows the 'EU Taxonomy Navigator' website. At the top, there is the European Commission logo and a search bar for activities. Below the navigation bar, the 'EU Taxonomy Compass' section is visible. It includes a filter bar with a search button and checkboxes for 'Transitional' and 'Enabling' activities. The main content is a table with columns for Sector, Activity, and various taxonomy criteria: Climate mitigation, Climate adaptation, Water, Circular economy, Pollution prevention, and Biodiversity.

Sector	Activity	Climate mitigation	Climate adaptation	Water	Circular economy	Pollution prevention	Biodiversity
Accommodation activities	Hotels, holiday, camping grounds and similar accommodation						⊕
Arts, entertainment and recreation	Creative, arts and entertainment activities		⊕ E				
Arts, entertainment and recreation	Libraries, archives, museums and cultural activities		⊕ E				
Arts, entertainment and recreation	Motion picture, video and television programme production, sound recording and music publishing activities		⊕ E				
Construction and real estate activities	Acquisition and ownership of buildings	⊕	⊕				

Figure 1: EU Taxonomy Compass

Source: <https://ec.europa.eu/sustainable-finance-taxonomy/taxonomy-compass>

In practice, the BIOFIN-EU dashboard will act as a bridge between NbS providers and financial institutions by integrating and providing interoperability with the EU Taxonomy Compass. This integration will help address two key challenges.

1. Data collected and subsequently made available via the dashboard will align with taxonomy criteria, e.g. sectors, activities and objectives.
2. Workflows within the dashboard will identify gaps for NbS providers and financial institutions that may need addressing to comply with specific criteria.

In an example scenario, an NbS provider uses the BIOFIN-EU dashboard to:

- 1) Classify their project according to relevant economic activities within the EU Taxonomy (e.g., restoration of habitats or ecosystems)
- 2) Perform checks against criteria to ensure their project aligns with the "Do No Significant Harm" (DNSH) principles for the other five environmental objectives.
- 3) Provide transparency and potential methods for validating the expected environmental and social impacts the NbS seeks to achieve.
- 4) Automate reporting workflows; including CSRD disclosures (see section 3.3.1).

In summary, the BIOFIN-EU dashboard facilitates collaboration between NbS providers and financial institutions by streamlining compliance with the EU Taxonomy, ensuring transparency, and supporting sustainable investments that align with biodiversity and broader climate and environmental goals.

3.2. Appraisal: Evaluating Risks and Ecosystem Services

Appraisal involves assessing the financial and environmental viability of NbS projects by analysing biodiversity and related financial data. As described in the BIOFIN-EU proposal, the BIOFIN-EU dashboard will provide both guided analytics and data discovery tools, enabling stakeholders, such as banks and other financial institutions, to evaluate NbS projects comprehensively.

Work package 5 is actively engaged with external project stakeholders to analyse the requirements different financial industries and funding methods will have with respect to the dashboard. These requirements, written in the form of use-cases, will be tested and validated via the Minimum Viable Product (MVP) prototype of the dashboard, as introduced in section 4.1. The next version of this deliverable will provide the results of this process and their impact on specific feature requirements for the BIOFIN-EU dashboard itself.

In addition to the use-cases, the following subsections focus on known requirements financial institutions have beyond basic traditional financing metrics (i.e. loan amount, term, interest rate) to encourage investment in nature positive initiatives, including bespoke risk assessment for an individual NbS, and valuation of biodiversity benefits in terms of the ecosystem services the investment will realise.

3.2.1. Risk Assessment

Task 4.3 in the BIOFIN-EU project involves creation of risk assessment tools designed for financial institutions. These tools will integrate open-source temporal (i.e. historical and predictions for weather and climate) and spatial (e.g. land use, oceanic, socioeconomic, remote sensing etc.) data into machine learning (ML) models. The purpose of the ML models is to evaluate potential future threats to NbS projects and their financial investment. By analysing historical data on climate change and extreme weather events, as well as project-specific factors such as geographic location and environmental stressors, indications of risks such as extreme weather events will be key model outputs, both in terms of likelihood and impact.

The intention of such risk models is to help financial institutions understand how external environmental factors might affect project outcomes and returns. For example, a coastal NbS may be vulnerable to rising sea levels or increased storm activity, indicating to a potential funder that the project may be outside of their risk criteria for investments, or that the NbS provider must adopt mitigations through contingency planning or insurance mechanisms prior to agreeing financing.

Research and development within task 4.3 has commenced, and sections 4 and 5 provide specific detail of the work already done regarding the approach to risk assessment in this project.

3.2.2. Valuation of Ecosystem services

To ensure the BIOFIN-EU dashboard is effective at appraising biodiversity initiatives, it must have a robust method for identifying and evaluating ecosystem services for a given NbS project.

It is not within the scope of BIOFIN-EU to redefine methods for valuing ecosystem services. However, the online tool ENCORE (Exploring Natural Capital Opportunities, Risks, and Exposure) provides a robust framework for identifying ecosystem service dependencies and impacts, linking them to economic activities, and assessing associated risks. These insights can support decision-making and inform the financial valuation of NbS projects.

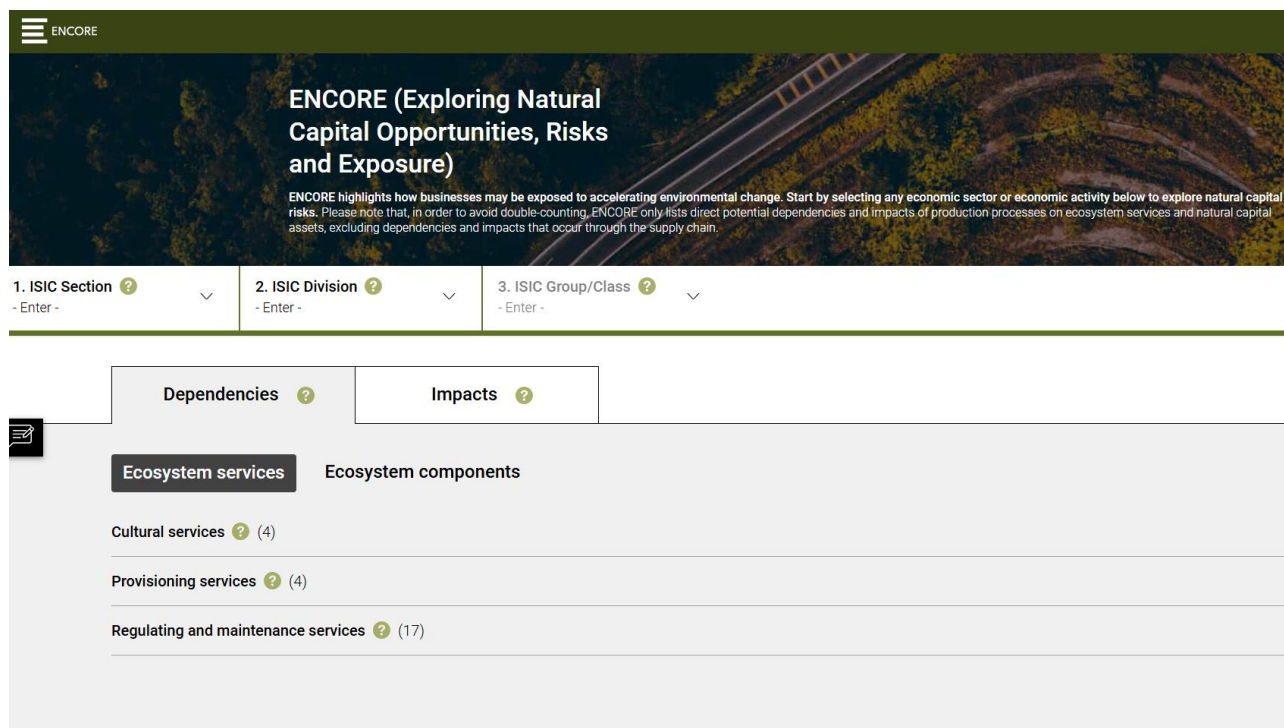


Figure 2: The ENCORE Tool

Source: <https://www.enconenature.org/en/explore>

ENCORE's data resources (i.e. the underlying ENCORE data model) is available for export and can be integrated into the BIOFIN-EU dashboard. In doing so, the dashboard can help NbS providers and financial institutions identify and assess ecosystem service dependencies and impacts for each NbS project. Already under research for the dashboard's feature requirements is enabling incorporation of such outputs into financial and investment appraisal models, for example, via an export tool or directly via API (Application Programming Interface) integration.

3.3. Reporting and Regulatory Compliance

Reporting is the disclosure of environmental and biodiversity-related information, as required by regulatory frameworks such as the Corporate Sustainability Reporting Directive (CSRD) and the Taskforce on Nature-related Financial Disclosures (TNFD). These frameworks mandate that organisations under certain criteria must provide transparent, standardised, and comprehensive reports on their environmental impacts, dependencies, and contributions, particularly in relation to biodiversity.

Effective reporting ensures that financial institutions, NbS providers, and other stakeholders can demonstrate compliance with regulatory requirements while enhancing accountability and supporting decision-making. A key feature of the BIOFIN-EU dashboard is to align its biodiversity data with these reporting standards, to facilitate the preparation of disclosures that meet regulatory expectations and support informed investment in NbS. The aim is to reduce reporting costs and to overcome the high administrative burden institutions increasingly face which in some cases make investments in NbS less attractive in comparison to traditional financial products.

This section focuses on CSRD and TNFD due to their relevance to the project learning sites (i.e. European and Globally respectively), while the final version of this deliverable will include additional reporting frameworks where relevant for the BIOFIN-EU dashboard.

3.3.1. CSRD

The Corporate Sustainability Reporting Directive (CSRD) sets out specific reporting requirements for large and listed companies within the European Union. It replaces the previous Non-Financial Reporting Directive (NFRD), expanding the scope and granularity of sustainability disclosures.

As stated by the European Commission, “EU law requires all large companies and all listed companies (except listed micro-enterprises) to disclose information on what they see as the risks and opportunities arising from social and environmental issues, and on the impact of their activities on people and the environment. This helps investors, civil society organisations, consumers and other stakeholders to evaluate the sustainability performance of companies, as part of the European green deal.” (EC, 2022)

The CSRD introduces mandatory sustainability reporting standards, requiring organisations to report on a wide range of environmental (e.g. biodiversity loss), social (e.g. workforce diversity), and governance (e.g. board accountability) metrics.

The BIOFIN-EU dashboard will support organisations in meeting CSRD requirements, specifically those related to biodiversity and environmental sustainability. The dashboard can contribute by:

- Providing Biodiversity Data: Offering robust datasets and visualisation on NbS and their environmental impacts, enabling companies to analyse and disclose accurate information on biodiversity-related risks and contributions.
- Enabling ESG Metrics Tracking: Supporting the integration of biodiversity data into broader ESG reporting frameworks, ensuring alignment with CSRD standards.
- Facilitating Compliance: Streamlining workflows for companies to assess, track, and report their biodiversity impacts and dependencies in line with the CSRD requirements.
- Automating Reporting Outputs: Generating structured, CSRD-compliant reports, reducing the burden of manual data collection and reporting.

In an example scenario, a company investing in a wetland restoration project can use the BIOFIN-EU dashboard to:

- Quantify the project’s positive impact on biodiversity, such as increased species diversity or improved water quality.

- Report on dependencies, such as the role of wetlands in providing flood protection and carbon sequestration.
- Demonstrate alignment with the CSRD's environmental reporting standards, highlighting their commitment to sustainability and regulatory compliance.

By aligning with the CSRD framework, the BIOFIN-EU dashboard can act as a practical tool for companies to help meet their reporting obligations, enhance transparency, and contribute to sustainable development goals.

3.3.2. TNFD

The Taskforce on Nature-related Financial Disclosures (TNFD) provides a global framework for organisations to assess, disclose, and manage nature-related risks and opportunities. Its aim is to guide businesses and financial institutions in integrating nature-related considerations into their decision-making processes and reporting structures, similar to the established Taskforce on Climate-related Financial Disclosures (TCFD).

The TNFD framework emphasises the dependency of businesses on natural capital and the risks posed by its degradation. These risks are categorised as:

- Physical risks: Impacts arising from the loss or degradation of natural ecosystems (e.g., loss of biodiversity-dependent resources).
- Transition risks: Economic and policy risks associated with transitioning to a nature-positive economy (e.g., regulatory changes).
- Systemic risks: Broad-scale impacts resulting from the interdependence of natural systems and economic activities.

The framework also highlights nature-related opportunities, such as investments in NbS and sustainable supply chains, which contribute to long-term resilience and financial value.

The TNFD framework aligns closely with the goals of the BIOFIN-EU dashboard by focusing on dependencies and impacts related to natural capital. The dashboard can support TNFD-aligned disclosures by:

- Mapping Dependencies and Impacts: Identifying how NbS projects interact with natural capital assets and ecosystem services.
- Quantifying Risks: Using spatial and temporal data to assess physical and systemic risks associated with biodiversity loss or climate change.

- **Highlighting Opportunities:** Providing insights into the value of NbS projects for enhancing biodiversity, reducing risks, and generating financial returns.
- **Supporting Reporting Requirements:** Enabling financial institutions to generate data-driven, TNFD-compliant reports on their investments in biodiversity initiatives.

For example, a financial institution investing in reforestation projects can use the BIOFIN-EU dashboard to assess potential physical risks, such as drought or fire, and quantify the ecosystem service benefits, such as carbon sequestration. These insights support TNFD-aligned disclosures, demonstrating the institution's commitment to managing nature-related risks and contributing to nature-positive outcomes.

By integrating TNFD principles into its framework, the BIOFIN-EU dashboard can play a pivotal role in advancing nature-related financial transparency and fostering sustainable investment practices.

4. Methodology

4.1. The BIOFIN-EU MVP Prototype

As the BIOFIN-EU Dashboard itself will mediate access to biodiversity data for financial institutions, it is important to describe the methodology behind its development. With support from all work packages in the project, work package 4 are first developing a Minimum Viable Product (MVP) dashboard, intended as an initial prototype. The MVP approach is long-standing in software development and serves as a mechanism for defining, developing, and testing the project's assumptions about the dashboard and its user's requirements before finalising requirements for the actual dashboard.

Although not explicitly described in the DoA, the management board and work package leaders opted for the MVP approach for BIOFIN-EU. This decision facilitates the design and testing of specific requirements through a prototype while providing key input to Task 5.3, "BIOFIN-EU NBS Dashboard Proof-of-Concept Design and Implementation." It gives the consortium a tangible user interface to visualise and test use cases and data workflows, with the benefit of short development and testing cycles without the risk of consuming project resources (i.e. person months) on robust outputs which are considered unsuitable for the final dashboard.

From August 2024 (Month 8), work package 4 has adopted the MVP methodology, creating test versions of the BIOFIN-EU dashboard based on requirements agreed with work packages and external project stakeholders during workshops and dedicated meetings. This iterative approach enables rapid development and enhancement of core functionalities based on feedback from users. It ensures the dashboard evolves to meet the actual needs of its audience and helps find bottlenecks and potential issues in advance of the formal development. The end state of the MVP will serve as the primary basis of requirements for the BIOFIN-EU dashboard itself and gives the project confidence that the final product will be fit for purpose and meet the needs of its users and stakeholders.

4.2. Data Collection Strategy

To develop the BIOFIN-EU Dashboard and its biodiversity risk assessment framework, the project employs a structured and comprehensive data collection strategy. The strategy combines top-down and bottom-up approaches to ensure that biodiversity data is captured at both macro and micro scales (Eicken, 2021). By integrating global-scale data with site-specific observations, the methodology creates a holistic and validated understanding of biodiversity risks, disturbances, and ecosystem changes (Ding, 2022). The approach not only leverages existing open-source datasets and cutting-edge tools like remote sensing but also will actively engage local stakeholders, ensuring that the collected data is both relevant and actionable.

4.2.1. Top-Down Approach

The top-down approach focuses on macro-level data collection and analysis by utilizing open-source global datasets, remote sensing technologies, and climate databases (Cowell et al., 2020). It allows for the

identification of large-scale biodiversity patterns, land-use changes, and ecosystem disturbances across geographical scales. For instance, remote sensing tools such as Sentinel-2 and Landsat provide high-resolution imagery that supports the mapping of land cover changes, vegetation loss, and climate extremes such as droughts or flooding. These datasets form a foundation for grouping regions into climate zones and understanding ecosystem-level biodiversity threats driven by natural and anthropogenic factors (Prakash et al., 2022).

Existing studies have demonstrated the effectiveness of remote sensing and large-scale databases in biodiversity monitoring (Kerry, 2022; Reboud, 2021; Vihervaara, 2017). Platforms such as the Global Biodiversity Information Facility (GBIF) and UNEP-WCMC have been instrumental in assessing species distributions, protected areas, and ecosystem degradation. Additionally, climate data repositories like WorldClim and ERA5 have been widely utilized to monitor temperature and precipitation trends, providing critical insights into environmental disturbances. By leveraging these tools, the top-down approach delivers comprehensive spatial and temporal data that inform regional biodiversity risk assessments, enabling decision-makers to prioritize critical zones for intervention.

In the BIOFIN-EU project, the top-down approach is applied to categorize regions into specific climate and geographical zones based on temperature, weather patterns, ecosystems, and land-use classifications. The application of remote sensing tools ensures consistent, scalable data acquisition that can be compared across regions (Cavender-Bares et al., 2022). However, recognizing that macro-level data may lack granularity, the top-down approach is complemented by bottom-up methods to capture site-specific nuances. The integration ensures that regional biodiversity risks are well-identified and validated, laying the groundwork for effective biodiversity risk modelling.

4.2.2. Bottom-Up Approach

The bottom-up approach complements the macro-scale insights of the top-down methodology by capturing detailed, site-specific biodiversity data through ground-truthing techniques, questionnaires, and stakeholder engagement (Pielke et al., 2021). Learning site questionnaires serve as a primary tool for gathering localized information about biodiversity conditions, disturbances, and ecosystem health. These questionnaires are distributed to key stakeholders, including local managers, auditors, and communities, who offer qualitative and quantitative insights into biodiversity dynamics that often are not visible in large-scale datasets. For instance, the effects of localized land-use changes, such as agricultural practices, can be directly observed and assessed through stakeholder responses (Asah, 2020).

In addition to questionnaires, scorecards provide a structured, systematic way to evaluate biodiversity indicators at learning sites. These scorecards measure ecological conditions such as habitat quality, species abundance, and disturbance impacts, ensuring consistency and comparability across different sites. Previous research has demonstrated the utility of site-based scorecards and stakeholder input in validating top-down findings and filling gaps in global datasets (Pereira, 2019; Tsiripidis, 2018). This participatory approach

enhances the accuracy and credibility of the data, as it incorporates local expertise and knowledge not captured in remote sensing analyses.

The bottom-up approach in the BIOFIN-EU project ensures that the insights from local learning sites are effectively integrated into the broader analysis. Site-specific data validate top-down findings, offering a more granular understanding of disturbances such as habitat fragmentation, hydrological issues, and biodiversity degradation. The active engagement of stakeholders ensures that the collected data reflects on-the-ground realities, making it a critical component of the BIOFIN-EU Dashboard. While bottom-up methods can be resource-intensive, their ability to enhance the reliability and context of biodiversity data justifies their inclusion as a core element of the methodology.

The BIOFIN-EU project's data collection strategy achieves a balance between macro-level scalability and micro-level precision through the integration of top-down and bottom-up approaches. The top-down approach leverages global datasets, remote sensing, and climate databases to identify large-scale biodiversity disturbances and patterns, enabling regional classification and risk prioritization. Conversely, the bottom-up approach enriches this analysis by capturing site-specific biodiversity insights through learning site questionnaires, scorecards, and stakeholder engagement. Together, these methods ensure a robust and validated dataset that informs the biodiversity risk assessment framework and supports the development of the BIOFIN-EU Dashboard. By combining these approaches, the project delivers actionable, reliable biodiversity data that meets the needs of financial institutions, stakeholders, and policymakers, driving evidence-based decision-making for sustainable investments.

5. Biodiversity data framework

5.1. Framework for Biodiversity Data Integration

The Framework for Biodiversity Data Integration in the BIOFIN-EU project is designed to merge high-resolution spatial and temporal data (remote sensing data) with multisource biodiversity information (in-situ, regional or national data) (Helfenstein et al., 2022). This approach ensures comprehensive and accurate biodiversity assessments that align with policy frameworks and financial decision-making. The data collection and integration process involved identifying datasets that provide regional and site-specific insights, capturing the diverse aspects of biodiversity, including ecosystem services, species occurrences, and human impacts (IPBES, 2019; Jetz et al., 2016). This section details the methodological steps, challenges encountered, and strategies used to overcome them.

5.1.1. Current Challenges and Framework Approach

Integrating biodiversity data into financial decision-making processes requires addressing critical limitations in existing methodologies (Nedopil et al., 2023). While approaches such as Mean Species Abundance (MSA) provide insights into ecosystem health by assessing biodiversity relative to ideal ecosystem baselines, they often lack sufficient spatial and temporal granularity to effectively capture localized disturbances or predict long-term biodiversity risks (Hoeks, 2020). Furthermore, global datasets, though extensive, frequently fail to account for region-specific ecological variations, limiting their utility for precise investment strategies or compliance with financial and regulatory reporting standards (Ploton, 2020).

To address these challenges, the data collection process initially leveraged the dataset by Román-Palacios et al. (2020), which employs the DPSIR framework (Driver, Pressure, State, Impact, Response). This dataset provides a structured overview of environmental research sources across Europe but poses challenges, including inconsistent temporal coverage and an over-dependence on remote sensing data. Despite these issues, key resources were identified, including Copernicus products for land cover and the Global Biodiversity Information Facility (GBIF) for species occurrence data, which formed the foundation for subsequent integration efforts.

Further refinement of the approach focused on Ireland's Nature-Based Solutions (NbS) in the Burren region, celebrated for its unique biodiversity and environmental initiatives. Programs such as the BurrenLIFE Project, the Burren Farming for Conservation Program, and the Burren Program provided comprehensive datasets derived from environmental health assessment systems. These regional efforts highlighted thriving biodiversity indicators but were limited by their highly localized focus and the absence of comparable datasets in other regions. Nevertheless, Ireland's extensive regional and national biodiversity data from government sources, particularly on environmental and human impact data (Mac Domhnaill et al., 2020), offered broader applicability. These datasets, which include groundwater chemical concentrations and water quality map layers across Ireland, bring significant value to the framework.

Attention then shifted to Italy's NbS in the Lombardy region, where regional and national data availability proved significantly lower compared to Ireland. Metadata gaps and inconsistent resolution or temporal

frequency posed additional challenges. However, some valuable datasets were identified, including historical water quality, carbon absorption by soil, soil quality (type and nutrient content), future groundwater flooding probability, historical air quality zones, and waste treatment records. These datasets were sourced from the GeoPortal of the Lombardy Region, the Open Data of the Italian Public Administration Portal, the National Institute of Statistics of Italy, and the Ministry of Environment of Italy.

The BIOFIN-EU Framework evolved to prioritize datasets offering both regional and global coverage, facilitating the development of a scalable and policy-aligned approach. After analysing regional and national datasets, we incorporated remote sensing data to enhance granularity and coverage. The next section will detail the remote sensing datasets considered and explore the potential benefits of data fusion, which combines regional/national and remote sensing datasets to achieve more accurate insights.

5.1.2. Spatial-Temporal Integration and Multisource Data Fusion

A central focus of the BIOFIN-EU framework is addressing challenges arising from the use of large, heterogeneous datasets and designing actions to mitigate the negative impacts on Nature-Based Solutions (NBS). To address these challenges effectively, spatial and temporal multi-source data must be combined and analysed within a coherent data fusion framework (Castrignanò,2020). Various classifications for data fusion approaches have been proposed, as summarized by (Castanedo,2013). These classifications provide a comprehensive overview of data fusion at different levels: (i) relationships between input data sources, (ii) input/output data types, and (iii) the level of fusion. These levels describe data fusion from a methodological perspective and define how and to what extent different types of data can work together to improve result reliability. This facilitates mapping biodiversity disturbances, including habitat fragmentation, deforestation, and land-use changes. Spatial granularity aids in identifying biodiversity hotspots and areas under ecological stress, enabling targeted interventions. Temporal resolution is achieved by integrating time-series data, allowing for both short-term monitoring and long-term forecasting of ecosystem health over periods of 10, 20, or 30+ years.

The framework incorporates a diverse set of data sources to comprehensively capture the complexity of biodiversity systems. As a first step, initial efforts focused on establishing a catalogue of datasets related to ecosystem services, categorized into species data, habitat and land use, human impacts, conservation and protected areas, and socio-economic factors (VanderWilde,2021; La Notte,2017). Key global datasets include CORINE Land Cover 2018, Copernicus temperature and precipitation products, and Natura 2000 zones, which collectively provide resolutions up to 100 meters, making them ideal for analysing both NBS sites and their surrounding areas. This catalogue supports the development of a reference framework for future NBS projects across Europe.

For species-level biodiversity assessments, the framework integrates GBIF and the IUCN Red List to quantify species occurrences and protection statuses (Bellard,2022). These datasets are enhanced using forecasting algorithms, which predict future species distributions under changing land-use and climate scenarios. To account for anthropogenic impacts, OpenStreetMap (OSM) has been utilized to extract vector features such as highways and urban infrastructure. Using QuickOSM in QGIS, standardized queries enable efficient spatial analysis of human impacts on biodiversity, such as the habitat fragmentation caused by urbanization. By pairing these data with remote sensing products such as Copernicus, potential species distributions can be modelled even under evolving environmental conditions (Bühler et al., 2021).

The framework bridges these gaps by harmonizing datasets, ensuring scalability, relevance, and accuracy. This integration supports policy-driven metrics while reflecting real-world biodiversity conditions, enabling the BIOFIN-EU Dashboard to deliver actionable outputs for financial institutions and ecological stakeholders.

5.1.3. Standardisation and Alignment with Indicators

The final step in the framework involved standardizing biodiversity data and aligning it with validated indicators and financial taxonomies. To ensure consistency, all datasets were processed using the T4.2 ontology framework, which facilitated semantic interoperability between biodiversity metrics and financial systems. This standardization ensured that biodiversity data could be seamlessly integrated into the BIOFIN-EU Dashboard for risk modelling and sustainability reporting.

The selection of biodiversity indicators was guided by their relevance to ecosystem health and policy frameworks. Key indicators included:

- Mean Species Abundance (MSA): A baseline metric for ecosystem health.
- Habitat Quality Index (HQI): To measure habitat conditions and their ability to sustain biodiversity.
- Carbon Sequestration Potential: To evaluate the contributions of ecosystems to climate change mitigation.

These indicators were further aligned with the ENCORE taxonomy, which links biodiversity dependencies and impacts to economic activities. This alignment ensured compatibility with global sustainability frameworks such as the EU Taxonomy, TNFD, and CSRD.

Transparency and accuracy were prioritized throughout the process. Local data validation, stakeholder engagement, and the documentation of methodologies enhanced the credibility of the framework. By integrating local observations with high-resolution remote sensing data, the framework achieved a balance between scientific rigor and practical usability.

6. Risk modelling biodiversity

The BIOFIN-EU project methodology follows a structured, step-by-step process to collect, analyse, and utilize biodiversity data for financial decision-making (Figure 3). It integrates top-down and bottom-up approaches to ensure both global and site-specific perspectives. The process begins with geographical categorization, identifies biodiversity disturbances, collects and analyses data, and applies machine learning (ML) techniques to predict and assess risks. These output indices and catalogues of biodiversity risks, enabling stakeholders to visualize, compare, and prioritize regions or interventions through the BIOFIN-EU Dashboard. This systematic approach ensures that biodiversity risks are quantified, monitored, and communicated effectively, supporting evidence-based decision-making for financial institutions and policymakers. The following subsections detail the methodology phases and tools used.

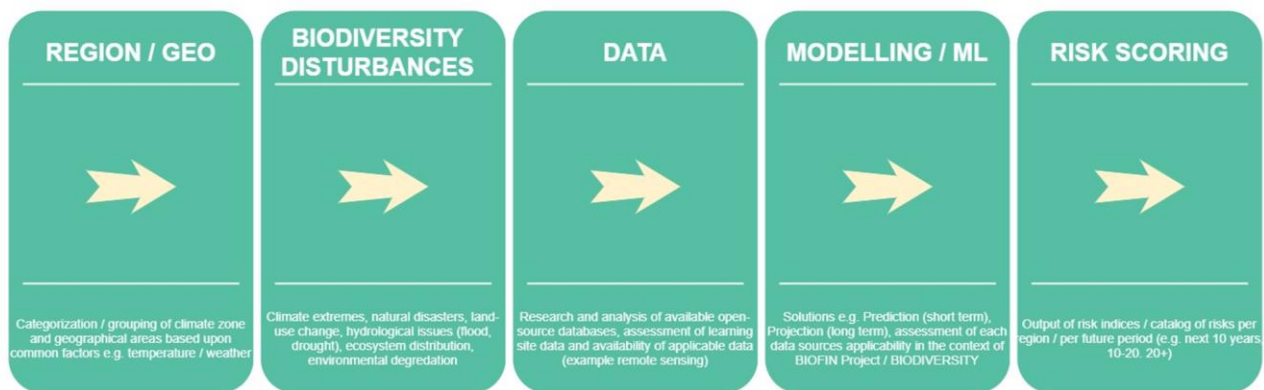


Figure 3: Integrated Biodiversity Risk Assessment Framework for the BIOFIN-EU Project

6.1. Region and Geographical Categorization

The first step in the biodiversity risk modelling process vision will involve the categorization of regions and geographical areas based on shared environmental and climatic features. This categorization is essential to establish a baseline for analysing biodiversity conditions and identifying region-specific risks (Zhao et al., 2024). Using high-resolution remote sensing data (e.g., Sentinel-2, Landsat) and global climate datasets (e.g., WorldClim, Copernicus Climate Data Store), regions are grouped into climate and ecological zones. Key factors such as temperature, precipitation, land cover, and topography are analysed to identify spatial patterns and classify regions with similar environmental characteristics. To complement remote sensing outputs, learning site observations and localized data from stakeholder inputs (e.g., surveys, scorecards) are incorporated to validate and refine the categorization. For instance, data collected from Ireland's Burren region and Italy's Lombardy region provide valuable insights into localized ecological variations and human impacts.

The output of this step is a spatially explicit classification of regions, which serves as the foundation for subsequent analyses. This structured approach ensures that biodiversity disturbances and risks are assessed

within a regional context, supporting targeted interventions and comparative evaluations across geographic areas (Hoffmann et al.,2022).

6.2. Identification of Biodiversity Disturbances

The second step in the biodiversity risk modelling process emphasizes identifying key disturbances that threaten ecosystems, as these are often context-specific and dynamic (Prakash, 2022). These threats stem from both natural and anthropogenic factors, including climate extremes (e.g., floods, droughts), natural disasters (e.g., storms, fires), and ecosystem degradation (e.g., habitat fragmentation, pollution) (Burton et al., 2020). Notably, contemporary challenges such as climate change and rapid urbanization have emerged as critical drivers of biodiversity loss, reshaping habitats and intensifying stressors on ecosystems. To capture these disturbances comprehensively, the framework integrates high-resolution satellite imagery (e.g., Sentinel-2, Landsat) for detecting land cover changes, such as urban sprawl and deforestation, alongside climate datasets (e.g., Copernicus Climate Data) to monitor extreme weather events. These data are further enriched with field insights from learning sites, including community surveys and scorecards, which provide localized details and context that complement the broader perspective offered by global datasets (Atkinson et al.,2022).

By merging global remote sensing data with field observations, this step offers a holistic view of biodiversity disturbances. The focus on climate change and urbanization highlights their pivotal role in exacerbating ecological imbalances, facilitating targeted interventions. Identifying these disturbances provides essential input for predictive models and the development of strategic mitigation plans, aligning with global conservation priorities.

6.3. Data Collection and Integration

The third step in the biodiversity risk modelling process emphasizes the collection and integration of diverse datasets to create a comprehensive foundation for analysis. This approach merges global-scale datasets with site-specific observations, ensuring both wide coverage and regional accuracy (Nursamsi, 2024). Global open-source datasets, such as GBIF for species occurrence, Copernicus products for land cover, temperature, and precipitation, and WorldClim for climate trends, provide macro-level insights into biodiversity patterns and environmental conditions. At the regional scale, detailed field data is collected from learning sites like Ireland's Burren region and Italy's Lombardy region. Stakeholder-driven inputs, including questionnaires, scorecards, and environmental assessments, contribute localized insights that complement and validate broader datasets.

To ensure consistency and usability, the collected data is standardized and processed using tools like the T4.2 ontology framework, which harmonizes diverse formats and ensures interoperability for downstream modelling. Spatial data from remote sensing is combined with temporal trends derived from time-series analyses, while field observations enhance accuracy and granularity. This integration process results in a

robust, multi-source dataset that serves as the backbone of the risk modelling framework, enabling scalable and relevant predictions of biodiversity risks across short- and long-term timeframes (Zhu,2024; Ma,2024).

6.4. Modelling and Machine Learning

The fourth step in the biodiversity modelling process applies machine learning (ML) techniques and statistical models to assess and predict biodiversity patterns and dynamics over varying time horizons. This phase focuses on transforming integrated datasets into actionable insights by developing predictive models that address both short-term and long-term biodiversity trends. Short-term analyses utilize current and historical datasets, such as land cover changes, species occurrence, and climate variability, to assess immediate changes in biodiversity, including habitat dynamics and species distributions (Branco et al., 2023). For long-term projections, advanced ML models, including Random Forest and time-series forecasting, are employed to simulate future biodiversity scenarios under different conditions, such as climate change, land-use transitions, and human interventions (Eddamiri et al., 2024). The modelling process integrates spatial data from remote sensing products with temporal trends and ground-truth observations to enhance accuracy and reliability. Scenario analysis is also conducted to evaluate the potential impacts of environmental and anthropogenic changes, enabling the assessment of Nature-Based Solutions (NBS) performance under varying ecological and economic conditions. Outputs from the ML models include biodiversity prediction maps, species distribution forecasts, and ecosystem assessments, providing critical insights for stakeholders.

This phase ensures that biodiversity trends are not only quantified but also projected into the future, empowering decision-makers to anticipate changes, prioritize conservation actions, and assess long-term sustainability outcomes.

6.5. Risk Assessment Approach

The risk assessment approach integrates predictive modelling and quantitative analysis to evaluate biodiversity risks across spatial and temporal scales. By leveraging machine learning outputs and statistical models, this approach generates risk scores that quantify the severity and likelihood of biodiversity disturbances. These scores are calculated for both short-term and long-term timeframes, enabling the identification of immediate risks and the projection of future vulnerabilities over 10, 20, or 30+ years.

The risk scores are compiled into comprehensive risk indices and catalogues, ranking regions, ecosystems, and learning sites based on their exposure to critical stressors such as land-use changes, climate extremes, and ecosystem degradation. Inspired by global assessments of socio-ecological risks (Yang,2021; Klippel,2024), this framework incorporates a sensitivity analysis to account for overlapping influences from multiple stressors, including development pressures, biodiversity hotspots, and socio-economic contexts. Particular attention is given to high-risk areas like critical habitats, protected zones, and lands where anthropogenic activities can have disproportionately negative impacts (Bowler et al.,2020).

As a future enhancement, the framework will introduce a dedicated biodiversity risk index, designed to synthesize spatial and temporal data, model ecosystem vulnerabilities, and provide a unified metric for biodiversity threats. This index will allow stakeholders to benchmark risks across different regions, track trends over time, and better prioritize conservation efforts (Rout et al.,2021). These outputs are presented

through the BIOFIN-EU Dashboard, an interactive platform that allows stakeholders to visualize, explore, and analyse biodiversity risks. Incorporating spatial data from ground-truthed surveys and remote sensing, the dashboard supports evidence-based decisions by comparing region-specific vulnerabilities with global trends. The platform's tools facilitate comparative assessments and provide customizable options to prioritize interventions, evaluate the performance of Nature-Based Solutions (NbS), and align conservation actions with sustainability and financial goals.

By combining data-driven risk scoring with user-friendly visualization, the risk assessment approach ensures that biodiversity insights are accessible, actionable, and scientifically robust. This systematic process is essential for addressing the dual challenges of biodiversity conservation and socio-economic development. It empowers stakeholders, including financial institutions and policymakers, to make informed decisions, proactively address biodiversity challenges, and implement strategies that support long-term ecological resilience (Katic et al.,2023).

7. Recommendations and roadmap to version 2

Before the final version of this deliverable can be completed in December 2025 (M24), there are several key priorities which must be addressed. The following sub-sections briefly introduce the priorities and how they will be addressed over the upcoming 12 months.

7.1. Analysis of classification taxonomies and reporting frameworks

As outlined in Section 3, the success of the BIOFIN-EU dashboard relies on its ability to align with relevant taxonomies and frameworks. This alignment ensures that financial institutions can assess the relevance and value of NbS investments and meet reporting and disclosure requirements.

In collaboration with Work Package 5, a comprehensive analysis of existing frameworks and taxonomies will be conducted. The findings, along with decisions about their integration into the dashboard and the rationale behind these decisions, will be presented in the final deliverable. This will ensure the dashboard supports consistent and robust classification and reporting processes.

Key Actions:

- Conduct a comprehensive review of existing taxonomies (e.g., EU Taxonomy) and reporting frameworks (e.g., CSRD, TNFD) in collaboration with Work Packages 2 and 5.
- Evaluate the applicability of each taxonomy and framework to the BIOFIN-EU dashboard.
- Define clear criteria for integration into the dashboard, including coverage of biodiversity impacts, economic activity categorisation, and reporting requirements.
- Document decisions and rationale for integration or exclusion, providing transparency and alignment with project objectives.

7.2. Scoping of use-cases for financial institutions

As introduced in section 3.2, use cases are in development in collaboration with Work Packages 2, 3 and 5. These use cases are intended to demonstrate potential real-world scenarios in which a specific financial institution would interact with the BIOFIN-EU dashboard.

The objectives are to:

- Identify practical applications for the dashboard.
- Stress-test features and functionalities using prototypes.
- Derive key requirements for dashboard development based on validated use case results.

This iterative approach ensures the development aligns with the needs of financial institutions and regulatory frameworks.

Key Actions:

- Collaborate with Work Packages 2, 3 and 5, as well as external stakeholders, to identify high-priority use cases relevant to financial institutions and their biodiversity-related activities.
- Define scenarios (i.e. workflows) that cover key operations, such as assessing the viability of NbS projects, tracking biodiversity dependencies, and reporting on environmental impacts.
- Map the scenarios into a set of requirements and feature requests for the BIOFIN-EU dashboard MVP.

7.3. Development iterations of BIOFIN-EU dashboard

As introduced in Section 4.1, the BIOFIN-EU dashboard will follow an iterative development approach to maintain continuous alignment with stakeholder needs and build the overall requirements for the final dashboard. The focus will initially be on delivering a Minimum Viable Product (MVP) that addresses the defined use cases (Section 7.2). Subsequent iterations will refine and expand the dashboard's features based on testing, feedback, and evolving requirements.

Key Actions:

- Plan and Execute Iterative Development Cycles
 - Adopt short development cycles (2–4 weeks) to allow rapid implementation and testing of features.
 - Focus each cycle on delivering functionalities tied to specific use case scenarios.
 - Prioritise features critical to MVP delivery, such as biodiversity data integration, reporting tools, and machine learning outputs.
- Develop Use-Case Specific Prototypes
 - Create MVP prototypes tailored to high priority use cases (defined in section 8.2) to simulate real-world application scenarios.
 - Use these prototypes to test and validate core dashboard functionalities, including classification, reporting, and data visualisation.
- Engage Stakeholders Through Workshops and Demonstrations
 - Conduct regular internal workshops to present progress, demonstrate use case scenarios, and collect feedback.
 - Address identified gaps, risks, or potential issues during these sessions.
 - Engage project stakeholders actively to ensure the dashboard meets practical and regulatory requirements.

- Gather and Analyse Feedback
 - Continuously gather input from stakeholders during and after prototype testing.
 - Use structured feedback mechanisms to capture insights on usability, feature relevance, and technical performance.
 - Incorporate feedback into subsequent development cycles to refine features and address stakeholder concerns.

- Define Key Requirements for the Final Dashboard
 - Document the requirements for the final dashboard based on MVP testing results and stakeholder feedback.
 - Prioritise requirements that align with project objectives, regulatory frameworks, and stakeholder expectations.

8. Challenges, Limitations and Risks

8.1. Data availability and completeness

Challenge

The BIOFIN-EU dashboard depends on comprehensive data, namely biodiversity data to evaluate and report on NbS investments. Data is also the main input into the Machine Learning models introduced in section 4. Challenges in ensuring the availability, completeness, accuracy, and compatibility of this data can undermine the dashboard's functionality and its ability to provide reliable insights.

Limitations

- Difficulty in obtaining region-specific, high-resolution biodiversity data for a specific NbS location
- Difficulty ensuring consistency and compatibility between datasets from different sources.

Risks

- **Data Gaps:** Lack of comprehensive biodiversity data, particularly in underrepresented regions or for certain ecosystem services.
- **Data Quality:** Variations in methodologies and inaccuracies in existing datasets can lead to inconsistent results.
- **Outdated Information:** Static datasets failing to reflect recent ecological changes.
- **Access Challenges:** Limited availability of proprietary or high-resolution data due to restrictions or costs.

To mitigate the limitations and risks detailed above, task 4.2 will define the data model and standards for the BIOFIN-EU dashboard i.e. the BIOFIN-EU Ontology. This ontology will be core to aligning disparate datasets and providing meaning and transparency to the data within the dashboard, by means of FAIR metadata and clear definitions for concepts and values. An already agreed core feature of the dashboard is to ensure financial institutions can trace data provenance and access data from the dashboard directly (via API) to integrate it into their own systems.

8.2. Machine Learning Models (ML)

Challenge

Machine learning (ML) models are central to the dashboard's risk modelling and analytical functionalities, but their development and implementation are fraught with challenges such as ensuring model accuracy, avoiding bias, maintaining transparency, and adapting to dynamic and complex biodiversity data.

Limitations

- ML models require significant computational resources and expertise, which may limit scalability.
- Training and refining models is time-intensive, potentially delaying MVP development.
- Dependence on historical data limits the ability to capture dynamic, real-time ecosystem changes.

Risks

- Model Bias: Limited or unbalanced training data can lead to biased predictions, particularly in areas with scarce biodiversity data.
- Overfitting: Models may perform well on training data but fail to generalise to unseen scenarios or regions.
- Interpretability: Complex models may lack transparency, making it difficult for users to trust or understand their outputs.
- Data Sensitivity: ML models are highly sensitive to data quality and completeness, magnifying the impact of data-related risks.

Although the above risks and limitations are typical in machine learning projects, focusing on diverse training data, explainable models, and iterative testing should help mitigate issues like bias, overfitting, and lack of interpretability, ensuring the models are both robust and practical for the BIOFIN-EU dashboard.

This project will also explore whether the ML models will run in real time (i.e. in response to input criteria from a dashboard user), or whether the model outputs can be pre generated, thus reducing potential impact on computational resources.

8.3. Dashboard use cases and MVP development

Challenge

Gathering requirements for the BIOFIN-EU dashboard and translating them into technical feature definitions is a core challenge for the project, given the dashboard's application spans a diverse range of use cases. It must address needs across diverse financial institutions and heterogeneous NbS and biodiversity initiatives. The iterative development approach based on use case defining and testing ensures practicality and speed but also introduces risks and limitations.

Risks

- Scope Creep: Expanding use case definitions during development may lead to delays and resource constraints.
- Misalignment with Needs: Prototypes may not fully align with stakeholder expectations due to incomplete feedback or evolving requirements.

Limitations

- The MVP may lack advanced features, leading to reduced functionality in initial deployments.
- Testing with a limited number of stakeholders may not capture all real-world scenarios, leading to gaps in functionality.
- Prototypes developed for specific use cases may not scale well to other scenarios without significant rework.

Although the above risks and limitations are quite normal for dashboard development, and software in general, the MVP approach, its quick iterations and focus on functionality over design, should help to mitigate such issues, and ensure that a large amount of resources is not used up building full features which are not fit for purpose.

The lack of advanced features limitation can be addressed by clear communication of the MVP approach and in more comprehensive use cases, by dedicating resources to more complete feature development where the developed software can be reused in the final dashboard.

8.4. General limitations

Limitation with ENCORE

Section 3.2.2 introduced the ENCORE tool as a means for assessing ecosystem services. While ENCORE provides a useful framework, it has limitations that need addressing to achieve a more comprehensive appraisal. For example, it does not directly quantify ecosystem services in monetary terms and focuses solely on direct dependencies and impacts of production processes, excluding those that occur through the supply chain. The next version of this deliverable will explore strategies to address these limitations, potentially through the integration of supplementary tools

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