

# Navigating nature-related data: metrics, sources and uses

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## Executive Summary

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**The aim of this note is to provide an overview of available nature-related data resources and methods to integrate them in risks assessment by gathering the experience of various actors:** corporate firms, financial firms, multilateral organizations, central banks, and supervisory regulators. It highlights the commonality of their approaches and the wide use of nature-related data in building metrics and indicators for multiple purposes: micro-prudential supervision, macro-prudential oversight for financial stability, macroeconomic analysis for informing monetary policy, statistical indicators, general research, non-supervisory engagement, and portfolio management.

**Although these resources and methods are key, the quality of risk and impact assessments relies on the choice of metrics and indicators.** The note explains how to explore the metrics and indicators used by the *Task Force on Nature-Related Financial Disclosures* (TNFD) by applying five criteria: relevance for metrics of land use and land cover change; importance of the climate-nature nexus; consideration of the geographical location of impacts and dependencies; multidimensionality of nature-related risk; and data availability.

**Four case studies are presented to illustrate how nature-related indicators can be integrated into risk analysis and the lessons to be learned.** The first two cases – from the euro area and Malaysia – highlight the dependency of economic sectors to ecosystem services and show the need for centralized data infrastructure to support risks assessment and the limitations of current methods to account for geographic variations or supply chain dependencies. The third case – water pollution analysis in the Oder River – demonstrates how real-time monitoring tools and genomic data can be used for risk assessment. The fourth – Milan's green infrastructure initiatives – shows that data and methods for assessing the economic impacts of nature-based solutions already exist.

**For financial authorities, nature-related risks need to be addressed both at the individual and systemic level.** The case studies show that nature-related risk assessment requires the combination of several databases, to overcome time or spatial gaps within each data source. In this context, access to granular credit databases is key for nature-related

risks assessment. This note highlights several dimensions of data measurement, ranging from agricultural geospatial analysis to the location, characterization and valuation of infrastructure and assets.

**Despite these advancements, progress should be made in terms of data quality and availability.** Nature-related data collection suffers geographical restrictions due to the need for physical sampling; many ecosystem services require more precise geospatial and interdependency data to assess cascading effects; and financial risk assessment suffers from the absence of standardized reporting frameworks. Integrating machine learning tools is both an opportunity and a challenge: while it can identify the statistical relationship between input and output data without knowing the physical process, there is a risk of overlooking intricate complexities and producing misleading evaluations.

**These challenges can be addressed through public-private collaboration** by implementing a roadmap that optimises the generation of both existing and new data, complements public sample collections with private data from specific monitoring locations, and leverages technological innovations to generate local data. Data management and application can be improved with open-source databases, more granular information to calibrate biophysical models, and valuation of ecosystem services that accounts for the heterogeneity of their spatial characteristics.

**Overall, nature data gaps can be overcome** by first characterizing missing data and then applying statistical approaches to each class, encouraging citizen science for a greater spatial coverage and synthesizing local data from non-English sources. The use of ground-based images is also key, alongside targeted investments in data-scarce regions where biodiversity loss has significant ecological and economic implications.

# Technical Summary

## Range and use cases of nature indicators and metrics

**The Network of Central Banks and Supervisors for Greening the Financial System (NGFS), Organisation for Economic Co-operation and Development (OECD), International Monetary Fund (IMF) and Taskforce on Nature-related Financial Disclosures (TNFD) conceptual frameworks to address nature-related risks operate in distinct yet complementary ways. Together, they provide a comprehensive analysis of the drivers of change in nature and their complex direct and indirect interplay.**

Each framework brings a complementary lens: the TNFD emphasises corporate disclosure, the NGFS focuses on macro-prudential analysis, the IMF links to macroeconomic vulnerabilities, and the OECD stresses policy design. These frameworks all highlight that local environmental impacts can have significant global repercussions, illustrating how global economic activities can convert localised risks into widespread threats. They all task financial authorities with identifying the primary drivers of ecosystem loss and understanding how these factors affect ecosystem services and their associated impacts.

**Commonalities in addressing drivers of nature change can be seen in the different metrics and data points used to disclose nature-related risks.** In many cases, these

metrics also incorporate a location-based dimension, such as the proximity of operations to sensitive ecosystems or biodiversity hotspots, which is critical for understanding context-specific risks. Despite differences in emphasis, all frameworks acknowledge that climate-related and nature-related risks are systemic and interdependent, and that measuring nature-related risks is more complex due to the multiple dimensions, non-linearities, and location-specific features involved in ecosystem dynamics, which requires localised assessments rather than global models. Furthermore, uncertainty around nature-related risks is greater, stemming from knowledge gaps in biosphere processes and ecosystem dynamics.

**There are different use cases for nature-related indicators and metrics, from statistical analysis to the actual assessment of nature related risks and opportunities, which are summarized in Table 1.**

Table 1 Use cases and targeted metrics for nature-related data

Use cases	Description	Targeted Metrics	Data requirement	Tools and purpose
<b>Micro-Prudential Supervision</b>	Focuses on the safety and soundness of individual financial institutions.	Specific indicators of nature-related exposure and dependencies of financial institution assets.	Detailed data on localized nature-related impacts, dependencies and opportunities to assess risks at the company level.	Quantitative metrics to measure financial vulnerabilities due to nature-related changes.
<b>Macro-Prudential for Financial Stability</b>	Focuses on the stability of the financial system.	System-wide indicators of nature-related risks and dependencies across sectors.	Broad-scale data on systemic nature-related risks and their potential impacts on financial stability.	Models to evaluate economic consequences of nature-related losses on systemic risks.
<b>Monetary Policy</b>	Uses data to analyse macroeconomic conditions and inform monetary policy decisions.	Metrics reflecting broader economic impacts of nature-related changes (e.g., inflation, employment).	Data on nature-related factors influencing economic variables.	Tools to quantify economic impacts of nature-related losses on monetary policy objectives.
<b>Statistical analysis and research</b>	Provides data for general economic analysis and reporting.	Indicators for benchmarking and longitudinal studies (e.g. nature-related indexes, ecosystem service valuations).	Data supporting trend analysis and comparisons over time.	Statistical tools to analyse the interaction of nature with broader economic and financial variables.
<b>Non-Supervisory Engagement</b>	Uses data to engage stakeholders outside regulatory frameworks.	Metrics for public communication and stakeholder engagement.	Data supporting narratives on nature-related impacts relevant to broader society.	Metrics demonstrating nature's value to non-financial stakeholders.
<b>Portfolio Management</b>	Helps investors manage risk and optimize returns by considering nature-related impacts.	Indicators of nature-related risks, opportunities, dependencies and impacts associated with investments.	Tools for scenario-based risk assessments integrating nature-related factors.	Quantitative metrics for evaluating nature-related risks, opportunities, dependencies and impacts.

## Exploring TNFD metrics and indicators

### Measuring nature-related risks involves navigating frameworks and identifying relevant metrics.

There exist several initiatives at different level and scale aimed at assessing the interaction between economic activities and nature. International standards and guidelines, such as the TNFD and the European Union Corporate Sustainability Reporting Directive (CSRD), focus on disclosure and risk management, while initiatives like ENCORE and the WWF biodiversity and water filters provide nature-related data to quantify environmental dependencies and impacts at a high-level.

**This information note explores metrics and indicators proposed by TNFD (2024a; 2024b) and presents an example selection of relevant and easily implementable metrics to perform risk and opportunities assessment. This selection is based on the following set of criteria to perform risk and opportunities assessment:**

- **Land-use change** due to agricultural forestry and industrial activities is a priority metric, as it is the main driver of nature degradation, biodiversity loss and water stress.
- The **multidimensionality** of nature-related risks should be addressed when selecting complementary metrics to account for complexity in risk assessment.
- The **geographical location of impacts and dependencies** on nature is crucial for a correct assessment and consideration of the supply value chain.
- **Data availability** is crucial for the implementation of metrics and indicators.
- **Climate-Nature Nexus** needs to be considered when selecting metrics given the relevant interaction between climate change and nature change.

This metrics selection initiative aims to highlight indicators which display good practical usability for NGFS members and stakeholders, considering data availability constraints and relying as much as possible on open-source data. The selection narrows the scope of the TNFD framework from 146 to 50 metrics overall. However, it should not be viewed as a standalone framework, but rather as an entry point into the broader TNFD metrics landscape.

## Case studies: applications of nature-related risk frameworks

the note presents four case studies where nature-related risk assessment frameworks were used to identify risks and opportunities arising from nature:

- A joint report prepared by Bank Negara Malaysia and the World Bank, which explores the **financial risks associated with nature loss in Malaysia** using ENCORE and the World Database of Key Biodiversity databases.
- A study of **water pollution risk assessment in the Oder River** after an environmental disaster affected this watershed, including the economic losses for the fishing and tourism industries, and the methodological and data challenges involved in its evaluation.
- An assessment of the **dependency of euro area economy and banks on ecosystem services** prepared by the European Central Bank using several tools and database such as the Anacredit data, ENCORE, EXIOBASE, and Globio.
- A research paper studying the **effects of green infrastructure networks on pluvial flood risk and direct economic damage to buildings and population exposed in the Milan metropolitan area** using EU databases.

In general, the review of these case studies shows the relevance of nature for the economy and financial sector. Table 5 below provides a summary of the challenges and lessons learnt across these four case studies.

Table 5 Summary of the challenges and lessons learnt from the case studies

Case	Challenges	Lessons Learnt
Nature-related financial risks in Malaysia	<ul style="list-style-type: none"> <li>Limited availability of geospatial data for nature and ecosystem services.</li> <li>Limited integration of high natural resources dependency into financial risk assessment.</li> <li>Reliance on multiple databases with different granularity and coverage.</li> </ul>	<ul style="list-style-type: none"> <li>Useful approach to approximate vulnerabilities for the financial sector.</li> <li>Need for centralised data infrastructure to support risk assessment.</li> <li>Recommendation of mandatory nature-related data disclosure and improvement in data collection.</li> </ul>
Water pollution risk assessment in the Oder River	<ul style="list-style-type: none"> <li>Monitoring data is not centralized nor harmonised.</li> <li>Lack of pre-disaster benchmark data.</li> <li>Insufficient genomic and ecological data on harmful algal blooms.</li> </ul>	<ul style="list-style-type: none"> <li>Real-time monitoring and genomic tools are needed for risk assessment.</li> <li>Inter-institutional collaboration enhances data synthesis.</li> </ul>
Nature-related risks and financial risks in the Euro Area	<ul style="list-style-type: none"> <li>ENCORE does not account for spatial variations in ecosystem services dependencies.</li> <li>Problems with data harmonisation due to misalignment between AnaCredit (NACE classification) and ENCORE (GICS classification).</li> <li>Restricted access to Anacredit might limit external research and findings replication.</li> </ul>	<ul style="list-style-type: none"> <li>Systemic financial risks from nature loss are significant and need to be accounted for.</li> <li>Dependency score framework can help to quantify exposure.</li> <li>Data harmonisation, transparency and location-specific dependencies are essential for nature-related risk modelling.</li> <li>Need to integrate supply chain dependencies in risk assessment.</li> </ul>
Nature-based solutions: Green infrastructure initiatives in Milan	<ul style="list-style-type: none"> <li>Availability and costs of a laser remote sensing technology (LIDAR) data and updated construction costs data.</li> <li>Flood modelling requires detailed elevation, soil, and rainfall data.</li> </ul>	<ul style="list-style-type: none"> <li>Urban-green infrastructure can significantly reduce flood risk and economic damages.</li> <li>High-resolution geospatial data is crucial for nature-based solutions assessment.</li> <li>Developing scenarios allows to assess trade-offs and benefits of green investments.</li> <li>Need of public investment on data infrastructure to support urban resilience to climate change.</li> </ul>

## Data sources for the financial assessment of nature-related risks

**Financial authorities should address physical and transition risks according to metrics that measure and assess risk at individual and system-wide level.**

Therefore, it is necessary to assess drivers individually through evaluating the extent and nature of reliance and impact on ecosystems stemming from the activities of portfolio companies. In addition, financial institutions should effectively quantify the magnitude of financial losses. The review of the data from the TNFD’s selection of metrics, the case studies and other sources of data suggest that several databases available for nature-related risk assessment may be considered as complement given gaps in periodicity and spatial granularity observed on them. Micro and macro prudential assessments can benefit from the use of these sets of information, especially for sectoral analysis where more aggregated risk analysis can rest in less granular data.

## Challenges for nature-related data

**Data quality and availability.** Due to the necessity of physically collecting samples from specific monitoring locations, nature-related data collection suffers from geographical restrictions with relevant effects on estimates from biophysical modelling. Although global sources can be useful in providing relevant data for ecosystem assessment, accuracy of the estimates depends on the precision of geospatial data. Overall, data gaps persist for key environmental inputs in ecosystem services assessment, which may be critical to many business processes. Moreover, when the focus on the analysis is at single entities’ level, a proper and comprehensive assessment of nature-related financial risks will ultimately rely on data that come directly from companies (corporate issuers and other entities in general).

**Opportunities and challenges of artificial intelligence (AI) applications.** Machine learning (ML) and deep learning (DL) models can identify the statistical relationship between input and output data without the explicit requirement of knowing the physical processes, overcoming the limitations of biophysical modelling. However, nature-related data generation through AI techniques is highly demanding in geospatial and in-situ data and may oversimplify the assessment environmental processes when the quality of the data is low.

**Climate-nature nexus data integration.** Interplay can occur between different nature and climate risks and the interaction of physical and transition risks (driven by climate and/or nature). For example, deforestation and land cover changes can have implications for water because they affect key parameters in biophysical models of water-related ecosystem services. Data gaps persist for these key climate-nature interplays in assessments of nature and climate-related risks.

## Way forward

**Public-private collaboration for improved data collection and use.** Cooperation and coordination between public and private agents are necessary to implement a roadmap that optimizes the generation of data for multiples metrics. In this sense, the adoption of approaches that utilise effective data collection and analysis is essential for developing comprehensive nature-related risk analysis. Technological innovations can foster collaboration to generate local driven data.

### **Best practices in data management and application.**

There is a need for more systematic and transparent data collection based on open-source databases organised by assessment methodology with parameterised and validated data specifically. Moreover, biophysical models have to be validated using observed data from field sampling or monitoring stations when they are available. Geographic spatial heterogeneity in the demand and supply of ecosystem services should be addressed for a correct valuation of ecosystem services, to avoid errors when using benefit-transfer methods in addressing data gaps for location-specific valuations.

**Accounting for biodiversity data gaps.** Recommended actions to bridge biodiversity data and knowledge gaps include:

- Provide a classification of biodiversity data gaps and apply statistical approaches (subsampling, weighting and imputation).
- Encourage citizen science to expand spatial collection and minimize geographical and site-selection bias.
- Use ground-based images to model habitat complexity at relevant spatial and temporal resolutions.
- Synthesize local data from non-English sources to overcome underuse of biodiversity data due to language barriers.
- Target investment in biodiversity monitoring, particularly in data-scarce regions where biodiversity loss has significant ecological and economic implications.

Summing up, improved coordination, methodological innovation, and targeted investments in data infrastructure are essential to close nature-related data gaps.

# 1. Introduction

**Nature is essential for human wellbeing, providing firms and households with multiple ecosystem services,** such as food, raw materials, climate regulation, disease and disaster prevention, air and water purification, and recreation – among others. **However, its degradation has been increasing due to multiple drivers** (e.g. land cover change, overexploitation of marine resources, increasing pollution, climate change, and the spread of invasive species), **undermining the resilience and stability of the ecosystems that sustain human life and the economy.** In response, **governments, private and multilateral actors have begun to follow the recommendations of the Kunming-Montreal Global Biodiversity Framework (GBF)<sup>1</sup>** and have engaged in the implementation of policies and activities to foster the preservation and restoration of nature by 2050.

**The support of the economic and financial sectors to achieve the GBF goals is crucial, as corporate and financial firms and the macroeconomic conditions ultimately depend upon and impact nature.** Microprudential and macroprudential regulation can play a role in this regard by providing the financial sector with a framework to assess the financial materiality of nature for individual firms and the financial sector<sup>2</sup>, and through it encourage investment decisions and production processes aligned with nature’s sustainability. Central banks also care about the macroeconomic effects of nature such as inflationary pressures or lower productivity (NGFS, 2023a). Moreover, nature-related risks associated with regulatory changes or reputational risks may negatively affect certain activities and types of financing and potentially increase risks to the economy and financial system (Gardes-Landolfini *et al.*, 2024).

**The NGFS has progressively expanded its focus on nature-related financial risks through dedicated task forces and data initiatives since 2023.** As a first step,

the NGFS Task Force on Nature-related risks’ (TF Nature) **published a conceptual framework on nature-related financial risks (2023a).** **Following up on this work, it appears that availability of data at different levels of granularity is essential to study, monitor, and assess the interdependence between nature, the real economy and the financial sector.** In this context, the NGFS launched the Subgroup on Exploring Nature-Related Data as part of its Expert Network on Data (EN Data) in March 2024 to contribute to the analysis of the risks and opportunities that nature imposes on the financial sector.

**The existing diversity of approaches to identify, monitor and assess nature-related risks creates challenges for how to put data sets into practice and present concrete metrics and indicators for nature-related risks.** Benchmarking and standardization of existing metrics and indicators could contribute to informing users. A selection of metrics could help central banks, supervisors, corporate or financial firms, and policymakers in the assessment of the economy-finance-nature nexus<sup>3</sup>.

**This information note is intended to provide a basis for analysing metrics and indicators to help address nature-related data gaps. The issues outlined can also serve to set up a roadmap to develop initiatives to address different issues regarding the use of nature-related data in finance.** Section 2 describes the existing frameworks of indicators and metrics related to nature-related risks. Section 3 discusses and applies criteria for navigating and selecting indicators and metrics for risk assessment, based on the TNFD framework for disclosure. Section 4 integrates metrics/indicators into the NGFS risk analysis and scenario frameworks through a set of four case studies. Finally, sections 5 and 6 describe the main challenges and opportunities for the use of nature-related data in financial analysis.

1 The Kunming-Montreal Global Biodiversity Framework (see <https://www.cbd.int/gbf>).

2 Impact materiality refers to actual or potential, positive or negative impacts on nature or people from own operations and upstream and downstream value chain. Nature is material from a financial perspective if it generates risks or opportunities that affect (or could reasonably be expected to affect) the undertaking’s financial position, financial performance, cash flows, access to finance or cost of capital over the short, medium or long term (EU Commission, 2023).

3 The nexus come from the fact that nature-related risks affect the economy through damages to real and financial assets, as well regulations and legal liabilities (Gardes-Landolfini *et al.*, 2024).

## 2. Range and use cases of nature indicators and metrics

This section leverages on the significant amount of work regarding metrics and indicators for nature-related disclosure and financial risk assessment with the objective of standardising concepts and frameworks and highlighting data requirements associated to the use cases in financial analysis.

### 2.1 Nature and approaches to assess nature-related risks

**The NGFS conceptual framework for nature-related risks has defined nature as “the natural world with an emphasis on the diversity of living organisms and their interactions among themselves and with their environment” where the term ‘nature’ considers both the biotic (living) and abiotic (non-living) elements of our planet, including biodiversity but also climate.** Changes in nature and the ensuing impact on ecosystem services create physical and transition risks and opportunities for firms, households and governments through complex dynamics that need to be accounted for by metrics and indicators.

**Climate and nature-related risks are distinct yet interrelated issues that require analysis in an integrated manner (Gardes-Landolfini *et al.*, 2024).** Although climate-related and nature-related risks overlap, as climate risks are a subset of nature-related risks<sup>4</sup>, nature-related risks beyond climate exhibit specific features, including diverse drivers – both local and global in scale – and more complex transmission channels. Climate change can amplify the effects of direct drivers of nature change via chronic and acute stressors, while its mitigation and adaptation can be potential drivers of nature risk when policies influence either land use change, overexploitation of species, pollution or other stressors which impairs ecosystem integrity and functioning. Conversely, nature degradation can significantly reduce the resilience of ecosystems to climate change and exacerbate climate dynamics by increasing greenhouse gas emissions and weakening natural carbon

sinks. Nature-based solutions can be implemented not only to reduce the risk of climate change, but also to support healthy ecosystems.

**Several conceptual frameworks have emerged to address nature-related risks, including those from the Network of Central Banks and Supervisors for Greening the Financial System (NGFS 2023a), Organisation for Economic Co-operation and Development (OECD 2023a and 2023b), International Monetary Fund (Gardes-Landolfini *et al.*, 2024) and Taskforce on Nature-related Financial Disclosures (TNFD 2023a).**

Taken together, these frameworks provide a comprehensive analysis of the drivers of change affecting nature and describe the complex interplay between direct and indirect drivers. They also explain how local environmental impacts can generate significant global repercussions, as global economic activities can turn localised risks into widespread threats. Because these drivers often occur simultaneously, the likelihood of multiple environmental shifts increases, raising the risk of reaching critical tipping points that could drastically and permanently alter ecosystems (OECD, 2023a; 2023b).

**In the NGFS framework, central banks and authorities are “encouraged to act on material economic and financial risks stemming from dependencies and impacts on nature” (NGFS, 2023a).** As such, financial authorities should consider the primary drivers of ecosystem loss to understand how these factors affect ecosystem services and their associated impacts on the financial system. To enhance their understanding of these risks, they may conduct literature reviews and consult experts to gain insights into the functioning of ecosystems and the threats they face, for instance by referring to the five main drivers of nature loss identified by the IPBES. The frameworks emphasise that both physical and transition risks should be analysed to comprehend how nature loss impacts the economy and, consequently, the financial sector. These risk drivers can influence economic activities through both direct and indirect channels, causing varying degrees of impact depending on the severity and

4 Environmental risks are often used interchangeably with nature-related risks in financial and policy discussions.

frequency of events, as well as whether transitions occur in an orderly or disorderly manner<sup>5</sup>. In addition, these frameworks also provide a common methodology for understanding how interconnected drivers of nature loss are crucial for developing effective strategies to mitigate the impacts of nature loss on the economy and the financial system: they argue that nature-related risk drivers can manifest as economic risks, directly or indirectly affecting sectors closely tied to natural resources. These risks may also spread through supply chains in the global economy, impacting various sectors, including resource conversion, manufacturing, transportation, and consumption.

**Commonalities in addressing drivers of nature change can be seen in the different metrics and data points used to disclose nature-related risks** (changes in land and sea use, over-exploitation of resources, pollution, and the introduction of invasive alien species), **which factor in location** (such as the proximity of operations to sensitive ecosystems or biodiversity hotspots) **to help understand context-specific risks**. Climate-related and nature-related risks are systemic and interdependent – nature loss can exacerbate climate change through the release of stored greenhouse gases, while climate change accelerates ecosystem degradation. Measuring nature risks is however inherently more complex due to the multidimensional nature of ecosystems and requires localised assessments. Furthermore, uncertainty around nature-related risks is significant, stemming from knowledge and data gaps in biosphere processes and ecosystem dynamics. While these differences pose challenges for risk quantification and management, the need for an integrated approach remains clear given their mutual reinforcement, to avoid unintended trade-offs.

## 2.2 Types of metrics and indicators for different use cases

**Nature-related data plays a pivotal role in understanding, managing, and mitigating environmental risks while supporting sustainable development. Its applications among central banks and supervisory functions span micro-prudential supervision, macro-prudential oversight and monetary policy, as well as more general statistical analysis and research, non-supervisory engagement and portfolio management.** Table 1 is an exploration of nature-related data use cases, metrics, and methodologies.

**Annex 1 illustrates the use cases and targeted metrics for nature-related data, providing overviews of data needs for the respective use cases.** For example, micro-prudential supervision would require specific indicators that measure nature-related exposure and dependencies of financial institution assets such as exposure metrics (e.g. proportion of assets exposed to sectors with high nature-related risks) and risk assessment metrics (e.g. impact of regulatory changes related to environmental policies on asset values). To generate such indicators and assess institution-specific risk, detailed data on localised nature-related impacts should be collected, such as information on water availability, scarcity, and stress in particular regions, as well as data on local ecosystems and biodiversity where institutions rely on ecosystem services.

<sup>5</sup> Orderly assumes climate policies are introduced early and become gradually more stringent while disorderly explores higher transition risks due to policies being delayed or divergent across countries and sectors (NGFS, 2023a).

Table 1 Use cases and targeted metrics for nature-related data

Use cases	Description	Targeted Metrics	Data requirement	Tools and purpose
<b>Micro-Prudential Supervision</b>	Focuses on the safety and soundness of individual financial institutions.	Specific indicators of nature-related exposure and dependencies of financial institution assets.	Detailed data on localized nature-related impacts, dependencies and opportunities to assess risks at the company level.	Quantitative metrics to measure financial vulnerabilities due to nature-related changes.
<b>Macro-Prudential for Financial Stability</b>	Focuses on the stability of the financial system.	System-wide indicators of nature-related risks and dependencies across sectors.	Broad-scale data on systemic nature-related risks and their potential impacts on financial stability.	Models to evaluate economic consequences of nature-related losses on systemic risks.
<b>Monetary Policy</b>	Uses data to analyse macroeconomic conditions and inform monetary policy decisions.	Metrics reflecting broader economic impacts of nature-related changes (e.g., inflation, employment).	Data on nature-related factors influencing economic variables.	Tools to quantify economic impacts of nature-related losses on monetary policy objectives.
<b>Statistical analysis and research</b>	Provides data for general economic analysis and reporting.	Indicators for benchmarking and longitudinal studies (e.g. nature-related indexes, ecosystem service valuations).	Data supporting trend analysis and comparisons over time.	Statistical tools to analyse the interaction of nature with broader economic and financial variables.
<b>Non-Supervisory Engagement</b>	Uses data to engage stakeholders outside regulatory frameworks.	Metrics for public communication and stakeholder engagement.	Data supporting narratives on nature-related impacts relevant to broader society.	Metrics demonstrating nature's value to non-financial stakeholders.
<b>Portfolio Management</b>	Helps investors manage risk and optimize returns by considering nature-related impacts.	Indicators of nature-related risks, opportunities, dependencies and impacts associated with investments.	Tools for scenario-based risk assessments integrating nature-related factors.	Quantitative metrics for evaluating nature-related risks, opportunities, dependencies and impacts.

**Micro-prudential supervision focuses on the soundness of individual financial institutions by assessing their exposure to nature-related risks.**

This involves analysing sectoral exposure, which examines the proportion of assets tied to sectors that are exposed to higher intrinsic risk, such as agriculture, forestry, and fisheries, as well as geographical exposure, identifying assets located in regions vulnerable to natural hazards or ecosystem services loss. Risk assessment metrics are critical, encompassing physical risk assessment to evaluate the frequency and severity of nature degradation and biodiversity loss and their direct impact on assets, and transition risk assessment that gauge regulatory and market shifts due to environmental policies. Disclosure metrics focus on the quality and frequency of environmental risk disclosures and alignment with frameworks such as the TNFD. Intermediaries and supervisors should also devote attention to the risk mitigation measures implemented by borrowers at the individual as well as sectoral level. Scenario construction integrates localised data on physical and transition risks enabling institutions to simulate potential impacts of environmental changes on their operations and stability.

**Macro-prudential supervision focuses on ensuring the stability of the overall financial system by assessing systemic exposure to nature-related risks.**

This involves analysing the interconnections and dependencies of financial institutions and markets concerning large-scale environmental risks.

**Monetary policy relies on nature-related data to assess macroeconomic stability, inflation dynamics, and financial conditions.**

Analytical tools such as biodiversity stress tests and ecosystem degradation scenarios integrate these data to model potential economic disruptions, supporting monetary policy strategies (e.g. promoting price stability in the event of such disruptions).

**Statistical analysis and research rely on nature-related data to support benchmarking, scenario development, and the generation of knowledge on environmental trends and impacts.**

Indicators such as biodiversity indexes, by sector, ecosystem service valuations, and adjusted GDP metrics are used to track changes in natural capital and assess environmental risks over time. Research deepens this understanding by applying high-resolution spatial

and temporal data<sup>6</sup> to develop predictive models and test hypotheses on nature-related dynamics. These use cases often combine statistical modelling, machine learning, and geospatial analysis to inform both policy and risk assessments.

**Public communication metrics beyond supervisory engagement**, such as biodiversity indexes measuring species variety in an area and carbon sequestration metrics estimating CO<sub>2</sub> captured by ecosystems, **are instrumental in raising the awareness of firms, households and government regarding the economic importance of nature-related risks**. Societal impact metrics, like air and water quality indexes and data on public engagement in conservation activities, underscore the tangible benefits of environmental stewardship. Data-driven narratives emphasise the advantages of preserving biodiversity, promoting public awareness, and encouraging action.

**Portfolio management helps investors manage nature-related risk and optimise returns, considering related impacts**. Investments need indicators of nature-related physical, regulatory, market and transition risks, and opportunities such as resource efficiency, sustainable products and services, innovations, regulatory incentives and enhanced resilience. Quantitative metrics include carbon footprint, water usage, biodiversity impact, value at risk, stranded assets, green revenue percentage, sustainable investment ratio, and green bond allocation – among others.

**This analysis highlights the multifaceted applications of nature-related data in addressing environmental challenges, ensuring financial stability, and fostering sustainable development**. By leveraging advanced tools and metrics, stakeholders can make informed decisions that balance economic growth with ecological preservation.

## 2.3 Overview of existing initiatives for metrics and indicators

**There exist several initiatives at different levels and scales to assess the impact of economic activities on nature**. The International Sustainability Standards Board (ISSB) developed the IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information, a global standard for sustainability-related disclosure. It requires entities to disclose sustainability-related risks and opportunities expected to affect its cash flows, its access to finance or its cost of capital. IFRS S1 covers all sustainability-related risks and opportunities, including those related to nature, taking into account existing standards such as Sustainability Accounting Standards Board (SASB) and the TNFD, among others.

**The TNFD released in 2023 a set of nature-related disclosure metrics to assess and report business activities which includes disclosure metrics for dependencies and impacts on nature; organisation-level risk and opportunities; responses to nature-related issues, and metrics exclusively focused on the agriculture and food sector**. The TNFD has also proposed an approach – the LEAP (Locate, Evaluate, Assess and Prepare)<sup>7</sup> – to assess nature-related risk, and launched additional guidance for financial institutions regarding TNFD metrics for sectors asset management and custody activities, investment banking and brokerage, security and commodity exchanges, commercial banks, consumer finance, mortgage finance and insurance<sup>8</sup>.

**The EU Corporate Sustainability Reporting Directive (CSRD)<sup>9</sup> specifies disclosure requirements for 5 sustainability reporting standards (ESRS): Climate change mitigation and adaptation (ESRS E1); Water and marine resources (ESRS E2); Pollution (ESRS E3); Biodiversity and ecosystems (ESRS E4); and Resource use and the circular economy (ESRS E5)**. In the case of ESRS E4, financial agents shall disclose identified and assessed actual and potential impacts, dependencies, transition and physical opportunities related to biodiversity and ecosystems at their own site locations and their value chain,

6 Geolocation data used for physical risk analysis typically includes high-resolution satellite imagery and spatial datasets from environmental monitoring networks that support localised assessments of environmental changes.

7 <https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/>.

8 <https://tnfd.global/publication/additional-disclosure-guidance-for-financial-institutions/>.

9 <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32023R2772>.

and impact metrics regarding biodiversity and ecosystems change, land-use change, and the extent and condition of ecosystems. On the other hand, while ESRS E1 does not explicitly refer to its nexus with nature, the others reporting standards – ESRS E2, ESRS E3 and ESRS E5 – explicitly list indicators or metrics that directly or indirectly are related to nature. These standards also address the definition of ecological thresholds and the assessment of financial effects arising from material risks and opportunities for each environmental objective.

**The Biodiversity Risk Filter – developed by the World Wildlife Fund (WWF)<sup>10</sup> – is a free online tool to assist companies and financial institutions in assessing the biodiversity – and water-related physical, regulatory, and reputational risks for corporations across their operations and value chains.** It includes 5 categories of physical risk and 3 of reputational risk, leading to 20 indicators for biodiversity physical risk and 13 for biodiversity reputational risk, and a total of 53 metrics. The tool is intended to inform sector-level impacts and dependencies on biodiversity, including the exploration of value chain location risks. It requires the user to upload location and activity data of company assets, which it then matches with location-specific biodiversity characteristics to get asset-level risk scores. As such, the user can better understand their biodiversity-related risks and prioritise the company's decisions and actions regarding biodiversity impacts and dependencies<sup>11</sup>.

**The Exploring Natural Capital Opportunities, Risks and Exposure framework and dataset (namely, ENCORE)<sup>12</sup> is a static tool to map the dependencies and impacts of economies and portfolios on ecosystem services based on sectors/economic activities and a coarse geospatial dataset.** It provides a two-level classification for natural capital (biomes and ecosystem components) and covers 271 economic activities according to the ISIC Industry Classification. The 15 ecosystem types are based on the biomes included in the IUCN Global Ecosystem Typology 2.0. It includes downstream and upstream value chain links where impact pathway follows the Driver-Pressure-State-Impact-Response framework. The tool also incorporates a biodiversity module that explores the potential material

impacts and dependencies on nature for the mining and agriculture sector regarding ecological integrity and species extinction risk.

**Other than the above tools and initiatives, firms may use scenarios for risk identification.** However, building scenarios for nature-related risk is at early stages. Key features of long-term nature change – such as ecological tipping points or abrupt regime shifts – remain difficult to represent in most current modelling frameworks due to their non-linear and uncertain nature.

- Recognising this challenge NGFS (2023b) has recommended to conduct exposure assessments using input-output (I-O) tables and biophysical models for short-term analysis and assess the sensitivity of the global economy to nature-related hazards Computable General Equilibrium (CGE) models.
- The NGFS (2023b) has promoted the use of narrative scenarios with assumptions on key driving forces and critical uncertainties behind nature-related risks in order to forecast possible future effects of nature decline and improvements due to direct drivers, especially when chronic nature risks are not so evident in the short run, and local thresholds and tipping points can shift rapidly with significant social and economic impacts. Once narrative scenarios are set up, it is possible to develop a risk-assessment analysis framework for nature-related risks where risks can be described as the result of the combination of hazard, exposure, and vulnerability (where exposure refers to the presence of subjects or objects in places that could be adversely affected by the hazard; and vulnerability depends on the sensitivity or susceptibility of exposure subjects or objects to be harmed because of their lack of capacity to cope and adapt).

**Ranger *et al.* (2023) approach narrative scenarios by building blocks, using the hazards (shocks) themselves to evaluate impact and quantify risks.** Shocks are mapped forward to economic impacts and backwards to ecosystem services, natural assets, and drivers of degradation along the impact chain. Hazard refers to the potential occurrence of a natural or human-induced physical event that may cause loss. Moving forward along the impact chain from the shock, the focus of the analysis

10 <https://riskfilter.org/>.

11 See De Nederlandsche Bank (2024) for an application of the Biodiversity Risk Filter to a central banks' own funds.

12 <https://encorenature.org/en>.

is on the 'primary economic receptors' in the economy, which facilitates the quantification of risk – including economic sectors, labour productivity, public expenditure, prices, terms of trade, demand, and capital stock. The following examples highlight the logic behind the blocks for narratives scenarios:

- **Wildfires** can be a driver of nature change since they imply land-use change and removal of vegetation, all of which reduce the ecosystem services of climate regulation and dilution provided by the atmosphere and ecosystems by affecting the natural asset of land. Climate change and drought/heat can amplify the negative effects of wildfires on ecosystem services. Wildfires are also acute events that can affect human health in urban centres.
- **Saltmarsh removal** through overexploitation, pollution, or removal, is a driver of nature change, all of which reduce the ecosystem services of flood and storm protection by impacting biodiversity. Climate change and heat can amplify these negative impacts on ecosystem assets and services. Therefore, saltmarsh removal is a regular event with negative local effects on the real estate and agriculture sectors that depend on the ecosystem services of flood and storm protection.
- **Trade can produce changes in the rural livelihoods** through the introduction of non-native species or increased tourism, and therefore, reduce the ecosystem service of pest control when the biodiversity is negatively impacted. These could lead to acute or chronic negative impacts at the local level on households that depend on the ecosystem service of provisioning of food and feed.

### 3. Exploring metrics for nature risks and opportunities

The TNFD’s metrics can serve as a benchmark for exploring the integration of nature-related data into financial assessments and its contribution for the implementation of different use cases. Although the TNFD’s metrics are driven by a corporate disclosure focus, they can be useful benchmarks to identify and assess the available data for nature-related risks and opportunities analysis as drivers, impacts, dependencies and opportunities are cross-scalar. The appropriate level (e.g. geography, asset class, portfolio, portion of a portfolio) should reflect in the most accurate way the magnitude of risks and opportunities.

TNFD (2024a) developed a total of 82 global core and additional disclosure metrics, distinguishing between (i) nature-related dependences and impacts, (ii) risks and opportunities and (iii) responses (see Table 4). The TNFD also identified 56 sector core and additional disclosure metrics for aquaculture, biotechnology and pharmaceuticals, electric utilities and power generation, food and agriculture, and forestry, pulp, and paper.

Table 2 Number of TNFD global core and additional disclosure metrics by category

Category	Nature-related dependences and impacts		Nature-related risks and opportunities		Responses to nature-related issues	Total
	Core	Additional	Core	Additional	Additional	
Driver: Climate change	1					1
Driver: Land/freshwater/ocean use change	1	1				2
Driver: Pollution/pollution removal	5	4				9
Driver: Resource use/replenishment	2	6				8
Driver: Invasive species and others	1	1				2
State of nature: ecosystem condition and species extinction risk	1					1
State of nature: ecosystem condition		1				1
State of nature: species extinction risk		1				1
State of nature: extent		1				1
State of nature: ecosystem connectivity		1				1
State of nature: species population size		1				1
Ecosystem services		2				2
Risk: general or multiple			3	2		5
Opportunity			2	3		5
Risk: physical risk				7		7
Risk: transition risk				7		7
Strategy					7	7
DIROM (dependency, impact, risk and opportunity management): value chain					5	5
DIROM: changes to nature					7	7
DIROM: voluntary conservation, restoration and regeneration					5	5
DIROM: general					4	4
<b>Total</b>	<b>11</b>	<b>19</b>	<b>5</b>	<b>19</b>	<b>28</b>	<b>82</b>

Furthermore, the TNFD additional guidance for financial institutions (TNFD, 2024b) lists the 27 most relevant metrics from the TNFD global core and additional disclosure metrics. TNFD also proposes the following supplementary metrics to be considered by the financial sector:

- European Union Sustainable Finance Disclosure Regulation (SFDR) principal adverse impact metrics, mapped to the TNFD core global metrics;
- Biodiversity footprint metrics: (i) ecological footprint; (ii) Living Planet Index; (iii) Mean Species Abundance; (iv) Potentially Disappeared Fraction of Species; (v) Range Size Rarity; (vi) Species Threat Abatement and Recovery; and (vii) Biodiversity Impact Credit<sup>13</sup>;
- Amount of exposure to companies that have harmful activities or sourcing in biodiversity-sensitive areas (total and/or proportion of total);
- Amount of exposure to companies without corporate biodiversity/nature-related policies (total and/or proportion of total);
- Amount of exposure to companies with science-based biodiversity/nature-related targets (total and/or proportion of total);
- Amount of exposure to companies with known biodiversity/nature-related controversies and incidents (total and proportion of total);
- Amount of exposure (and annual flows) to sectors in a government or regulator green investment taxonomy or third-party industry or NGO taxonomy, where relevant; and
- The NEC (Net Environmental Contribution) metric;
- Financial institution core disclosure metric (FI.C0.0) that represents the exposure to a defined set of sectors considered to have material nature-related dependencies and impacts, and financial institution core disclosure metric (FI.C0.1) that represents the exposure to companies with assets and/or activities in sensitive locations<sup>14</sup>.

### 3.1 Criteria for selecting metrics and indicators

*Disclaimer: This metrics-selection initiative does not constitute an NGFS position, nor a recommendation toward standard-setting initiatives. It should be understood as an entry point into the broader TNFD data landscape.*

<sup>13</sup> The Biodiversity Intactness Index is also a relevant metric considered in this note.

<sup>14</sup> The expected asset-class coverage for metrics FI.C0.0 and FI.C0.1 includes corporate equity and debt (both publicly listed and privately held), infrastructure and project-finance assets, commodities finance, and corporate lending. Sovereign exposures are not currently considered for inclusion but may be incorporated in future updates. Mortgage portfolios may be disclosed at the discretion of banks and insurers. The following are out of scope: cash and money-market instruments, derivatives and commodity futures, advisory and other off-balance-sheet activities, and retail or other consumer exposures.

**This note aims to provide a practical tool to help stakeholders from diverse backgrounds make an initial exploration of nature-related data based on their specific use cases.** In this regard, the initiative uses the TNFD's metrics as a starting point for examining data requirements and availability considerations when assessing nature-related risks and opportunities. These metrics also exhibit a strong level of consistency with the EU CRSD (EFRAG and TNFD, 2024) and are the base for the ISSB standard-setting for Biodiversity and Ecosystem Services as already mentioned. Focus has been put on a subset of TNFD's recommended metrics and indicators which have been selected using the following set of criteria:

- **Land-use change due to agricultural and industrial activities is a priority metric**, as it is the main driver of biodiversity loss and water stress (Gardes-Landolfini *et al.*, 2024). Deforestation causes nature loss that contributes to either the release of carbon and other greenhouse gases stored in forests and soils or the reduction of water-related ecosystem services that worsen the effects of climate change.
- The **climate-nature nexus** is a key issue to be considered when selecting metrics and indicators. Taking for instance the interaction among deforestation, water stress and climate, water metrics and indicators play a major role in this context.
- The **multidimensionality** of nature-related risks should be acknowledged, implying the **need for selecting complementary metrics to account for complexity in risk assessment**. The complexity of nature implies the need to consider a variety of existing metrics and indicators to assess the state and vulnerability of ecosystems.
- **The geographical location of both impacts and dependencies on nature** should also be emphasised. The analysis should be conducted at an appropriate level of granularity, ranging from high-level indicators to targeted metrics. In a globalised economy, supply chain traceability becomes essential, as environmental impacts occurring abroad can create significant risks for domestic companies. According to WWF, certain sectors are particularly exposed due to their direct impacts

and dependencies on nature, including agriculture, forestry and fisheries; energy (oil, gas and renewables) and utilities.

- The **availability of data and sources of data** needed to implement disclosure initiatives and risk assessment at different levels should finally be considered in the selection of metrics and indicators.

It must be emphasized that the proposed selection of metrics focuses on the availability of data and open-source data. Its utility for a specific use case will depend on the suitability of these kinds of data for the specific use. Corporate disclosure may require additional data to those presented in this selection.

### 3.2 Selected metrics and indicators

By using the 5 criteria above, this note identifies a subset of TNFD’s metrics and indicators, which should be considered as an entry point into the broader set of the TNFD data. The use of these criteria leads to a subset of 50 metrics and indicators from the total 146 TNFD indicators identified, as shown in Table 3. The actual selected metrics are reported in Table 4, where columns 1, 2, 3 and 4 describe the selected TNFD metrics and indicators. Column 5 indicates the criteria that the metric meets (Land cover and use; Climate-nature nexus; Multidimensionality; Location of the impacts and dependencies; Data availability) and column 6 presents the main use cases relevant for that metrics. Columns 7 and 8 present the requirements and availability of open-source data to build each metric.

Table 3 **Distribution of selected metrics according to the type of metric**

	Type of metric	Total metrics	Selected metrics
<b>Recommended metrics</b>	Core global disclosure metrics for nature-related dependencies and impacts	11	7
	Core global disclosure metrics for nature-related risks and opportunities	5	2
	Additional global disclosure metrics for dependencies and impacts on nature	19	9
	Additional global metrics for nature-related risks and opportunities	19	6
	Additional global disclosure metrics for responses to nature-related issues	28	1
<b>Sector metrics</b>	Core and additional sector metrics – Aquaculture	13	2
	Core and additional sector metrics – Biotechnology and pharmaceutical	6	0
	Core and additional sector metrics – Electric utilities and power	7	2
	Core and additional sector metrics – Food and agriculture	24	11
	Core and additional sector metrics – Forestry, pulp and paper	6	4
<b>Additional financial indicators and metrics</b>	Based on foot printing approaches	8	6
<b>Total</b>		<b>146</b>	<b>50</b>

Table 4 Indicative selection of metrics and indicators within TNFD

Type of metric	Driver of nature change	Metric No.	Metric	Criteria	Main Use Cases	Data need	Sources
TNFD core global disclosure indicators and metrics for nature-related dependencies and impacts	Climate change		Scope 1, 2 and 3 GHG emissions – refer to TCFD	<ul style="list-style-type: none"> <li>Climate nature nexus</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Statistics and Research</li> <li>Portfolio Management</li> </ul>	Data on GHG by sector or company	<p>NGFS (2024). Improving greenhouse gas emissions data <a href="https://www.ngfs.net/en/publications-and-statistics/publications/improving-greenhouse-gas-emissions-data-ngfs-information-note">https://www.ngfs.net/en/publications-and-statistics/publications/improving-greenhouse-gas-emissions-data-ngfs-information-note</a></p> <p>Links to external sources of data on greenhouse gas emissions and to socio-economic data and tools</p> <p><a href="https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-external-sources">https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-external-sources</a></p>
	Land/freshwater/ocean use change	C1.0	<p>Total spatial footprint (km<sup>2</sup>) (sum of):</p> <ul style="list-style-type: none"> <li>Total surface area controlled/ managed by the organisation, where the organisation has control (km<sup>2</sup>);</li> <li>Total disturbed area (km<sup>2</sup>); and</li> <li>Total rehabilitated/ restored area (km<sup>2</sup>).</li> </ul>	<ul style="list-style-type: none"> <li>Land use change</li> <li>Climate nature nexus</li> <li>Location of impacts and dependencies</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Statistics and Research</li> <li>Non-Supervisory Engagement</li> <li>Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>Land use and land cover mapping</li> <li>Ecosystem Classification and mapping</li> <li>Prioritised ecosystems</li> </ol>	<ol style="list-style-type: none"> <li>ESAWorld Land Cover <a href="https://esa-worldcover.org/en">https://esa-worldcover.org/en</a></li> <li>WRI-Google Land Cover <a href="https://dynamicworld.app/about">https://dynamicworld.app/about</a></li> <li>WWF Deforestation Fronts <a href="https://wwf.panda.org/discover/our_focus/forests_practice/deforestation_fronts/">https://wwf.panda.org/discover/our_focus/forests_practice/deforestation_fronts/</a></li> <li>WRI Data sets <a href="https://gfr.wri.org/data-methods">https://gfr.wri.org/data-methods</a></li> <li>Trase database (<a href="https://trase.earth/open-data">https://trase.earth/open-data</a>)</li> <li>IUCN Level 3 Typology <a href="https://global-ecosystems.org/">https://global-ecosystems.org/</a></li> <li>Global Ecosystem Atlas <a href="https://globalecosystemsatlas.org/">https://globalecosystemsatlas.org/</a></li> <li>Lane, C., D'Amico, E., Christensen, J., Golden, H., Wu, O., Rajib, A. (2023). "Mapping global non-floodplain wetlands", Earth System Scientific Data, 15, 2927–2955</li> <li>Golden <i>et al.</i> (2025). "Advancing the science of headwater streamflow for global water protection", Nature Water, 3, 16–26.</li> <li>Biodiversity Intactness Index <a href="https://gee-community-catalog.org/projects/bii/">https://gee-community-catalog.org/projects/bii/</a></li> </ol>

TNFD core global disclosure indicators and metrics for nature-related dependencies and impacts	Land/ freshwater/ ocean use change	C1.1	<p>Extent of land, freshwater, ocean ecosystem use change (km<sup>2</sup>) by:</p> <ul style="list-style-type: none"> <li>Type of ecosystem; and</li> <li>Type of business activity.</li> </ul> <p>Extent of land, freshwater, ocean ecosystem conserved or restored (km<sup>2</sup>), split into:</p> <ul style="list-style-type: none"> <li>Voluntary; and</li> <li>Required by statutes or regulations.</li> </ul> <p>Extent of land, freshwater, ocean ecosystem that is sustainably managed (km<sup>2</sup>) by:</p> <ul style="list-style-type: none"> <li>Type of ecosystem; and</li> <li>Type of business activity.</li> </ul>	<ul style="list-style-type: none"> <li>Land use change</li> <li>Climate nature nexus</li> <li>Location of impacts and dependencies</li> <li>Data availability</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Statistics and Research</li> <li>Non-Supervisory Engagement</li> <li>Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>Land use and land cover mapping</li> <li>Prioritised ecosystems</li> </ol>	<ol style="list-style-type: none"> <li>ESA (<a href="https://esa-worldcover.org/en/">https://esa-worldcover.org/en/</a>); WRI-Google (<a href="https://dynamicworld.app/about">https://dynamicworld.app/about</a>)</li> <li>WWF Deforestation Fronts (<a href="https://wwf.panda.org/discover/our_focus/forests_practice/deforestation_fronts/">https://wwf.panda.org/discover/our_focus/forests_practice/deforestation_fronts/</a>)</li> <li>WRI Data sets (<a href="https://gfr.wri.org/data-methods">https://gfr.wri.org/data-methods</a>)</li> <li>Trase database (<a href="https://trase.earth/open-data">https://trase.earth/open-data</a>)</li> <li>IUCN Level 3 Typology (<a href="https://global-ecosystems.org/">https://global-ecosystems.org/</a>)</li> <li>Global Ecosystem Atlas (<a href="https://globalecosystemsatlas.org/">https://globalecosystemsatlas.org/</a>)</li> <li>Lane, C., D'Amico, E., Christensen, J., Golden, H., Wu, O., Rajib, A. (2023). "Mapping global non-floodplain wetlands", Earth System Scientific Data, 15, 2927–2955</li> <li>Golden <i>et al.</i> (2025). "Advancing the science of headwater streamflow for global water protection", Nature Water, 3, 16–26.</li> </ol>
	Pollution/ pollution removal	C2.4	<p>Total non-GHG air pollutants by type:</p> <ol style="list-style-type: none"> <li>Tonnes of particulate matter (PM2.5 and/ or PM10);</li> <li>Tonnes of nitrogen oxides (NO<sub>2</sub>, NO and NO<sub>x</sub>);</li> <li>Tonnes of volatile organic compounds (VOC or NMVOC);</li> <li>Tonnes of sulphur oxides (SO<sub>2</sub>, SO<sub>3</sub>, SO<sub>x</sub>);</li> <li>Tonnes of ammonia (NH<sub>3</sub>)</li> </ol>	<ul style="list-style-type: none"> <li>Location of impacts and dependencies</li> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Statistics and Research</li> </ul>	<ol style="list-style-type: none"> <li>Emission by sector or company</li> <li>Air pollution quality</li> </ol>	<ol style="list-style-type: none"> <li>Pollutant Release and Transfer Registers (<a href="https://prtr.unepce.org/prtr-global-map">https://prtr.unepce.org/prtr-global-map</a>)</li> <li>OpenAQ (<a href="https://openaq.org/about/">https://openaq.org/about/</a>)</li> </ol>
	Resource use/ replenishment	C3.0	<p>Total water withdrawal and consumption from areas of water stress (cubic meters)</p>	<ul style="list-style-type: none"> <li>Climate nature nexus</li> <li>Location of impacts and dependencies</li> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Statistics and Research</li> <li>Non-Supervisory Engagement</li> <li>Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>Water consumption</li> <li>Areas of water stress</li> </ol>	<ol style="list-style-type: none"> <li>World Bank Water data (<a href="https://wbwaterdata.org/group/build-resilience">https://wbwaterdata.org/group/build-resilience</a>)</li> <li>Aqueduct water risk atlas (<a href="https://www.wri.org/data/aqueduct-water-risk-atlas">https://www.wri.org/data/aqueduct-water-risk-atlas</a>)</li> <li>Evaporative Stress Index (<a href="https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f">https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f</a>)</li> </ol>

TNFD core global disclosure indicators and metrics for nature-related dependencies and impacts	Land/ freshwater/ ocean use change	C3.1	<p>Quantity of high-risk natural commodities (tonnes) sourced from land, ocean, freshwater, split into types, including proportion of total natural commodities.</p> <p>Quantity of high-risk natural commodities (tonnes) sourced under a sustainable management plan or certification programme, including proportion of total high-risk natural commodities.</p>	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>1. List of high-risk commodities</li> <li>2. Certification data</li> </ol>	<ol style="list-style-type: none"> <li>1. Science based target network (<a href="https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fsciencebasedtargetsnetwork.org%2Fwp-content%2Fuploads%2F2024%2F07%2FHigh-Impact-Commodity-List-v1-1.xlsx&amp;wdOrigin=BROWSELINK">https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fsciencebasedtargetsnetwork.org%2Fwp-content%2Fuploads%2F2024%2F07%2FHigh-Impact-Commodity-List-v1-1.xlsx&amp;wdOrigin=BROWSELINK</a>)</li> <li>2. Tayleur <i>et al.</i> (2018). Where are commodity crops certified, and what does it mean for conservation and poverty alleviation?; Mendeley Data, V2. <a href="https://data.mendeley.com/datasets/mpdf6ytswm/2">https://data.mendeley.com/datasets/mpdf6ytswm/2</a></li> <li>2. Trase database <a href="https://trase.earth/open-data">https://trase.earth/open-data</a></li> </ol>
	State of nature	C5.0	<p>For those organisations that choose to report on state of nature metrics, the TNFD encourages them to report the following indicators:</p> <ul style="list-style-type: none"> <li>• Level of ecosystem condition by type of ecosystem and business activity; and</li> <li>• Species extinction risk.</li> </ul>	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>1. Ecosystem condition</li> <li>2. Species extinction risk</li> </ol>	<ol style="list-style-type: none"> <li>1. Globio Model <a href="https://www.Globio Model.info/resources">https://www.Globio Model.info/resources</a></li> <li>2. Irwin, A., Geschke, A., Brooks, T.M. <i>et al.</i> 2022. Quantifying and categorising national extinction-risk footprints. <i>Sci Rep</i> 12, 586. <a href="https://www.nature.com/articles/s41598-022-09827-0">https://www.nature.com/articles/s41598-022-09827-0</a></li> <li>2. IUCN Red List of Threatened Species <a href="https://www.iucnredlist.org/">https://www.iucnredlist.org/</a></li> </ol>
TNFD core global disclosure metrics nature-related risks & opportunities	Risk	C7.0	<p>Value of assets, liabilities, revenue and expenses that are assessed as vulnerable to nature-related transition risks (total and proportion of total).</p>	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Portfolio Management</li> </ul>	<p>Available platforms</p>	<p>ENCORE <a href="https://encorenature.org/en">https://encorenature.org/en</a></p> <p>TNFD LEAP <a href="https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/">https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/</a></p> <p>WWF Risk Filter <a href="https://riskfilter.org/biodiversity/home">https://riskfilter.org/biodiversity/home</a></p>
	Risk	C7.1	<p>Value of assets, liabilities, revenue and expenses that are assessed as vulnerable to nature-related physical risks (total and proportion of total).</p>	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Portfolio Management</li> </ul>	<p>Available platforms</p>	<p>ENCORE <a href="https://encorenature.org/en">https://encorenature.org/en</a></p> <p>TNFD LEAP <a href="https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/">https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/</a></p> <p>WWF Risk Filter <a href="https://riskfilter.org/biodiversity/home">https://riskfilter.org/biodiversity/home</a></p>
TNFD additional global disclosure metrics for dependencies and impacts on nature	Land/ freshwater/ ocean use change	A3.0	<p>Total water withdrawal and consumption (absolute, change from previous year)</p>	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>1. Water consumption</li> <li>2. Areas of water stress</li> </ol>	<ol style="list-style-type: none"> <li>2. Aqueduct water risk atlas <a href="https://www.wri.org/data/aqueduct-water-risk-atlas">https://www.wri.org/data/aqueduct-water-risk-atlas</a></li> <li>2. Evaporative Stress Index <a href="https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f">https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f</a></li> </ol>

TNFD additional global disclosure metrics for dependencies and impacts on nature	Pollution/pollution removal	A2.3	Light and noise pollution	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Statistics and Research</li> </ul>	<ol style="list-style-type: none"> <li>1. Light pollution data</li> <li>2. Noise pollution data</li> </ol>	<ol style="list-style-type: none"> <li>1. Global Annual Simulated NPP-VIIRS Nighttime Light Dataset <a href="https://figshare.com/articles/dataset/A_history_reconstructed_time_series_1992-2011_of_annual_global_NPP-VIIRS-V2-like_nighttime_light_data_through_Super-resolution_U-Net_model/22262545/8">https://figshare.com/articles/dataset/A_history_reconstructed_time_series_1992-2011_of_annual_global_NPP-VIIRS-V2-like_nighttime_light_data_through_Super-resolution_U-Net_model/22262545/8</a></li> <li>2. Flight Noise Map <a href="https://noise-map.com/">https://noise-map.com/</a></li> </ol>
	State of nature	A5.0	Level of ecosystem condition by type of ecosystem and business activity – refer to TNFD additional guidance on state of nature measurement in Annex 2 of the LEAP approach.	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Portfolio Management</li> </ul>	Ecosystem condition modelling and mapping	Globio Model <a href="https://www.Globio Model.info/resources">https://www.Globio Model.info/resources</a>
	State of nature	A5.1	Quantitative measure of ecosystem extent, e.g. change in habitat cover (km <sup>2</sup> ).	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>1. Land use and land cover mapping</li> <li>2. Ecosystem Classification and mapping</li> </ol>	<ol style="list-style-type: none"> <li>1. ESA (<a href="https://esa-worldcover.org/en">https://esa-worldcover.org/en</a>); WRI-Google <a href="https://dynamicworld.app/about">https://dynamicworld.app/about</a></li> <li>1. WWF Deforestation Fronts <a href="https://wwf.panda.org/discover/our_focus/forests_practice/deforestation_fronts/">https://wwf.panda.org/discover/our_focus/forests_practice/deforestation_fronts/</a></li> <li>1. WRI Data sets <a href="https://gfr.wri.org/data-methods">https://gfr.wri.org/data-methods</a></li> <li>1. Trase database <a href="https://trase.earth/open-data">https://trase.earth/open-data</a></li> <li>2. IUCN Level 3 Typology <a href="https://global-ecosystems.org/">https://global-ecosystems.org/</a></li> <li>2. Global Ecosystem Atlas <a href="https://globalecosystemsatlas.org/">https://globalecosystemsatlas.org/</a></li> </ol>
	State of nature	A5.2	Quantitative measure of ecosystem connectivity, e.g. Singapore Index.	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> </ul>	<ol style="list-style-type: none"> <li>1. Index</li> <li>2. Data for other indexes</li> </ol>	<ol style="list-style-type: none"> <li>1. Singapore index: <a href="https://www.cbd.int/doc/publications/cbd-ts-98-en.pdf">https://www.cbd.int/doc/publications/cbd-ts-98-en.pdf</a></li> <li>1. Forest Landscape Integrity Index <a href="https://www.forestintegrity.com/">https://www.forestintegrity.com/</a></li> <li>1. WWF Globil Forest Landscape Integrity Index <a href="https://hub.arcgis.com/datasets/3e5820bb80b54b83b9e52f310b461d3a/explore">https://hub.arcgis.com/datasets/3e5820bb80b54b83b9e52f310b461d3a/explore</a></li> </ol>

TNFD additional global disclosure metrics for dependencies and impacts on nature	State of nature	A5.3	Quantitative measure of species extinction risk – refer to TNFD additional guidance on state of nature measurement in Annex 2 of the LEAP approach.	<ul style="list-style-type: none"> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Statistics and Research</li> <li>Portfolio Management</li> </ul>	Extinction risk metric	<p>Irwin, A., Geschke, A., Brooks, T.M. <i>et al.</i> (2022). "Quantifying and categorising national extinction-risk footprints". <i>Sci Rep</i> 12, 586.  <a href="https://www.nature.com/articles/s41598-022-09827-0">https://www.nature.com/articles/s41598-022-09827-0</a></p> <p>IUCN Red List of Threatened Species  <a href="https://www.iucnredlist.org/">https://www.iucnredlist.org/</a></p>
	State of nature	A5.4	Quantitative measure of species population size.	<ul style="list-style-type: none"> <li>Location of impacts and dependencies</li> <li>Data availability</li> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Portfolio Management</li> </ul>	Distribution of species and population size	<p>Dasgupta, S., Blankespoor, S. and Wheeler, D. (2024). "Toward Better Conservation: A Spatial Analysis of Species Occurrence Data from the Global Biodiversity Information Facility", <i>Earth System Data Science</i>,  <a href="https://essd.copernicus.org/preprints/essd-2024-241/">https://essd.copernicus.org/preprints/essd-2024-241/</a></p>
	Ecosystem services	A6.0	Ecosystem services the organisation has an impact on: measurement of the change in the availability and quality of the ecosystem services	<ul style="list-style-type: none"> <li>Location of impacts and dependencies</li> <li>Data availability</li> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Non-Supervisory Engagement</li> <li>Portfolio Management</li> </ul>	Biophysical modelling	<p>SWAT  <a href="https://swat.tamu.edu/">https://swat.tamu.edu/</a></p> <p>InVEST  <a href="https://naturalcapitalproject.stanford.edu/software/invest">https://naturalcapitalproject.stanford.edu/software/invest</a></p> <p>Nature Braid  <a href="https://envi-met.com/">https://envi-met.com/</a></p> <p>ARIES  <a href="https://aries.integratedmodelling.org/">https://aries.integratedmodelling.org/</a></p>
	Ecosystem services	A6.1	Ecosystem services the organisation depends on: measurement of the change in the availability and quality of the ecosystem services	<ul style="list-style-type: none"> <li>Location of impacts and dependencies</li> <li>Data availability</li> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Non-Supervisory Engagement</li> <li>Portfolio Management</li> </ul>	Biophysical modelling	<p>SWAT  <a href="https://swat.tamu.edu/">https://swat.tamu.edu/</a></p> <p>InVEST  <a href="https://naturalcapitalproject.stanford.edu/software/invest">https://naturalcapitalproject.stanford.edu/software/invest</a></p> <p>Nature Braid  <a href="https://envi-met.com/">https://envi-met.com/</a></p> <p>ARIES  <a href="https://aries.integratedmodelling.org/">https://aries.integratedmodelling.org/</a></p>
TNFD additional global metrics nature-related risks & opportunities	Physical risk	A8.0	Description and value of assets/total annual revenue dependent on area affected by physical risk.	<ul style="list-style-type: none"> <li>Climate nature nexus</li> <li>Data availability</li> <li>Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>Micro-prudential</li> <li>Macro-prudential</li> <li>Monetary Policy</li> <li>Portfolio Management</li> </ul>	Available platforms	<p>ENCORE  <a href="https://encorenature.org/en">https://encorenature.org/en</a></p> <p>TNFD LEAP  <a href="https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/">https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/</a></p> <p>WWF Risk Filter  <a href="https://riskfilter.org/biodiversity/home">https://riskfilter.org/biodiversity/home</a></p>

TNFD additional global metrics nature-related risks & opportunities	Physical risk	A8.1	Number of locations/business lines/facilities exposed to physical risk	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	Available platforms	<p>ENCORE <a href="https://encorenature.org/en">https://encorenature.org/en</a></p> <p>TNFD LEAP <a href="https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/">https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/</a></p> <p>WWF Risk Filter <a href="https://riskfilter.org/biodiversity/home">https://riskfilter.org/biodiversity/home</a></p>
	Physical risk	A8.6	Value of assets, liabilities, revenue and expenses that are exposed to nature-related physical risks (total and proportion of total)	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Portfolio Management</li> </ul>	Available platforms	<p>ENCORE <a href="https://encorenature.org/en">https://encorenature.org/en</a></p> <p>TNFD LEAP <a href="https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/">https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/</a></p> <p>WWF Risk Filter <a href="https://riskfilter.org/biodiversity/home">https://riskfilter.org/biodiversity/home</a></p>
	Transition risk	A9.0	Value of assets, liabilities, revenue and expenses that are exposed to nature-related physical risks (total and proportion of total)	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Portfolio Management</li> </ul>	Available platforms	<p>ENCORE <a href="https://encorenature.org/en">https://encorenature.org/en</a></p> <p>TNFD LEAP <a href="https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/">https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach/</a></p> <p>WWF Risk Filter <a href="https://riskfilter.org/biodiversity/home">https://riskfilter.org/biodiversity/home</a></p>
	Opportunity: markets	A15.0	Year-on-year change in ESG rating scores for previous 3 years	<ul style="list-style-type: none"> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	Data on ESG ratings	Sustainalytics ESG Risk Ranking <a href="https://www.sustainalytics.com/esg-ratings">https://www.sustainalytics.com/esg-ratings</a>
	Opportunity: capital flow and financing	A16.0	Value of green finance instruments used, such as green bonds and sustainability-linked bonds	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	Data on sustainable finance	<p>Climate Bonds Initiative <a href="https://www.climatebonds.net/market/data/">https://www.climatebonds.net/market/data/</a></p> <p>IMF Green Bonds <a href="https://climatedata.imf.org/datasets/8e2772e0b65f4e33a80183ce9583d062_0/about">https://climatedata.imf.org/datasets/8e2772e0b65f4e33a80183ce9583d062_0/about</a></p>

TNFD additional global metrics for responses nature-related issues	Dependency, impact, risk and opportunity management: value chain	A22.2	Credible and transparent third-party certification: percentage and/or value of production, consumption and sourcing of raw materials, per certification type	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	Certification information by company	<p>International Sustainability &amp; Carbon Certification  <a href="https://www.iscc-system.org/certification/certificate-database/valid-certificates/">https://www.iscc-system.org/certification/certificate-database/valid-certificates/</a></p> <p>Trase database  <a href="https://trase.earth/open-data">https://trase.earth/open-data</a></p>
TNFD Core and additional sector disclosure indicators and metrics – Aquaculture	Invasive alien species and other	A.C4.0	Total number and percentage of escapes per species, including type of escape events (minor, major, catastrophic failure) by type of ecosystem affected (marine, freshwater, terrestrial), including in cases of extreme weather.	<ul style="list-style-type: none"> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Macro-prudential</li> <li>• Non-Supervisory Engagement</li> </ul>	Number of fish escapes	<p>Attalah and Sanchez-Jerez (2020). Global assessment of ecological risks associated with farmed fish escapes. Global Ecology and Conservation, 21 (March): e00842  <a href="https://www.sciencedirect.com/science/article/pii/S2351989419305888">https://www.sciencedirect.com/science/article/pii/S2351989419305888</a></p> <p>Fishsource  <a href="https://www.fishsource.org/">https://www.fishsource.org/</a></p>
	Strategy: policies commitments & targets	AA19.0	Proportion (%) of fishmeat suppliers that have policies in place to prevent illegal fishing.	<ul style="list-style-type: none"> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	List of certified suppliers	<p>Marine Stewardship Council – Sustainable Seafood Suppliers  <a href="https://www.msc.org/en-au/for-business/supply-chain/find-sustainable-seafood-suppliers">https://www.msc.org/en-au/for-business/supply-chain/find-sustainable-seafood-suppliers</a></p> <p>List of certification schemes accepted under the ASC Feed Standard  <a href="https://www.asc-aqua.org/wp-content/uploads/2022/09/ASC-Feed-Standard-list-of-accepted-certification-schemes.pdf">https://www.asc-aqua.org/wp-content/uploads/2022/09/ASC-Feed-Standard-list-of-accepted-certification-schemes.pdf</a></p>
TNFD Core and additional sector disclosure indicators and metrics – Electric utilities and power	Land/ freshwater/ ocean-use change	EPC1.0	Wind – Number of bird and bat casualties.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> </ul>	Data on mortality of bird & bat due to collision with wind plants	<p>Buchanan <i>et al.</i> 2017. "Bird and bat species' global vulnerability to collision mortality at wind farms revealed through a trait-based assessment", Proc. R. Soc. B.28420170829  <a href="https://royalsocietypublishing.org/doi/10.1098/rspb.2017.0829">https://royalsocietypublishing.org/doi/10.1098/rspb.2017.0829</a></p>
	Land/ freshwater/ ocean-use change	EPC1.1	Hydropower – Proportion (%) of environmental/ ecological flow versus total flow, considering climatic variability (e.g. El Niño–Southern Oscillation).	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> </ul>	Environmental/ ecological flow	<p>IWMI Environmental Flow Calculators  <a href="https://www.iwmi.org/news/environmental-flow-calculators/">https://www.iwmi.org/news/environmental-flow-calculators/</a></p>
TNFD Core and additional sector disclosure indicators and metrics – Food and agriculture	Land/ freshwater/ ocean-use change	FA.C1.0	Proportion (%) of production volume from land controlled, managed or sourced from that is determined to be deforestation and conversion-free (DCF), by product.	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Deforestation and conversion-free from suppliers and producers	<p>Habibur <i>et al.</i> (2025). Oil palm- and rubber-driven deforestation in Indonesia and Malaysia (2000–2021) and efforts toward zero deforestation commitments, Agroforestry Systems, 99(20).  <a href="https://link.springer.com/article/10.1007/s10457-024-01119-y">https://link.springer.com/article/10.1007/s10457-024-01119-y</a></p> <p>Trase database  <a href="https://trase.earth/open-data">https://trase.earth/open-data</a></p> <p>WWF Global deforestation fronts  <a href="https://www.panda.org/discover/our_focus/forests_practice/deforestation_fronts/">https://www.panda.org/discover/our_focus/forests_practice/deforestation_fronts/</a></p>

TNFD Core and additional sector disclosure indicators and metrics – Food and agriculture	Resource use/ replenishment	FA.C3.0	Proportion (%) of agricultural products or animal feed produced or sourced from regions with high or extremely high baseline water scarcity.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Land use and land cover mapping	<p>Fitton <i>et al.</i> (2019). "The vulnerabilities of agricultural land and food production to future water scarcity", <i>Global Environmental Change</i>, 58) – 101944  <a href="https://www.sciencedirect.com/science/article/pii/S0959378018307489#:~:text=Agriculture%20is%20the%20largest%20consumer,et%20al.%2C%202018">https://www.sciencedirect.com/science/article/pii/S0959378018307489#:~:text=Agriculture%20is%20the%20largest%20consumer,et%20al.%2C%202018</a></p> <p>Aqueduct water risk atlas  <a href="https://www.wri.org/data/aqueduct-water-risk-atlas">https://www.wri.org/data/aqueduct-water-risk-atlas</a></p> <p>Evaporative Stress Index  <a href="https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f">https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f</a></p>
	Pollution/ pollution removal	FAA2.1	Nitrogen use efficiency (NUE), ratio of total N inputs and total N outputs to produce a crop, animal product or agrifood product.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Statistics and Research</li> </ul>	NUE data	<p>Peng <i>et al.</i> (2023). "Global terrestrial nitrogen uptake and nitrogen use efficiency", <i>Journal of Ecology</i>, 111(12): 2676-2693.  <a href="https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2745.14208">https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2745.14208</a></p> <p>You <i>et al.</i> (2023). "Global mean nitrogen recovery efficiency in croplands can be enhanced by optimal nutrient, crop and soil management practices", <i>Nature Communications</i>, 14: 5747.  <a href="https://www.nature.com/articles/s41467-023-41504-2">https://www.nature.com/articles/s41467-023-41504-2</a></p>
	Pollution/ pollution removal	FAA2.3	Water pollutant loading rate (tonnes of pollutant/month). Reporting should include locally developed model results for pollutants from non-point source, based on average nitrogen and phosphorus nutrient loads over past 5 years of operations.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Water pollutant effluents data	<p>Nguyen, T. H., Tang, F. H. M., Conchedda, G. <i>et al.</i> NPKGRIDS: a global georeferenced dataset of N, P2O5, and K2O fertilizer application rates for 173 crops. <i>Sci Data</i> 11, 1179 (2024).  <a href="https://doi.org/10.1038/s41597-024-04030-4">https://doi.org/10.1038/s41597-024-04030-4</a>  <a href="https://www.nature.com/articles/s41597-024-04030-4">https://www.nature.com/articles/s41597-024-04030-4</a></p> <p>WWF Water Risk Filter  <a href="https://riskfilter.org/water/explore/map">https://riskfilter.org/water/explore/map</a></p>
	Resource use/ replenishment	FAA3.0	Actual and potential yield (kg/km <sup>2</sup> ), and yield gap, by type of crop.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> </ul>	Yields by type of crop	<p>Global Yield Gap Atlas  <a href="https://www.yieldgap.org/">https://www.yieldgap.org/</a></p>
	Ecosystem condition	FAA5.0	Coastal and freshwater eutrophication; plastic debris density; Chlorophyll-A concentration; In-situ concentration of nitrogen, phosphate and silica.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> </ul>	State (levels) for eutrophication; Chlorophyll-A; and levels of nitrogen, phosphate and silica in the environment.	<p>NASA Earth Observations  <a href="https://neo.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA">https://neo.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA</a></p> <p>Copernicus Nutrient and carbon profiles vertical distribution  <a href="https://data.marine.copernicus.eu/product/MULTIOBS_GLOBGC_NUTRIENTS_CARBON_PROFILES_MYNRT_015_009/description">https://data.marine.copernicus.eu/product/MULTIOBS_GLOBGC_NUTRIENTS_CARBON_PROFILES_MYNRT_015_009/description</a></p>

TNFD Core and additional sector disclosure indicators and metrics – Food and agriculture	Ecosystem condition	FAA5.1	Proportion (%) of cropland controlled, managed and/or sourced from with at least 10% natural vegetation per 1 km <sup>2</sup> cultivated area.  Proportion (%) of such land with more than 20% natural vegetation per 1 km <sup>2</sup> cultivated area.	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Portfolio Management</li> </ul>	Land use and land cover mapping	<p>ESA World Land Cover <a href="https://esa-worldcover.org/en">https://esa-worldcover.org/en</a></p> <p>WRI-Google Land Cover <a href="https://dynamicworld.app/about">https://dynamicworld.app/about</a></p>
	Ecosystem condition	FAA5.2	Proportion (%) of land with soil degradation in the total area of agricultural production, including soil erosion, reduction in soil fertility, salinisation of irrigated lands and waterlogging.	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	Land and soil quality data	<p>GLoSEM – Global Soil Erosion Modelling platform <a href="https://esdac.jrc.ec.europa.eu/themes/global-soil-erosion">https://esdac.jrc.ec.europa.eu/themes/global-soil-erosion</a></p>
	Ecosystem condition	FAA5.5	Antimicrobial residue in the soil (nano/milligrams per kilogram of soil).	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> </ul>	Land and soil quality data	<p>Zhao <i>et al.</i> (2025). "Global prediction of agricultural soil antibiotic susceptibility and safe boundary for biota", <i>iScience</i>, Feb 20;28(3):112066. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC11928842/">https://pmc.ncbi.nlm.nih.gov/articles/PMC11928842/</a></p> <p>Zheng <i>et al.</i> (2022). "Global biogeography and projection of soil antibiotic resistance genes", <i>Sciences Advances</i>, 8, eabq8015. <a href="https://www.science.org/doi/10.1126/sciadv.abq8015">https://www.science.org/doi/10.1126/sciadv.abq8015</a></p>
	Ecosystem condition	FAA5.6	Soil bulk density, measured as the ratio of a soil's dry mass and its volume (g/cm <sup>3</sup> ).	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Monetary Policy</li> </ul>	Land and soil quality data	<p>Batjes <i>et al.</i> (2019). "Standardised soil profile data to support global mapping and modelling (WoSIS snapshot 2019)", <i>Earth Syst. Sci. Data</i>, 12, 299–320. <a href="https://essd.copernicus.org/articles/12/299/2020/essd-12-299-2020.html">https://essd.copernicus.org/articles/12/299/2020/essd-12-299-2020.html</a></p>
	Ecosystem condition	FAA5.7	Soil organic carbon (tC).	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Monetary Policy</li> <li>• Statistics and Research</li> </ul>	Spatial soil organic carbon data	<p>Chen <i>et al.</i> (2024). "GSOCS-LULCC: the Global Soil Organic Carbon Stock dataset after Land Use and Land Cover Change", <a href="https://essd.copernicus.org/preprints/essd-2024-373/">https://essd.copernicus.org/preprints/essd-2024-373/</a></p>

TNFD Core and additional sector disclosure indicators and metrics – Forestry, pulp and paper	Dependency, impact, risk and opportunity management: Value chain	FPA22.0	The proportion of forest area (%) certified by broadly recognised third-party certification systems with a global presence, such as: the Forest Stewardship Council (FSC), Programme for the Endorsement of Forest Certification (PEFC) and Sustainable Forestry Initiative (SFI). 'Controlled Wood', 'Controlled Sources' or 'SFI Fiber Sourcing' are excluded.	<ul style="list-style-type: none"> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Certification list for forestry operations	<p>FSC GIS Portal – <a href="https://connect.fsc.org/innovation-sustainability/earth-observation">https://connect.fsc.org/innovation-sustainability/earth-observation</a></p> <p>Kraxner <i>et al.</i> (2017). "Mapping certified forests for sustainable management – A global tool for information improvement through participatory and collaborative mapping", <i>Forest Policy and Economics</i>, 83 (October): 10-18. <a href="https://www.sciencedirect.com/science/article/pii/S1389934116302246">https://www.sciencedirect.com/science/article/pii/S1389934116302246</a></p>
	Dependency, impact, risk and opportunity management: Voluntary conservation, restoration and regeneration	FPA24.0	Proportion (%) of land owned, leased or managed that is designated for restoration or conservation.	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	Spatial restoration and conservation dataset	<p>Society for Ecological Restoration – Restoration Database <a href="https://ser-rrc.org/restoration-database/?type=resource#database">https://ser-rrc.org/restoration-database/?type=resource#database</a></p>
	Climate change	FPAX.1.0	Carbon sequestered by land owned, leased or managed (t CO <sub>2</sub> e), broken down by forest plantations and natural/semi-natural land and products.	<ul style="list-style-type: none"> <li>• Climate nature nexus</li> <li>• Data availability</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Monetary Policy</li> <li>• Statistics and Research</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	<ol style="list-style-type: none"> <li>1. Land use and land cover mapping</li> <li>2. CO<sub>2</sub> sequestration mapping</li> </ol>	<ol style="list-style-type: none"> <li>1. ESAWorld Land Cover <a href="https://esa-worldcover.org/en">https://esa-worldcover.org/en</a></li> <li>1. WRI-Google Land Cover <a href="https://dynamicworld.app/about">https://dynamicworld.app/about</a></li> <li>2. Xu <i>et al.</i> (2024). "Global Forest Plantations Mapping and Biomass Carbon Estimation", 129(3): March, e2023JG007441. <a href="https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2023JG007441">https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2023JG007441</a></li> <li>2. Global Forest Carbon Fluxes <a href="https://www.globalforestwatch.org/map">https://www.globalforestwatch.org/map</a></li> </ol>
	Land/freshwater/ocean use change	FPA1.0	Area (km <sup>2</sup> ) of high biodiversity value or high conservation value protected.	<ul style="list-style-type: none"> <li>• Land use change</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Non-Supervisory Engagement</li> <li>• Portfolio Management</li> </ul>	High biodiversity and conservation value mapping	<p>Biodiversity Intactness Index (BII) <a href="https://gee-community-catalog.org/projects/bii/">https://gee-community-catalog.org/projects/bii/</a></p> <p>Schipper <i>et al.</i> (2017). Compiling biodiversity accounts with the GLOBIO MODEL model: A case study of Mexico, PBL Netherlands Environmental Assessment Agency <a href="https://www.pbl.nl/sites/default/files/downloads/pbl-2017-compiling-biodiversity-accounts-with-the-GLOBIO-MODEL-model-2607.pdf">https://www.pbl.nl/sites/default/files/downloads/pbl-2017-compiling-biodiversity-accounts-with-the-GLOBIO-MODEL-model-2607.pdf</a></p> <p>Globio Model <a href="https://www.Globio-Model.info/resources">https://www.Globio-Model.info/resources</a></p>

TNFD Additional financial indicators and metrics – Based on foot printing approaches	Footprinting approaches	Ecological footprint	<ul style="list-style-type: none"> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Data for ecological footprint	Global footprint network – <a href="https://www.footprintnetwork.org/our-work/ecological-footprint/">https://www.footprintnetwork.org/our-work/ecological-footprint/</a>
	Biodiversity footprints	Living Planet Index (LPI)	<ul style="list-style-type: none"> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Living Planet Index Data	Living Planet Index <a href="https://www.livingplanetindex.org/data_portal">https://www.livingplanetindex.org/data_portal</a>
	Biodiversity footprints	Ecosystem condition as measured by Mean Species Abundance (MSA) (adjusted for management in case of forest-based activities such as logging)	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Data on MSA	Globio Model <a href="https://www.Globio Model.info/resources">https://www.Globio Model.info/resources</a>
	Biodiversity footprints	Range Size Rarity (RSR)	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Data availability</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>		Species Richness and Rarity-Weighted Richness Data: <a href="https://www.iucnredlist.org/resources/other-spatial-downloads">https://www.iucnredlist.org/resources/other-spatial-downloads</a>
	Biodiversity footprints	Species threat, abatement and restoration (STAR)	<ul style="list-style-type: none"> <li>• Location of impacts and dependencies</li> <li>• Multi dimension</li> </ul>	<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>	Data on species threat, abatement and restoration	Mair <i>et al.</i> (2021): “A metric for spatially explicit contributions to science-based species targets”, <i>Nature Ecology &amp; Evolution</i> , 5: 836–844. <a href="https://www.nature.com/articles/s41559-021-01432-0.epdf?sharing_token=VtiBRXWsDKWppqvQnEHstNRgN0jAjWeI9jnR3ZoTv0MQPnY05OFo3jMj7mH0kelsuD_DN4rlrXuzkUWgDeilYuPSZseJ4ldoO55Gj9fEF34CAjgTt004NmbO2HGXqlALCPAjqBPYTq9ilGB1k2-epmm-0LGj43vxEmB-c6zqSLg%3D">https://www.nature.com/articles/s41559-021-01432-0.epdf?sharing_token=VtiBRXWsDKWppqvQnEHstNRgN0jAjWeI9jnR3ZoTv0MQPnY05OFo3jMj7mH0kelsuD_DN4rlrXuzkUWgDeilYuPSZseJ4ldoO55Gj9fEF34CAjgTt004NmbO2HGXqlALCPAjqBPYTq9ilGB1k2-epmm-0LGj43vxEmB-c6zqSLg%3D</a>
	Biodiversity footprints	Biodiversity change		<ul style="list-style-type: none"> <li>• Micro-prudential</li> <li>• Macro-prudential</li> <li>• Portfolio Management</li> </ul>		Biodiversity Intactness Index <a href="https://gee-community-catalog.org/projects/bii/">https://gee-community-catalog.org/projects/bii/</a>

## 4. Case studies for integrating nature indicators in risk analysis

**Nature-related risks are multi-dimensional, location-specific, and complex.** Scenarios are calibrated locally, representing the specific circumstances of natural assets and their linkages with people and the economy with higher levels of heterogeneity across areas. Narrative scenario approaches address limitations of scenarios that do not fully account for acute impacts of nature-related risks, including the feedback mechanisms triggered within the economy. Relevant methodological and data issues regarding integration of nature indicators in risk analysis include the following:

- **Changes in ecosystems services are state-dependent, i.e. the effect of actions taken by a firm or group of firms depends on the level of the variable of interest.** This implies to have a measure of the status of nature (e.g. water quality); the size of risk drivers (e.g. amount of water discharge from a factory); and the change in the status of nature by the drivers.
- **Exposure of stakeholders to hazard depends on their location.** While national authorities sometimes record cadastral information of properties and housing values, private assets values may be unavailable.
- **The assessment involves estimating potential impacts on assets, prices, productivity, and human health, among others, where it is essential to consider both direct and indirect economic effects, particularly in the value chains.** This includes analysing potential micro and macro-level effects, both regional and sectoral, considering geographical and technological substitutability, as well as the scale of impact including local and global feedback mechanisms.

- **The assessment involves evaluating credit, market, liquidity, and operational risks, which also includes understanding the impacts, dependencies, and opportunities related to chronic physical risks for the financial system.** For example, exposure to water-related risks can impact the credit rating of a sector by increasing its interest rate for borrowing and deter investments in new capex or efficient technologies that could improve water-use. This in turn can spread throughout financial systems and create feedback loops to the real economy if suppliers/buyers are affected by the financial constraints faced by the sector.
- **Calibration data is often unavailable for risk models used in scenario simulation or for deriving loss distribution from actual loss events, particularly for risks with high severity.** Moreover, scaling approaches – where operational risk exposures are benchmarked against peer data using gross income or balance sheet size as proxies for risk – are generally not feasible. This is due to the specific characteristics of each company's location and the unique nature of its operations, which limit comparability and undermine the validity of such scaling techniques.

This section provides case studies of the integration of these metrics/indicators for risk analysis. Cases 1 and 3 focus on assessments of nature and biodiversity risk at national (Malaysia) and regional (European Union) level economies using sectoral methods and data, while Cases 2 and 4 review assessments at a more micro or local level for examples of water pollution and nature-based solutions, respectively. Table 5 below provides a summary of the challenges and lessons learnt across these four case studies.

Table 5 Summary of the challenges and lessons learnt from the case studies

Case	Challenges	Lessons Learnt
Nature-related financial risks in Malaysia	<ul style="list-style-type: none"> <li>Limited availability of geospatial data for nature and ecosystem services.</li> <li>Limited integration of high natural resources dependency into financial risk assessment.</li> <li>Reliance on multiple databases with different granularity and coverage.</li> </ul>	<ul style="list-style-type: none"> <li>Useful approach to approximate vulnerabilities for the financial sector.</li> <li>Need for centralised data infrastructure to support risk assessment.</li> <li>Recommendation of mandatory nature-related data disclosure and improvement in data collection.</li> </ul>
Water pollution risk assessment in the Oder River	<ul style="list-style-type: none"> <li>Monitoring data is not centralized nor harmonised.</li> <li>Lack of pre-disaster benchmark data.</li> <li>Insufficient genomic and ecological data on harmful algal blooms.</li> </ul>	<ul style="list-style-type: none"> <li>Real-time monitoring and genomic tools are needed for risk assessment.</li> <li>Inter-institutional collaboration enhances data synthesis.</li> </ul>
Nature-related risks and financial risks in the Euro Area	<ul style="list-style-type: none"> <li>ENCORE does not account for spatial variations in ecosystem services dependencies.</li> <li>Problems with data harmonisation due to misalignment between AnaCredit (NACE classification) and ENCORE (GICS classification).</li> <li>Restricted access to Anacredit might limit external research and findings replication.</li> </ul>	<ul style="list-style-type: none"> <li>Systemic financial risks from nature loss are significant and need to be accounted for.</li> <li>Dependency score framework can help to quantify exposure.</li> <li>Data harmonisation, transparency and location-specific dependencies are essential for nature-related risk modelling.</li> <li>Need to integrate supply chain dependencies in risk assessment.</li> </ul>
Nature-based solutions: Green infrastructure initiatives in Milan	<ul style="list-style-type: none"> <li>Availability and costs of a laser remote sensing technology (LIDAR) data and updated construction costs data.</li> <li>Flood modelling requires detailed elevation, soil, and rainfall data.</li> </ul>	<ul style="list-style-type: none"> <li>Urban-green infrastructure can significantly reduce flood risk and economic damages.</li> <li>High-resolution geospatial data is crucial for nature-based solutions assessment.</li> <li>Developing scenarios allows to assess trade-offs and benefit of green investments.</li> <li>Need of public investment on data infrastructure to support urban resilience to climate change.</li> </ul>

## 4.1 Nature-related financial risks in Malaysia

**A joint report from Bank Negara Malaysia (BNM) and the World Bank explores the financial risks associated with nature loss in Malaysia (World Bank, 2022). It studies examples of nature loss due to different drivers such as significant cover loss due to deforestation, the impact of pollution and overfishing on Malaysia’s coral reefs and mangroves – crucial for coastal protection and fisheries, and the over-extraction of groundwater and contamination of water bodies, affecting both human and ecological health, among others. It also provides insights into how nature-related risks can impact the financial sector and offers recommendations for managing these risks.**

The study makes use of both Malaysian and global data. The sectoral mapping data is primarily obtained from the ENCORE database while the exposure data is obtained from

BNM. The spatial analysis uses data on Key Biodiversity Areas in Malaysia from the World Database of Key Biodiversity Areas, hosted by the Integrated Biodiversity Assessment Tool (IBAT)<sup>15</sup>. The sectoral analysis covers approximately 90% of the total commercial loan portfolio of Malaysian banks, whereas the data available for the spatial analysis are considerably more limited.

The report used a series of data and sources:

- **Environmental Data (Biodiversity and Ecosystem Services): the report uses data on biodiversity and ecosystem services to assess the dependency of various economic sectors on natural resources.** This includes data on forest cover, water resources, and marine ecosystems. For example, the report highlights the importance of mangroves in coastal protection and fisheries. Climate-related data, such as temperature and precipitation patterns, are also used to understand the impact of climate change on natural resources and the

<sup>15</sup> <https://www.ibat-alliance.org/>.

economy. The report includes projections of climate change impacts on agriculture and water availability.

- **Economic Data: the report examines the economic contribution of different sectors, such as agriculture, forestry, fisheries, and tourism, to understand their reliance on natural resources.** For instance, the agriculture sector's dependency on water resources is analysed using data on irrigation and rainfall patterns.
- **Financial Data: financial performance of companies in nature-dependent sectors are analysed to assess their exposure to nature-related risks.** This includes data on revenue, profit margins, and credit exposure of banks to these sectors.
- **Geospatial Data (Land Use and Land Cover): Geospatial data on land use and land cover changes are used to identify areas at risk of deforestation, habitat loss, and other environmental changes.** It includes maps showing deforestation rates and protected areas.
- **Protected Areas: Information on protected areas and conservation efforts is included to evaluate the effectiveness of current measures in preserving biodiversity.** The report uses data from the World Database on Protected Areas (WDPA).

**Risk assessment tools employ scenario analysis to project the potential impacts of different environmental and economic scenarios on financial stability.**

For example, scenarios of severe droughts affecting agricultural output and financial stability and examples of stress tests conducted on banks' loan portfolios to assess their vulnerability to environmental risks.

**The report includes a series of recommendations regarding data.** First, financial institutions should integrate nature-related risks into their risk management frameworks. This includes incorporating environmental risk assessments into lending and investment decisions. Second, improved data collection and monitoring of environmental indicators are essential for better risk assessment. The report recommends developing a centralised database for environmental data. Third, policymakers should implement measures to protect natural resources and promote sustainable economic practices. This includes strengthening regulations on land use and promoting conservation efforts.

## 4.2 Water pollution risk assessment in the Oder River

**In August 2022, the Oder River experienced an environmental disaster, resulting in the death of 360 tonnes of fish, about half of the river's stock. The pollution had significant ecological, economic, and social impacts, including disrupted ecosystems, economic losses for the fishing and tourism industries, and health risks for residents.** Ongoing investigations aim to identify and hold accountable the parties responsible, a process that may ultimately inform the development of new environmental regulations.

The "ODERSO" project<sup>16</sup> by the Leibniz Institute of Freshwater Ecology and Inland Fisheries, in collaboration with German universities, monitors and analyses pollutants, documents organism recovery, studies future poisoning events, and investigates floodplain ecology. The goal is to create a knowledge base for managing river-floodplain ecosystems and preventing algal blooms. The methods used in this project includes:

- Monitoring and analysis of algae and pollutant loads;
- Documentation of the remaining populations of important aquatic organism groups;
- Documentation of the regeneration of populations of important aquatic organism groups;
- Toxin precautionary studies in relation to possible further prymnes in poisoning and development of an early warning system;
- Presentation of the resilience and refugial function as well as ecosystem services of the floodplains in three development scenarios.

Several data collection initiatives were identified to fill gaps regarding the understanding of the impacts of water pollution on the biodiversity and economic activities in the Oder River:

- Data portal for use for spatio-temporal data structures;
- Data synthesis of monitoring and early warning systems as well as satellite data;
- Genomic prymnesium monitoring, e.g. for a better transcriptome-based understanding of prymnesium growth and toxin production;

<sup>16</sup> <https://www.oder-so.info/en/oderso-project>.

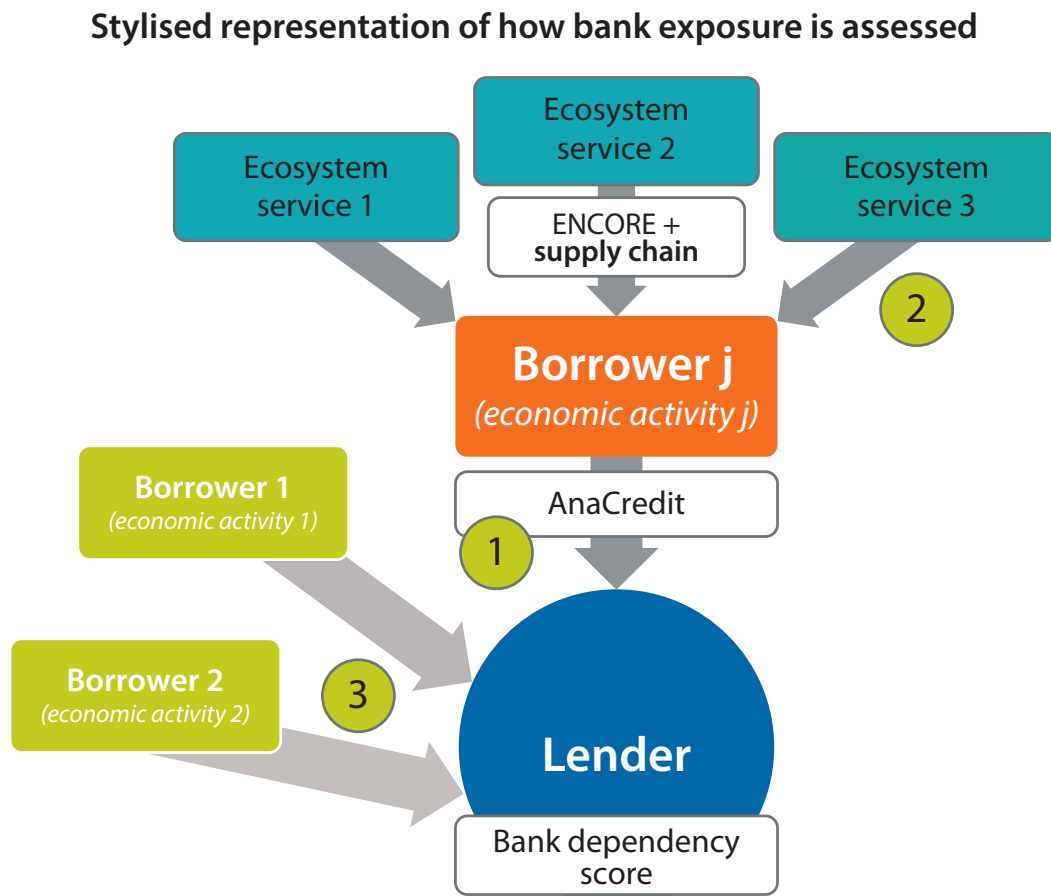
- Measurement of zooplankton and mussel filtration to visualise the biological control mechanisms of algal mass development;
- Determination of the decline of fish populations.

The project aims to deepen the understanding of functional relationships during an environmental disaster and provide a comprehensive description of the resulting ecological and economic damage. It formulates recommendations to mitigate future risks and benefits for regional authorities, committees, companies, and organisations, including the Lower Oder Valley National Park, by enhancing environmental monitoring and management of water and nature conservation in the Oder and its floodplains. The project also improves the knowledge base regarding the Oder, raises public and stakeholder awareness, and supports sustainable developments in the region.

### 4.3 Nature-related risks and financial stability in the Euro Area

The ECB assessed the dependency of euro area economy and banks on nature by focusing on the NFCs reliance on ecosystem services like food, water, climate regulation, and carbon storage (Boldrini *et al*, 2023). The analysis follows a three-step methodology (Figure 1). First, it links banks' loan exposures to their counterparties – NFCs that received the loans – using Anacredit data. Second, it assesses the dependency of each NFC on ecosystem services, distinguishing between direct and indirect dependencies that are then aggregated into a total dependency score – a weighted indicator that captures the borrower's overall reliance on ecosystem services. Lastly, this dependency score is assigned to the aggregate loan portfolio of euro area banks.

Figure 1 Framework for NFC and bank exposure assessment



Source: Boldrini *et al*. (2023).

The data sources for this analysis are the following:

- **Bank loan data – AnaCredit. The internal ECB’s Analytical Credit Dataset (AnaCredit)** provides detailed, instrument-level data on individual euro area banks’ loan portfolios which are updated monthly. It includes all loans granted by euro area banks to legal entities with a value of €25,000 or more, harmonized across Member States. However, the dataset excludes household credit, such as mortgages.
- **Borrowers’ direct industry dependency on ecosystem services – ENCORE.** The methodology assesses euro area NFCs and financial institutions’ exposure to ecosystem services using the ENCORE dataset (Exploring Natural Capital Opportunities, Risks and Exposure).
- **Borrowers’ indirect industry dependency on ecosystem services – EXIOBASE.** To account for indirect dependencies through supply chains, the ECB integrated ENCORE with the EXIOBASE input-output table, assigning each borrower a total dependency score. These scores are aggregated at the bank portfolio level, weighted by loan exposure. EXIOBASE<sup>17</sup> is a global, environmentally extended multiregional supply-use table (MR-SUT) and input-output table (MR-IOT) obtained as a harmonisation of different supply-use tables (SUTs) and input-output tables (IOTs). IOTs contain inter-industry/inter-product relationships within an economy. Environmentally extended input-output (EE-IO) tables combine these data with information on environmental flows.
- **Location-specific shocks to biodiversity – GLOBIO.** GLOBIO<sup>18</sup> is used to determine location-specific shocks to biodiversity and how the latter is affected by the different NFCs. The GLOBIO model is a global model of biodiversity intactness, expressed by the mean species abundance (MSA)<sup>19</sup> metric, as a function of multiple anthropogenic pressures the environment (Schipper *et al.*, 2020; Alkemade *et al.*, 2009). The GLOBIO model integrates the pressure-impact relationships with spatially resolved data on the pressures, resulting in high-resolution spatial maps with impact-specific MSA values.
- **Other financial data sources.** Finally, other data sources, such as commercial data provider Moody’s – Orbis or public iBACH<sup>20</sup> country data for company balance sheets,

as well as ECB’s supervisory statistics – FINREP/CONREP<sup>21</sup> for supervised banks’ financial statements and capital requirements, are used to complement our analyses with financial information.

**One of the data limitations stems from restrictive access to AnaCredit, the granular credit dataset maintained by the European Central Bank (ECB) and euro area National Central Banks (NCBs).** This dataset is not available to the public or non-euro area NCBs, which prevents conducting independent evaluations of credit exposures to nature-related risks, making it difficult to cross-validate findings with external data sources or apply them in a global context.

**A further data harmonisation problem arises from the differences in industry classification systems used by AnaCredit and ENCORE.** AnaCredit relies on the NACE (Statistical Classification of Economic Activities in the European Community) system, whereas ENCORE uses the GICS (Global Industry Classification Standard)<sup>22</sup>. To align the two, experts have to reclassify ENCORE data into NACE categories, a process that introduces potential mismatches and inconsistencies. In cases where multiple GICS industries correspond to a single NACE code, ECB experts assign the maximum dependency score within that category, which may overstate exposure in some cases.

#### 4.4 Nature-based solutions: Green infrastructure initiatives in Milan

**Staccione *et al.* (2024) simulate the effects of green infrastructure networks on pluvial flood risk on direct economic damage to buildings and population exposed in the Milan metropolitan area.** The article’s framework is shown in Figure 2. Their results show that extending the urban green networks by 25% can potentially decrease the damages to buildings and share of affected population, up to 60% and 50%, respectively.

17 <https://www.exiobase.eu/>.

18 <https://www.globio.info/>.

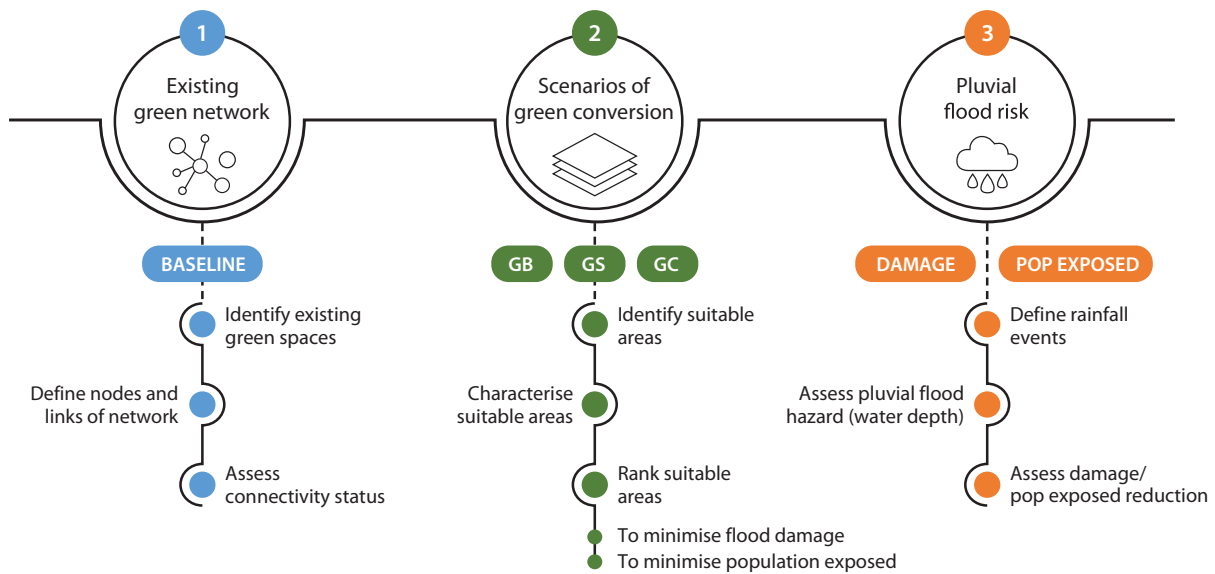
19 The MSA is calculated by dividing the abundance of each species found in the presence of the pressure by its abundance when undisturbed.

20 BACH is an aggregated and harmonised database compiled from annual accounts of non-financial companies and managed by the European Committee of Central Balance Sheet Data Offices, <https://www.eccbso.org/wba/databases>.

21 [https://www.ecb.europa.eu/stats/supervisory\\_prudential\\_statistics/html/index.en.html](https://www.ecb.europa.eu/stats/supervisory_prudential_statistics/html/index.en.html).

22 ENCORE uses the GICS for its first version. Its second version ENCORE v.2, published in 10/24, uses ISIC sectoral classification.

Figure 2 Methodological framework of the analysis



Source: Staccione et al. (2024).

### Phase 1 – Identification of the existing green network.

It consists of the implementation of an urban green infrastructure network analysis to define the green elements to be included in the network. The identification of existing green spaces through landscape connectivity indices (the Integrate Index of Connectivity, IIC) is built on data from the European Settlement Map<sup>23</sup>.

### Phase 2 – Definition of urban green infrastructure improvement scenarios.

The authors proposed three scenarios of green conversion (i) Green Buildings (GB) – establishment of new green roofs; (ii) Green Spaces – converting open, ground spaces to additional green spaces; and (iii) Green City (GC) – a combination of both GB and GS. Four different incremental percentages of green conversion are investigated for each scenario: 25%, 50%, 75%, and 100% for all potential green areas. Areas to be converted to green have been identified and characterised according to a set of criteria and data: (i) cumulative flood direct damages to buildings (Essenfelder *et al.*, 2022); (ii) the

current residential population per grid<sup>24</sup>; (iii) the share of existing open spaces that can be turned to green per cell; (iv) the impact of potential conversion to green roofs per cell<sup>25</sup>, and; (v) the share of roofs that are suitable to green roofs installation per cell<sup>26</sup>.

### Phase 3 – Assessment of the benefits of reductions in pluvial flood risk due to improvements in urban green infrastructure.

Pluvial flood risk is defined as a function of hazard, exposure, and vulnerability. Hazard is computed through the Safer\_RAIN model which uses a two-meter resolution elevation model derived from LIDAR data available from the Italian National Geoportal of the Italian Ministry of the Environment, soil properties from the European Soil Database<sup>27</sup>, imperviousness of the soil and extreme rainfall events of one hour from Essenfelder *et al.* (2022). Exposure is defined by means of built-up environment and population density. Built-up environment was assessed using OpenStreetMaps<sup>28</sup>, meanwhile population density comes from the 100-meter

23 <https://www.eea.europa.eu/en/datahub/datahubitem-view/42783031-34d5-4b38-b9ba-a0783723053c>.

24 <https://data.jrc.ec.europa.eu/dataset/0c6b9751-a71f-4062-830b-43c9f432370f>.

25 <https://op.europa.eu/en/publication-detail/-/publication/adc2d549-5c77-11e7-954d-01aa75ed71a1/language-en>.

26 Local data from the Comune di Milano.

27 <https://esdac.jrc.ec.europa.eu/content/european-soil-database-v20-vector-and-attribute-data>.

28 <https://www.openstreetmap.org/#map=4/-39.27/-73.60>.

resolutions dataset GHS-POP R2019A<sup>29</sup>. Vulnerability is assessed for built-up areas only and is computed by using a direct damage estimation function (Huizinga *et al.*, 2017). Building reconstruction costs are extracted from country-specific cadastral estimates and used to estimate damages for each scenario.

The analysis of nature-based solution for Milan implies some challenges in terms of data for its implementation in other jurisdictions. LIDAR data is often not publicly available for its use and expensive to obtain from private providers. As reconstruction costs from EC-Harris are from 2013, more recent information is needed to update the monetary value of avoided damages due to the implementation of nature-based solutions.

29 <https://data.jrc.ec.europa.eu/dataset/0c6b9751-a71f-4062-830b-43c9f432370f>.

## 5. Reviewing data sources for the financial assessment of nature-related risks

**The financial assessment of nature-related risks requires evaluating the extent and nature of institutions' reliance on, and impact on, ecosystems through the activities of portfolio companies, as well as quantifying the potential impact of nature-related risks.** The review of data presented in the preceding three sections – use cases of nature indicators and metrics, the TNFD's selection of metrics, and the case studies – offers an opportunity to reflect on how data availability and characteristics shape the assessment of nature-related risks for financial institutions. It considers the fact that the exposure of financial institutions to nature-related risk is associated with different channels, notably though loans to vulnerable sectors, claims from natural catastrophes, natural hazards on commodity prices (agriculture, energy markets and supply chain disruptions) and transition risk. Financial institutions and supervision authorities should thus address physical and transition risks according to metrics that measure and assess risk at individual and system-wide level. In order to analyze the impact of nature-related risks on financial institutions, this note reviews the main sources of data that may be used by stakeholders for such analyses.

**Agriculture geospatial data.** The agriculture sector is vulnerable to nature-related financial risks given its dependency on nature and ecosystem services such as soil health, water availability and pollination services. LULC and ecosystem data mentioned earlier could provide insights into the vulnerabilities of the agricultural sector, but addressing output and economic impacts associated with nature-related dependencies is less straightforward as data for these variables is available at a less granular level. Ru *et al.* (2023) provide a global gridded dataset statistic of agricultural GDP at approximately 10 × 10 km for the year 2010 which may help risk analysis at the sectoral level. Cao *et al.* (2021) developed a global cropland proportion dataset at a 1-km resolution spanning from 10,000 BCE to 2100 CE which was used by

Wang *et al.* (2025) to perform a global assessment of future cropland exposure to drought risks under climate change. The Food and Agricultural Organization (FAO) together with national statistical bureaus have developed Agro-MAPS, a global spatial database providing national and sub-national agricultural land statistics<sup>30</sup>.

**Biodiversity and ecosystem indicators.** Diverse indicators and metrics of impacts and opportunities regarding nature presented in the TNFD's selection are based on biodiversity and ecosystem data, particularly linked to risks from nature-related regulations, sectoral exposure to protected areas, and stranded asset risk in nature-intensive sectors<sup>31, 32</sup>. Biodiversity data are not uniformly available around the world (Mori *et al.* 2023) and there is a lack of data for restoration's actions and their outcomes. Recently, Barbosa-Dias *et al.* (2024) have critically reviewed experiences of ecosystem restoration based on data from restoration sites. John *et al.* (2025) provided a global dataset of location data of integrity-assessed reforestation efforts which could be helpful to complement this lack. Moreover, existing spatial data should be combined to improve the precision of the metrics and monitoring of biodiversity targets, since it is not possible to observe directly the actual distribution of habitats and species. As discussed in sections 6 and 7, some part of the biodiversity data gaps can be addressed by using artificial intelligence, statistical approaches and ground-based images, and systematizing of non-English sources of data. Gaps in terms of geographic, ecosystem and specie representativeness still need to be addressed through additional efforts in collecting in-situ data.

**Infrastructure and Asset Location.** There are some sources which can be helpful to identify the spatial locations and characterization of activities, infrastructure and assets, which are key for nature-related risk assessment. The World

30 <https://gaez.fao.org/pages/agromaps>.

31 Sensitive locations: Locations where the assets and/or activities in its direct operations – and, where possible, upstream and downstream value chain(s) – interface with nature in. They include areas important for biodiversity; areas of high ecosystem integrity; areas of rapid decline in ecosystem integrity; areas of high physical water risks; areas of importance for ecosystem service provision, including benefits to Indigenous Peoples, Local Communities and stakeholders (TNFD, 2023).

32 The UN Biodiversity Lab (<https://unbiodiversitylab.org/en/>) provides valuable open-source data for several ecosystem and biodiversity metrics with high/coarse resolution.

Bank through the INFRADATA<sup>33</sup> platform provides spatial data of existing infrastructure assets and services for the digital, energy and transport sectors. OpenStreetMap (OSM)<sup>34</sup> offers an open-source collaborative world map database containing tagged businesses/locations that can contribute to identify ownership of infrastructure or building for risk-assessment. However, OSM coverage is still incomplete as Gerhards (2025) exemplifies in the case of Germany where approximately 39% of all firms recorded in the official statistics can be identified in OSM. Regarding the characteristics of the infrastructure Zhu *et al.* (2025) use machine learning to derive building polygons and heights from global Planet Scope satellite data and were able to generate higher-quality polygons based on existing open building polygons with a spatial resolution of 3 m × 3 m. The final output – a model called GBA.LoD1 – can account 2.68 billion building instances with predicted heights across different continents. Oostwegel *et al.* (2025) combines the AI-derived Google Open Buildings and the Microsoft Global ML Building Footprints datasets and the crowd-sourced OpenStreetMap to create a detailed and extensive building dataset – also 2.68 billion building- which can identify vulnerabilities of buildings for natural hazards. The Global Building Exposure Model<sup>35</sup> provides data on the built environment following a top-down approach that transfers socio-economic, building type and capital stock at national or sub-national level (statistical data) to a regular grid.

**Land use change and ecosystem mapping.** When assessing nature-related risks coming mainly from land use changes, the mapping of either ecosystem or Land Use and Land Cover (LULC) change may be useful to assess the dependencies and impacts on nature of companies' activities and suppliers in the supply chain. Such data can be collected from various sources. Remote sensing and artificial intelligence advances are increasing the availability of global, regional and national geospatial data for LULC and ecosystems. The Copernicus Monitoring Land System<sup>36</sup> provides data for ecosystem assessment.

Globally, geospatial data inputs and LULC products can be derived from open-access imagery collections from the European Space Agency (ESA) and the National Aeronautic & Space Administration (NASA)<sup>37</sup>. Regarding ecosystem classification for mapping ecosystems, the U.S Geological Survey (USGS) has developed a global open-source product for ecosystem classification and mapping<sup>38</sup>. Recently, the Group on Earth Observation (GEO) has launched a Global Ecosystems Atlas following the ecosystem classification recommended by the SEEA – IUCN Level 3 Typology for Ecosystems, Functional Group of Ecosystems (FGE). This is a collaborative effort aimed at providing high-quality global, regional and national ecosystem maps into an open online resource<sup>39</sup> which is at early stages. The United Nations System of Economic and Ecosystem Accounting (SEEA) classification differs from the TNFD's LEAP methodological framework for nature-related risk assessment, the latter using IUCN Level 2 Typology, Biomes.

However, there exists potential limitations of global sources, given the dependency of the analysis on the location of portfolios and related LULC and ecosystems:

- Global sources often exhibit problems with accuracy and land cover identification, especially for natural forests in the Global South, which are frequently combined with exotic forest plantations into a single class ("Forest"). The MapBiomas initiative has developed LULC maps for several countries (Brazil, Bolivia, Colombia, Ecuador, Peru, Venezuela, Argentina, Paraguay, Chile, Uruguay, Guyana, Suriname, and Indonesia) that distinguish natural forests from anthropogenic plantations (such as oil-palm and pulpwood plantations), allowing financial agents to use a more precise source for assessing impacts and dependencies arising from changes in LULC and ecosystems.
- There is a trade-off between feasibility and precision when IUCN Level 2 vs Level 3 ecosystem classifications. It is easier to detect changes using remote sensing and AI modeling at the Level 2 (biomes) classification than at Level 3 (FGE), as spatial analysis and modeling at the

33 <https://datacatalog.worldbank.org/infrastructure-data>.

34 <https://www.openstreetmap.org/>.

35 <https://giri.unepgrid.ch/>.

36 JCR (<https://data.jrc.ec.europa.eu/dataset>), EEA (<https://www.eea.europa.eu/en/datahub>), Copernicus Monitoring Land System (<https://land.copernicus.eu/en>).

37 ESA ([www.esa.int](http://www.esa.int)), NASA ([www.nasa.gov](http://www.nasa.gov)).

38 <https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/global-ecosystems>.

39 <https://globalecosystemsatlas.org/>.

latter level are more complex and expensive. However, a biome-level analysis cannot identify variations in the provision of ecosystem services between FGEs or impacts on the most threatened ecosystems. The use of complementary information sources, such as vegetation indices and species-distribution modeling, can mitigate these concerns. Moreover, robustness analyses are recommended when uncertainty is material in modeling ecosystem services.

- Advances in remote sensing data and modeling are improving the measurement of land and freshwater covers and the drivers of changes in nature, which are key inputs for different metrics and indicators of nature-related risk. For example, Lane *et al.* (2023) and Golden *et al.* (2025) have mapped important ecosystem such as headwaters and wetlands, respectively. AlphaEarth – a tool integrating an AI model and an embedding of Earth observation data – can detect LULC changes with high precision.

**Pollution.** The negative human health effects of acute and chronic nature degradation reduce productivity and impact life insurers mainly through pollutants discharge to nature<sup>40</sup>. This may not only increase disbursements and costs for insurers but also affect long-term corporate financing costs and corporate investment (Lelieveld *et al.* 2020; Birnbaum *et al.*, 2020; Chen *et al.*, 2023).

- Sources of air-related data can be collected in several ways. Emission by firm or by sector can be obtained directly from national inventories or indirectly from emission/output or emission/revenue indicators built from aggregated data<sup>41</sup>. However, the translation of individual/sector contribution to the negative health effects of pollution requires estimates of exposure and vulnerability for the affected stakeholders. Exposure can be approximated by spatial modeling of pollution and population, while socio-economic and epidemiological characteristics serves as proxies for vulnerability. Pollution modelling – used to analyse air, water or soil quality,

and to assess the impact of actions and policies aimed at reducing pollution – is data intensive. Pollution modelling is a complex task because of the dynamic nature of pollutant dispersion and persistence in the environment which requires geospatial data to deal not only with the spatial distribution of pollution but also with baseline levels of pollution, among others. There are efforts to produce open-source data in this regard. A 0.1°×0.1° high spatial resolution dataset of global surface PM2.5 concentrations was calculated by Donkelaar *et al.* (2025) using MODIS, MISR and SeaWiFS AOD products combined with geochemical models, and corrected with a geo-weighted regression method. In addition, OpenAQ – an environmental tech nonprofit – provides aggregated and harmonized open air quality data from different public and private providers across the globe onto an open-source, access data platform<sup>42</sup>. Regrading epidemiological data, morbidity and mortality rates associated to air pollution for various countries can be obtained from the WHO<sup>43</sup>.

- There are several sources for water-related data, which remains limited globally. Although data from remote sensors can provide data on chlorophyll-A concentration and in-situ concentration of nitrogen and phosphate for marine ecosystems, data for water quality of inland water bodies (lakes, rivers, etc.) is indeed limited for recent years, with direct implications regarding the availability of epidemiological and dose-responses data related to water pollution<sup>44</sup>.

**Population and socio-economic data.** Impacts on human livelihoods and welfare require data on the agents being affected by nature degradation. The available existing sources offer a trade-off between temporality and spatial accuracy. The GHS-POP R2019A – GHS population grid multitemporal (1975-1990-2000-2015) dataset create by the European Commission Joint Research Centre (EC JRC) and the Columbia University provides a 250-meter resolution population grid generated by

40 See Yamada *et al.* (2025) for the effects of pollution on labor supply; Li *et al.* (2015) for the effects of severe pollution on productivity; and Ebestein *et al.* (2015) for the effects of pollution on life expectancy.

41 Today more than 40 countries have implemented Pollutant Release and Transfer Registers, see <https://prtr.unece.org/prtr-global-map>.

42 <https://openaq.org/about/>.

43 <https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database>.

44 For example, the World Bank Water Data website – <https://wbwaterdata.org/dataset/> – a directory of several sources of information on water resources- presents a globally gridded dataset of nitrate-nitrite in surface water for the years 1992-2010 at the 0.5x0.5 degree grid cell level from the report Quality Unknown from the World Bank.

disaggregating census or administrative unit population data<sup>45</sup>. Updated and coarse geospatial data for global population and age-specific grid data can be obtained from the WorldPop dataset<sup>46</sup> at a spatial resolution of 1 km × 1 km. The Spatial Data Repository<sup>47</sup> provides geographically linked health and demographic data from The DHS Program and the U.S. Census Bureau for mapping in a geographic information system.

**Supply chain data.** Disruptions in the supply chain can affect financial institutions as clients can be affected by volatility in commodity prices, exposure to nature-related risk that affects underlying assets and the cash flows. Disruptions in systemically important supply chains (SISCs) function as both initiators and amplifiers of broader systemic risks, contributing to cascading effects that impact global stability (Qazi, 2025). Therefore, as climate (nature) extreme events become more frequent, systemic disruptions in the supply chain would become more relevant over time. These disruptions can be either the result of transition risk (such as new regulations regarding ecological and social national objectives) or physical risk (such as extreme weather events). Disruptions in the supply chain due to regulations with ecological and social objectives can be avoided through the implementation of accreditation by credible third parties. The environmental record of the suppliers becomes relevant. The Trase database provides free-to-download data on commodity supply chains and sustainability data for some of the main countries exporting agriculture and food products in Latin America, Africa and Brazil. In addition, data for certification of products to a

third party may be found in academic papers as shown in Table 5. Tayleur *et al.* (2018) provides information for certification of commodity crops but lacks a recent update.

**Water use and stress mapping.** Water data is critical for nature-related risk as it is a key input for the analysis of impacts, dependencies and opportunities related to nature. Nature-related transition risks through existing and emerging policy changes and regulatory requirements related to climate change and nature loss could imply restrictions and adjustment to water withdrawals or land use depending to the degree of water stress in each location. At the same time, water shortages and water stress can generate disruptions in own productive activities and supply chain, particularly for water-intensive sectors such as agribusiness and mining. Fitton *et al.* (2019) estimate that between 10%-11% of current crop- and grasslands could be vulnerable to reduction in water availability and see negatively affected some of its productive capacity, particularly Africa and the Middle East, Asia and Europe. The availability of the two main metrics needed to assess the risk and opportunities related to water, water use and water stress, is mixed. Modeling plays a key role in estimating the water use from agribusiness, which needs geospatial data for climate, LULC, irrigation and agriculture inventories. Water use for human consumption and industrial activities can be traced from national census and governmental records, respectively, with heterogeneous availability by country. On the other hand, water stress area geospatial data can be obtained from the Aqueduct water risk atlas or the Evaporative Stress Index<sup>48</sup>.

45 <https://data.jrc.ec.europa.eu/dataset/0c6b9751-a71f-4062-830b-43c9f432370f>.

46 <https://hub.worldpop.org/>.

47 <https://spatialdata.dhsprogram.com/home/>.

48 Aqueduct water risk atlas (<https://www.wri.org/data/aqueduct-water-risk-atlas>), Evaporative Stress Index. (<https://gis1.servirglobal.net/geonetwork/srv/eng/catalog.search#/metadata/97082c3e-a136-4689-bcdf-517a4bb6907f>).

## 6. Challenges for nature-related data

### 6.1 Data quality and availability

**Due to the necessity of physically collecting samples from specific monitoring locations, nature-related data collection suffers from geographical restrictions with relevant effects on estimates from biophysical modelling.** For example, the lack of historical data on water quality can make the application of models difficult and limit the understanding of how water quality varies over bigger watershed areas, having implications over the accuracy of modelling and the spatial patterns of water quality. On the other hand, rainfall data – a primary data for biophysical modelling – should be regular, continuous and complete to be used in modelling. However, recorded rainfall data frequently fails to meet these standards, thereby reducing the overall quality of model simulations (Gibbs *et al.*, 2024).

**Although global sources can be useful in providing relevant data for ecosystem assessment, accuracy of the estimates tends to improve with more precise geospatial data.** Many available datasets do not have sufficient resolution to assess asset-level impacts or are not updated frequently enough to reflect real-time environmental changes or assess ecosystem services. For example, available data on hourly precipitation, a key input-data for landslide or flooding analysis, is only globally available at 9 km x 9 km resolution and open-source LULC products perform worse in the Global South. Initiatives such as the MapBiomass Project or the FLOPROS database on flood protection standards are welcomed in this regard (Scussolini *et al.*, 2016).

**There is also a data gap on key parameters for ecosystem services, which are critical to many business processes.** This deficiency hampers the understanding of economic dependencies and financial risks associated with ecosystem degradation. Furthermore, inadequate data on the interdependencies between different ecosystems complicates the assessment of cascading effects when one ecosystem service is disrupted. For example, empirical evidence on the link between forest quality improvements and water resource benefits remains limited. The World Bank (2021) highlights gaps on impact parameters (elasticities) in existing studies, which restricts the ability to model these relationships accurately.

**Furthermore, proprietary vendor databases often lack third-party verification or independent assessment, raising concerns about data reliability.** The absence of standardised reporting frameworks and accounting rules further complicates cross-sectoral and cross-regional comparisons. These issues are particularly pronounced in emerging markets and developing economies (EMDEs), where data gaps are more significant, limiting effective nature-related risk assessments and financial decision-making.

**A proper and comprehensive assessment of financial risks from nature-related and biodiversity aspects should ultimately rely on data that come directly from companies (corporate issuers and other entities in general).** The degree of quality and quantity of data availability will then depend on a mix of entities' willingness to disclose and the regulatory environment in which they operate. In this regard, while TNFD guidance and CSRD explicit mention of ESRS principles will help with incentivizing or mandating disclosures and risk assessment, consistency among different companies as well as having a comprehensive set of indicators are factors that cannot be taken for granted and may require additional efforts from investors and other stakeholders.

**Broader data limitations in nature-related financial risk assessment further complicate accurate estimation of companies' (and, therefore, banks') exposures.** One key issue is the lack of granular data linking financial institutions' exposures to sectors and activities that significantly impact or depend on biodiversity and ecosystem services. Without detailed firm-level information (e.g. value chain, pressures they put on the environment such as the level of pollutants emitted), it is difficult to quantify how ecosystem degradation translates into financial risks. Additionally, the absence of standardised metrics and taxonomies for nature-related financial information creates inconsistencies in reporting and risk assessment, making it challenging for financial institutions to systematically evaluate their exposure to biodiversity loss.

## 6.2 Opportunities and challenges of machine learning applications

**Machine learning (ML) and deep learning (DL) models can identify the statistical relationship between input and output data without the explicit requirement of knowing the physical processes.** They have come to play an important role for data generation where leveraging techniques for classification and prediction of environmental parameters may offer valuable insights for metrics and indicators. Artificial Neural Network (ANN) models can unravel complex relationships between predictors and environmental outcomes such as dissolved oxygen (DO), electrical conductivity (EC), land cover, and biodiversity (Dorado *et al.*, 2022; Kwame *et al.*, 2022; Essamlali *et al.*, 2024; Basse *et al.*, 2024). ML is often used to model the relationship between environmental variables and water quality parameters. Feature selection (FS) methods, random forest (RF) and eXtreme Gradient Boosting (XGBoost) trees can predict nutrient concentration and land cover with high accuracy (Dorado *et al.*, 2022; Zhao *et al.*, 2024). However, it is worth mentioning that approaching nature-related data generation through ML techniques may oversimplify the assessment of environmental processes, potentially overlooking intricate complexities (such as interactions between parameters or undetected spatial patterns) and resulting in insufficient or misleading evaluations.

**Furthermore, AI can play a key role in supporting developments and analysis of biodiversity data as explored by Gallet *et al.* (2024).** On the one hand, biodiversity data is essential for AI models and innovations. Companies with long-term innovation strategies that depend on AI and biodiversity can have interests to support biodiversity conservation, not only to preserve existing biodiversity data but also to enable future discoveries that could provide additional biodiversity data<sup>49</sup>. Today, companies that directly or indirectly benefit from the use of digital sequence information can make contributions to finance the implementation of the Kunming-Montreal Global Biodiversity Framework through the Cali Fund. On the other hand, AI can contribute to the implementation of effective and efficient conservation by using complex

data from satellites, sensors and fieldwork to enable faster and more targeted responses to ecosystem degradation or biodiversity loss. It can be a vital tool providing accurate and reliable data for monitoring reporting and verification for investors and financial institutions. Providing this information should ultimately help channel more funding towards biodiversity protection across industry sectors as the dependency becomes more visible. Dasgupta *et al.* (2024) try to overcome the problem of insufficient information on crucial ecosystems by employing ML and geospatial data from GBIF to estimate species occurrence maps that are helpful for biodiversity protection.

## 6.3 Climate-nature nexus data integration

**Interplay can occur between different nature and climate risks.** This risk interplay should be assessed by combining the interaction of physical and transition risks (driven by climate and/or nature). For instance, industries that rely on natural capital from regions where mineral mining supplies the resources for EV production may face compounded vulnerabilities as economies shift to emission-neutral transport modes. A more specific illustration of climate–nature interconnectedness arises when the implementation of nature-based solutions is not feasible and conflicts emerge between climate mitigation measures and biodiversity protection. Large-scale solar panel installations or biofuel crop plantations, for example, targeted at climate mitigation are conflicting with biodiversity protection, which often requires fragmented land use and preserving ecosystems in (partially) their original state. Moreover, deforestation and land cover changes can have implications for water-related ecosystem services when soil impermeability is affected by climate (Davis and Martini, 2023). Similarly, loss of soil moisture in peatlands can lead to a release of stored greenhouse gas emissions. However, empirical data on how crucial biophysical modelling parameters are modified by climate change are not publicly available. There is a need for work on collecting and compiling scientific research regarding this issue and addressing this data gap.

<sup>49</sup> For example, this may be the case of companies depending on biodiversity as a source of genetic data such as pharmaceutical drugs.

**Stevanovic et al. (2024) discuss key challenges and data gaps in financial risk assessment related to integrated assessment of climate change and nature degradation, the so-called climate-nature nexus.** A major challenge is the complex interplay between climate and biodiversity dynamics, making it difficult to model how environmental changes translate into economic and financial risks. Gaps in natural capital data may hinder the ability to integrate ecosystem services into sectoral production functions,

limiting the assessment of economy-wide nature-related risks. Additionally, limited correlation evidence between climate change, ecosystem service losses, and interdependencies among ecosystem services restricts predictive accuracy. Finally, a lack of localised data prevents more granular modelling of sector-specific impacts, particularly in agriculture. Addressing these gaps will be essential for improving the robustness of integrated climate- and nature-related financial risk assessments.

## 7. Way forward

### 7.1 Public-private collaboration for improved data collection and use

**Cooperation and coordination between public- and private-sector actors are necessary to implement a roadmap that optimizes the generation of both legacy and new data for multiple metrics.** National government agencies and private actors often provide relevant geospatial data with varying temporal and spatial coverage, which may serve several use cases but not all. Identifying data gaps for priority metrics and implementing a strategy to close them require public-private agreements to avoid duplication and to make new spatial data available, whether used directly as inputs or indirectly as training labels for machine- and deep-learning models, thereby enabling additional relevant metrics.

**Adopting approaches that utilise effective data collection and analysis is essential for developing comprehensive nature-related risk analysis.** This is especially relevant in developing countries with lack of data. Private data samples from specific monitoring locations of private projects can supplement public data from monitoring stations for biophysical modelling and machine learning.

**Technological innovations can foster collaboration to generate local driven data.** For example, the OpenET project, a community-driven effort generates and shares evapotranspiration data at a field scale built upon Google Earth Engine platform and open-source software tools that facilitate collaboration governmental agencies, scientific teams, and private agents.

### 7.2 Best practices in data management and application

**There is a need for more systematic and transparent data collection based on open-source databases organised by assessment methodology with parameterised and validated data.** A database like this would improve data accessibility, reduce time spent on data collection and parameterisation, ultimately improving the

performance, and strengthening the scientific basis for NBSs implementation. The use of Findable, Accessible, Interoperable and Reusable (FAIR) Data Principles for reusing scholarly data can ensure data quality, in line with the G20 Sustainable Finance Working Group (SFWG) overarching objective of promoting interoperability of nature-related data and reporting across authorities and international organizations.

**It is important to calibrate biophysical models using observed data from field sampling or monitoring stations when they are available.** On the other hand, coarser sources of information can lead to biased estimates for ecosystem services, so it would be advisable to use sufficiently granular information to feed as input in biophysical modelling. Exercises to validate and contrast model results with baseline data are necessary. Moreover, lack of data in water streams imposes challenges regarding calibration and validation of biophysical modelling (Calfucura, 2024). Moreover, there is need to incorporate uncertainty in the estimates of metrics and indicators.

**A common practice for the valuation of ecosystem services is to map values using proxy methods because the accessibility of valuation data is limited.** Such methods known as benefit transfer values commonly present the same value for each LULC class at different locations without considering the heterogeneity in spatial characteristics between the sites such as soil type, bioclimatic parameters, ecological relevance, water availability and location-specific demand factors (preferences, income). This practice tends to produce inaccurate valuation because of the spatial heterogeneity of ecosystems, specially affecting the value of small-scale biodiversity hotspots or priority areas for multiple services that cannot be identified in LULC map. A better approach to ecosystem valuation should account for the spatial heterogeneity of supply and demand factors (Ovando and Brower, 2019).

**Comprehensive frameworks that effectively integrate nature-related data into financial decision-making for financial institutions are needed to embed specific risks like biodiversity risks into risk management, lending policies, and investment strategies, potentially underestimating long-term financial vulnerabilities.**

One promising development in this field involves the integration of global Earth system data with socio-economic data to analyse the impact of economic activities on environmental degradation<sup>50</sup>. This approach not only facilitates the assessment of climate change, biodiversity loss, and ecosystem service declines but also provides insights into the reciprocal impact of ecosystem degradation on financial stability.

### 7.3 Accounting for biodiversity data gaps

Biodiversity data and knowledge gaps can be addressed by financial authorities through multi-disciplinary collaboration with natural sciences academics to collect and process dispersed data and apply proper techniques. Recommendations in this regard can include:

- Characterise the data gaps as different classes of missing data and apply statistical approaches to deal with this problem (subsampling, weighting and imputation) together with coordinated data collection across to improve biodiversity data in spatial and temporal terms (Bowler *et al.*, 2025).
- Use citizen science<sup>51</sup> when developing monitoring programs in a way toward greater spatial coverage to minimize potential spatial distribution and site-selection bias, especially when local communities and environmental conscious travellers can have more frequent access to less accessible areas for biodiversity monitoring (Mentges *et al.*, 2020).
- Use ground-based images, such as Street View, social media, photo deposits such as Flickr, camera trap databases. It can be useful to model habitat complexity at relevant spatial and temporal resolutions (Morueta-Holme *et al.*, 2024).
- Overcome the underuse of vast amount of data and information due to language barriers by synthesizing local data from non-English sources (Mori *et al.*, 2023).
- Targeted investment is needed to improve biodiversity monitoring, particularly in data-scarce regions where biodiversity loss has significant ecological and economic implications.
- Standardizing monitoring methodologies and increasing funding for long-term biodiversity research programs would enhance the consistency and comparability of biodiversity data across regions (Mori *et al.*, 2023).

<sup>50</sup> <https://earthmonitor.org/use-cases/planet-health-index/>.

<sup>51</sup> For example, iNaturalist, which is an online network of naturalists, citizen scientists and biologists aimed at providing open data for public use (<https://www.inaturalist.org/>).

## 8. Conclusion

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This note provided an overview of available nature-related data resources and methods to integrate them in risks assessment by gathering the experience of various actors, with a particular focus on multilateral organizations, central banks, and supervisory regulators.

The note finds that nature-related data may be used for various purposes, including risk assessments by financial institutions. Available metrics and indicators may seem numerous, but a selection can be made based on a key set of criteria, such as the materiality of underlying perils. Case studies highlight the dependency on nature of economic sectors and the role of climate change as an amplifier of nature-related risk.

Beyond the existing availability of nature-related data, several challenges remain which need to be addressed. Geographic constraints restrict the monitoring and collection of nature-related data and limit the estimation of spatial distribution of biodiversity and environmental impacts or the application of biophysical modelling for

ecosystem services estimation. Novel approaches to data generation, such as machine and deep learning, are essential to close nature-related data gaps. Finally, climate change imposes further data requirements for assessing nature-related risks, particularly regarding development, collection, and compilation of scientific research.

Public-private collaboration is essential to strengthen the collection and use of nature-related data. Applying best practices in data management – such as ensuring data are findable, accessible, interoperable, and reusable (FAIR) – is key. In addition, both the physical measurements and the valuation of ecosystem services should be carefully validated when relying on nature-related data.

Finally, actions need to be taken to address nature data gaps. Some recommendations in this matter are the use of statistical approaches, encouragement of citizen science, use of ground-based images, a systematisation of non-English sources of data, and increased targeted investment for in-situ collection and remote sensing.

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# Annex 1: Use cases and targeted metrics for nature-related data

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
1. Micro-Prudential Supervision	Focuses on the stability and soundness of individual financial institutions.	<p>Specific indicators nature related exposure and dependencies of financial institution assets.</p> <p><b>1. Exposure Metrics:</b></p> <ul style="list-style-type: none"> <li>• <b>Sectoral Exposure:</b> Proportion of assets exposed to sectors with high nature-related risks (e.g., agriculture, forestry).</li> <li>• <b>Geographical Exposure:</b> Assets located in regions prone to natural hazards (e.g., flood zones, areas with high biodiversity loss).</li> </ul> <p><b>2. Risk Assessment Metrics:</b></p> <ul style="list-style-type: none"> <li>• <b>Physical Risk Assessment:</b> Frequency and severity of natural disasters impacting assets.</li> <li>• <b>Transition Risk Assessment:</b> Impact of regulatory changes related to environmental policies on asset values.</li> </ul> <p><b>3. Capital Adequacy Metrics:</b></p> <ul style="list-style-type: none"> <li>• <b>Risk-Weighted Assets (RWA):</b> Adjustments to RWA to account for nature-related risks.</li> <li>• <b>Capital Buffers:</b> Additional capital requirements to cover potential losses from nature-related risks.</li> </ul> <p><b>4. Governance Metrics:</b></p> <ul style="list-style-type: none"> <li>• <b>Board Oversight:</b> Frequency of board discussions on nature-related risks.</li> <li>• <b>Risk Management Policies:</b> Existence and comprehensiveness of policies addressing nature-related risks.</li> </ul> <p><b>5. Disclosure Metrics:</b></p> <ul style="list-style-type: none"> <li>• <b>Transparency:</b> Quality and frequency of disclosures related to nature-related risks.</li> <li>• <b>Alignment with Standards:</b> Compliance with frameworks like the Task Force on Nature-related Financial Disclosures (TNFD).</li> </ul>	<p>Detailed data on localised nature related impacts to assess risks to individual institutions.</p> <p>Constructing scenarios for nature-related risks in the context of <b>micro prudential supervision</b> requires a robust framework to assess the potential impacts of environmental changes on individual financial institutions. These scenarios help supervisors, regulators, and institutions understand how nature-related risks (both physical and transition-related) can affect an institution's financial stability and operations. The key data needed for constructing these scenarios can be categorized into several core areas: <b>physical risk data, transition risk data, financial data, and institution-specific vulnerability data.</b></p> <p><b>1. Physical Risk Data</b></p> <p>Physical risks are those related to environmental events and chronic changes, which can have direct or indirect financial implications for institutions. Data for physical risks must capture both <b>acute</b> (sudden, catastrophic) and <b>chronic</b> (long-term, gradual) environmental changes.</p> <p><b>Acute Physical Risks (Extreme Events):</b></p> <ul style="list-style-type: none"> <li>• <b>Historical Environmental Data:</b> Data on past environmental disasters, usually from 1950 on<sup>52</sup>, such as: <ul style="list-style-type: none"> <li>- Floods, wildfires, hurricanes, droughts, and storms.</li> <li>- <b>Frequency, severity, and geographic distribution</b> of these events.</li> <li>- <b>Recorded damages</b> from environmental events to assets and infrastructure.</li> </ul> </li> <li>• <b>Climate Hazard Maps:</b> Localized risk maps that show vulnerability to extreme weather events. These include: <ul style="list-style-type: none"> <li>- <b>Flood zones:</b> Identifying flood-prone areas based on river levels, storm surges, and sea-level rise projections.</li> <li>- <b>Storm tracks:</b> Regional vulnerability to cyclones, hurricanes, and other storms.</li> <li>- <b>Fire risk zones:</b> Wildfire susceptibility based on vegetation, climate conditions, and historical fire activity.</li> </ul> </li> </ul>	<p>Quantitative metrics to measure financial vulnerabilities due to nature related changes.</p> <p>In the context of <b>micro prudential supervision</b>, the aim is to assess and mitigate risks at the individual financial institution level to ensure financial stability. When integrating <b>nature-related risks</b> (e.g., environmental, social, and governance (ESG) factors, climate change risks, biodiversity loss, etc.) into micro prudential supervision, the analysis should focus on understanding how these risks impact individual institutions' balance sheets, operations, and risk management frameworks.</p> <p><b>Types of Analysis for Nature-Related Risks in Micro prudential Supervision</b></p> <p><b>1. Risk Identification and Quantification</b></p> <ul style="list-style-type: none"> <li>• <b>Climate and Environmental Risk Exposure:</b> Identify and quantify the direct and indirect exposure of financial institutions to climate and environmental risks. This includes: <ul style="list-style-type: none"> <li>- <b>Physical Risks:</b> Risks related to climate change impacts (e.g., flooding, wildfires, droughts) that can affect institutions' assets, lending portfolios, and operations.</li> <li>- <b>Transition Risks:</b> Risks arising from the shift toward a low-carbon economy (e.g., changes in regulation, market preferences, and technological disruptions).</li> <li>- <b>Biodiversity Risks:</b> Exposure to environmental degradation or loss of biodiversity, which can affect sectors such as agriculture, forestry, and fisheries.</li> </ul> </li> </ul> <p><b>2. Key Methods:</b></p> <ul style="list-style-type: none"> <li>• <b>Stress Testing:</b> Assess how extreme environmental events (e.g., severe weather, regulatory changes) could affect financial stability. This can include both <b>physical stress tests</b> (focusing on impacts like natural disasters) and <b>transition stress tests</b> (focusing on policy shifts and market changes).</li> <li>• <b>Scenario Analysis:</b> Analyze potential future scenarios related to climate change (e.g., a 2°C global warming scenario) and its impact on specific financial assets or sectors.</li> </ul> <p><b>3. Credit Risk Analysis</b></p> <ul style="list-style-type: none"> <li>• <b>Exposure to High-Risk Sectors:</b> Evaluate the exposure of financial institutions' loan portfolios to sectors vulnerable to environmental risks (e.g., fossil fuels, agriculture, real estate in flood-prone areas).</li> </ul>

52 Bressan et al. (2024). "Asset-level assessment of climate physical risk matters for adaptation finance", Nature Communications, <https://doi.org/10.1038/s41467-024-48820-1>.

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
1. Micro-Prudential Supervision			<ul style="list-style-type: none"> <li><b>Geospatial Data:</b> GIS-based data showing the location and risk exposure of assets (e.g., bank branches, manufacturing plants, agricultural operations) to extreme weather.</li> <li><b>Insurance Claims Data:</b> Historical data<sup>53</sup> on insurance claims due to natural disasters, for at least 10 years, to estimate the potential financial losses institutions could face during future events.</li> </ul> <p><b>Chronic Physical Risks (Long-Term Environmental Changes):</b></p> <ul style="list-style-type: none"> <li><b>Climate Projections:</b> Data from climate models that project future changes in temperature, rainfall, and sea level over specific time horizons (e.g., 10, 20, or 50 years). <ul style="list-style-type: none"> <li><b>Temperature increases:</b> Regional and global projections of temperature rise and its potential impacts (e.g., energy demand, agricultural yields).</li> <li><b>Precipitation changes:</b> Regional projections of changes in rainfall patterns, which can affect water availability and agricultural output.</li> <li><b>Sea-level rise:</b> Projections of future sea-level rise, particularly for coastal assets, and its impact on infrastructure and real estate.</li> </ul> </li> <li><b>Water Stress Index:</b> Data on water availability, scarcity, and stress in specific regions, which is important for institutions dependent on water (e.g., agriculture, energy).</li> <li><b>Biodiversity Data:</b> Information on local ecosystems and biodiversity, especially in regions where businesses or financial institutions rely on ecosystem services (e.g., forestry, fisheries).</li> <li><b>Soil Quality and Degradation Data:</b> Data related to soil erosion, nutrient depletion, and other forms of land degradation affecting agricultural institutions.</li> </ul> <p><b>2. Transition Risk Data</b></p> <p>Transition risks are linked to the shift towards a low-carbon economy and how local, regional, and global policy and market changes could impact institutions.</p> <p><b>Regulatory and Policy Data:</b></p> <ul style="list-style-type: none"> <li><b>Carbon Pricing and Emissions Regulations:</b> Data on current and projected carbon taxes, cap-and-trade systems, or regulatory requirements (e.g., carbon emission limits) in specific regions.</li> </ul>	<ul style="list-style-type: none"> <li><b>Counterparty Risk:</b> Assess whether a financial institution's counterparties (e.g., borrowers, suppliers) are adequately managing nature-related risks, such as carbon emissions or biodiversity impacts.</li> </ul> <p><b>4. Key Methods:</b></p> <ul style="list-style-type: none"> <li><b>Risk-Weighted Asset Adjustments:</b> Adjust the risk weights for loan portfolios to reflect the nature-related risks in certain sectors. For instance, fossil fuel assets might require higher capital buffers due to transition risks.</li> <li><b>Climate Risk-adjusted Credit Ratings:</b> Evaluate the creditworthiness of borrowers based on their exposure to climate and environmental risks (e.g., higher credit risk for industries or regions with high physical or transition risks).</li> </ul> <p><b>5. Market Risk and Asset Valuation</b></p> <ul style="list-style-type: none"> <li><b>Impact of Environmental Shocks on Asset Prices:</b> Analyse how nature-related risks (such as extreme weather events, changes in regulations, or shifts in market demand for sustainable goods) may affect asset prices (e.g., real estate, bonds, equities).</li> <li><b>Valuation of Green Assets:</b> Assess the value of assets linked to sustainability, including green bonds, renewable energy projects, or carbon credits. Understand how market price volatility in these assets might impact an institution's portfolio.</li> </ul> <p><b>6. Key Methods:</b></p> <ul style="list-style-type: none"> <li><b>Scenario-based Price Sensitivity Analysis:</b> Examine how extreme climate events or shifts in environmental regulations affect the prices of assets in a financial institution's portfolio.</li> <li><b>Carbon Exposure Risk:</b> Analyse the exposure of investment portfolios to carbon-intensive industries and the potential impact of carbon pricing or regulations (e.g., carbon taxes).</li> </ul> <p><b>7. Liquidity Risk Analysis</b></p> <ul style="list-style-type: none"> <li><b>Impact of Environmental Events on Cash Flow:</b> Assess how environmental risks, such as natural disasters or droughts, could disrupt business operations and affect the liquidity of financial institutions.</li> <li><b>Regulatory and Market Liquidity Shifts:</b> Evaluate how market responses to environmental regulations (e.g., carbon trading schemes or changes in public subsidies) could alter market liquidity and the institution's ability to meet obligations.</li> </ul>

53 Malariou, D. (2022). "Development and application of statistical learning methods in insurance and finance", The London School of Economics and Political Science.

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
1. Micro-Prudential Supervision			<ul style="list-style-type: none"> <li>• <b>Energy Transition Policies:</b> National and local policies promoting renewable energy, energy efficiency, and decarbonisation efforts.</li> <li>• <b>Land Use and Environmental Regulations:</b> Data on regulations related to deforestation, biodiversity protection, pollution control, and sustainable agriculture practices.</li> <li>• <b>Subsidies and Incentives:</b> Government subsidies or incentives for adopting renewable technologies or implementing environmentally friendly practices.</li> </ul> <p><b>Market Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Energy and Carbon Intensity Data:</b> Regional energy mix, with emphasis on the proportion of renewable vs. fossil-based energy, to assess exposure to transition risks in the energy sector.</li> <li>• <b>Transition Investment Trends:</b> Market shifts in favour of low-carbon technologies, such as electric vehicles (EVs), renewable energy infrastructure, or energy-efficient products.</li> <li>• <b>Commodity Price Trends:</b> Data on how the prices of key commodities (e.g., oil, gas, metals) are shifting due to changing demand, regulatory pressures, or technological advancements.</li> <li>• <b>Consumer Preferences and Trends:</b> Local and regional market shifts toward sustainable products and services, and how businesses are adapting to these changes (e.g., demand for sustainable agriculture, green buildings, or low-carbon goods).</li> </ul> <p><b>Technology and Innovation Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Green Technology Adoption:</b> Data on the deployment of clean technologies, renewable energy solutions, and decarbonisation technologies.</li> <li>• <b>Technological Disruption Projections:</b> Scenarios modelling how technological advancements, such as battery storage, carbon capture, and renewable energy infrastructure, may disrupt existing industries.</li> </ul>	<p><b>8. Key Methods:</b></p> <ul style="list-style-type: none"> <li>• <b>Stress Testing for Liquidity Shocks:</b> Simulate liquidity stress tests considering the potential effects of environmental disruptions on the market or specific asset classes.</li> <li>• <b>Scenario Analysis on Regulatory Changes:</b> Model scenarios where regulatory changes (e.g., stricter environmental regulations or carbon pricing) might affect liquidity conditions or capital markets.</li> </ul> <p><b>9. Operational and Strategic Risk</b></p> <ul style="list-style-type: none"> <li>• <b>Environmental Operational Risks:</b> Analyse how climate change or biodiversity loss may directly impact an institution's operations, such as supply chain disruptions, facility damage, or increased insurance costs.</li> <li>• <b>Transition to Sustainable Business Models:</b> Evaluate the risks related to a financial institution's transition to sustainability, including the costs of shifting to green technologies, compliance with new regulations, or reputational risks.</li> </ul> <p><b>10. Key Methods:</b></p> <ul style="list-style-type: none"> <li>• <b>Supply Chain Risk Analysis:</b> Analyse the resilience of an institution's supply chain and how environmental risks could disrupt its operations or those of its customers and suppliers.</li> <li>• <b>Reputational Risk:</b> Evaluate reputational risks associated with lending to or investing in sectors that are perceived to be contributing to environmental harm.</li> </ul> <p><b>11. Capital Adequacy and Resilience Analysis</b></p> <ul style="list-style-type: none"> <li>• <b>Capital Buffers for Nature-Related Risks:</b> Examine whether financial institutions hold adequate capital buffers to absorb losses arising from environmental risks. This can involve adjusting capital requirements based on the level of exposure to climate and biodiversity risks.</li> <li>• <b>Liquidity and Solvency Stress Testing:</b> Use stress testing to assess whether financial institutions have sufficient liquidity and solvency to survive a severe environmental shock or the gradual impact of climate change.</li> </ul> <p><b>12. Key Methods:</b></p> <ul style="list-style-type: none"> <li>• <b>Climate-Adjusted Capital Adequacy Ratios:</b> Incorporate nature-related risk factors into the capital adequacy framework, adjusting the regulatory capital ratios based on institutions' exposure to environmental risks.</li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
1. Micro-Prudential Supervision			<p><b>3. Financial Data</b></p> <p>For constructing scenarios related to how nature-related risks could impact individual institutions, the following financial data is essential:</p> <p><b>Institution-Specific Financial Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Asset Exposure to Physical Risks:</b> Data on the geographic distribution of a financial institution's physical assets (e.g., branches, data centres, real estate) and exposure to climate-related risks, based on projections of hazards and existing and potential regulations.</li> <li>• <b>Investment Portfolio Analysis:</b> Breakdown of the institution's investment portfolio by asset class, sector, and geographic location, with particular focus on sectors vulnerable to nature-related risks (e.g., fossil fuels, agriculture, insurance).</li> <li>• <b>Insurance and Liability Exposure:</b> Data on the institution's insurance portfolio, including exposure to natural disaster claims, underwriting policies, and historical claims experience.</li> <li>• <b>Credit Risk Data:</b> Information on the exposure of loans and credit portfolios to sectors and regions at risk from physical or transition-related changes (e.g., loans to agriculture in water-stressed areas, real estate in flood-prone zones).</li> <li>• <b>Revenue and Cost Projections:</b> Revenue sensitivity to environmental changes (e.g., agriculture or energy companies affected by climate change) and cost sensitivity to environmental regulations (e.g., carbon taxes, clean energy investments).</li> </ul> <p><b>Stress Test Results and Scenarios:</b></p> <ul style="list-style-type: none"> <li>• <b>Historical Loss Data:</b> Data on how institutions have been impacted by historical extreme events and regulatory changes related to nature (e.g., flood damage, wildfire losses, or transition to renewable energy policies).</li> <li>• <b>Scenario Analysis:</b> Results from existing or simulated stress tests that show how different nature-related scenarios (e.g., temperature rise, carbon pricing) would impact an institution's balance sheet, income statement, and risk profile.</li> </ul> <p><b>4. Institution-Specific Vulnerability Data</b></p> <p>Each institution will have unique exposures and vulnerabilities based on its business model, geographic footprint, and sectoral focus.</p>	<ul style="list-style-type: none"> <li>• <b>Solvency and Stress Testing for Long-Term Risks:</b> Implement long-term stress tests that model the effects of climate change, environmental regulations, and ecosystem collapse on solvency over extended periods.</li> </ul> <p><b>13. Disclosure and Transparency Analysis</b></p> <ul style="list-style-type: none"> <li>• <b>ESG Disclosures:</b> Ensure that institutions are providing adequate disclosure on their exposure to nature-related risks (e.g., climate risk, biodiversity loss). This can include transparency around carbon footprints, environmental management strategies, and governance practices.</li> <li>• <b>Data Quality and Reporting Standards:</b> Evaluate the quality and accuracy of the data being used for nature-related disclosures, including the consistency of environmental risk reporting with global standards (e.g., <b>Task Force on Climate-related Financial Disclosures (TCFD)</b>, <b>EU Taxonomy</b>).</li> </ul> <p><b>14. Key Methods:</b></p> <ul style="list-style-type: none"> <li>• <b>Gap Analysis on ESG Reporting:</b> Assess the completeness and quality of disclosures against international standards and regulatory requirements.</li> <li>• <b>Third-Party Verification:</b> Implement mechanisms for verifying the accuracy of environmental disclosures through third-party audits or ESG rating agencies.</li> </ul> <p><b>Analytical Tools and Frameworks for Micro prudential Supervision of Nature-Related Risks.</b></p> <p><b>1. Stress Testing and Scenario Analysis:</b></p> <ul style="list-style-type: none"> <li>• Run scenarios that model potential environmental risks (both physical and transition-related) under different climate scenarios, such as the <b>Shared Socio economic Pathways (SSPs)</b> and <b>Representative Concentration Pathways (RCPs)</b>.</li> </ul> <p><b>2. Environmental Risk-Adjusted Capital Requirements:</b></p> <ul style="list-style-type: none"> <li>• Adjust capital adequacy requirements based on the exposure to environmental and climate-related risks (e.g., higher capital charges for assets that are highly exposed to transition risks).</li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
1. Micro-Prudential Supervision			<p>Collecting the following institution-specific data is crucial for scenario analysis:</p> <ul style="list-style-type: none"> <li>• <b>Risk Management Framework:</b> Information on the institution's existing risk management practices related to climate and environmental factors. This includes data on how environmental risks are integrated into risk assessments and governance structures.</li> <li>• <b>Supply Chain Dependencies:</b> Data on the institution's exposure to suppliers and partners that may be affected by environmental risks, including geographic data and supply chain mapping.</li> <li>• <b>Operational Resilience:</b> Data on the institution's resilience to disruptions caused by environmental events, such as business continuity plans, alternative suppliers, and infrastructure robustness.</li> <li>• <b>Reputational Risk Data:</b> Information on how environmental issues (e.g., deforestation, pollution) have impacted the institution's brand and customer relations, in terms of positive and negative sentiments.</li> </ul> <p><b>5. Macro-Economic and Systemic Data</b></p> <p>Broader macroeconomic factors that might affect nature-related risks include:</p> <ul style="list-style-type: none"> <li>• <b>Regional Economic Growth Projections:</b> How economic development in certain regions might affect environmental degradation or resilience.</li> <li>• <b>Global Supply Chain Trends:</b> How shifts in global trade, such as the transition to more sustainable products, might affect localized institutions.</li> <li>• <b>Monetary and Fiscal Policy:</b> How monetary policy or fiscal stimulus (e.g., investments in green infrastructure) may affect financial institutions' vulnerability to environmental risks.</li> </ul>	<p><b>3. Integration of Nature-Related Financial Risks into Risk Management Frameworks:</b></p> <ul style="list-style-type: none"> <li>• Ensure financial institutions have integrated nature-related risks into their overall risk management frameworks, particularly with regard to credit, market, and operational risks.</li> </ul> <p><b>4. Regulatory Reporting Standards:</b></p> <ul style="list-style-type: none"> <li>• Incorporate ESG and climate risk disclosures into regulatory reporting requirements (e.g., TCFD alignment), ensuring that financial institutions provide transparent and comparable data on their exposure to nature-related risks.</li> </ul>
2. Macro-Prudential for Financial Stability	Ensures the stability of the financial system.	<p>System-wide indicators of nature related risks and dependencies across sectors.</p> <p>For macro-prudential supervision focused on financial stability in the context of nature-related risks, here are some specific metrics:</p> <p><b>1. Systemic Risk Metrics:</b></p> <ul style="list-style-type: none"> <li>• <b>Long-Run Marginal Expected Shortfall (LRMES):</b> Measures the expected loss in a financial system during extreme market conditions.</li> <li>• <b>Systemic Risk (SRISK):</b> Assesses the capital shortfall of financial institutions in a crisis.</li> <li>• <b>Country-Level Index of Financial Stress (CLIFS):</b> Tracks financial stress across different countries.</li> </ul>	<p>Broad-scale data on systemic nature related risks and their potential impacts on financial stability.</p> <p>Here are some key categories and examples:</p> <p><b>1. Biodiversity and Ecosystem Services Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Species Population Trends:</b> Data on the decline or recovery of species populations, which can indicate ecosystem health.</li> <li>• <b>Habitat Loss and Degradation:</b> Information on deforestation rates, wetland loss, and other habitat changes.</li> </ul>	<p>Models to evaluate economic consequences of nature related loss on systemic risks.</p> <p>Here are some of the key macroprudential models and approaches used for financial stability that incorporate nature-related data:</p> <p><b>1. Systemic Risk and Network Models</b></p> <p>Systemic risk models assess how risks from biodiversity loss and environmental degradation might propagate through the interconnected financial system. These models consider the links between different financial institutions, asset classes, and sectors, and how shocks in one part of the system can spill over and affect the broader economy.</p>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
2. Macro-Prudential for Financial Stability		<p><b>2. Exposure Metrics:</b></p> <ul style="list-style-type: none"> <li><b>Sectoral Exposure:</b> Proportion of financial assets exposed to sectors with high nature-related risks (e.g., agriculture, forestry).</li> <li><b>Geographical Exposure:</b> Assets located in regions prone to environmental risks (e.g., flood zones, areas with high biodiversity loss).</li> </ul> <p><b>3. Risk Assessment Metrics:</b></p> <ul style="list-style-type: none"> <li><b>Physical Risk Assessment:</b> Frequency and severity of natural disasters impacting financial stability.</li> <li><b>Transition Risk Assessment:</b> Impact of regulatory changes related to environmental policies on financial institutions.</li> </ul> <p><b>4. Capital Adequacy Metrics:</b></p> <ul style="list-style-type: none"> <li><b>Risk-Weighted Assets (RWA):</b> Adjustments to RWA to account for nature-related risks.</li> <li><b>Capital Buffers:</b> Additional capital requirements to cover potential losses from nature-related risks.</li> </ul> <p><b>5. Governance and Risk Management Metrics:</b></p> <ul style="list-style-type: none"> <li><b>Board Oversight:</b> Frequency of board discussions on nature-related risks.</li> <li><b>Risk Management Policies:</b> Existence and comprehensiveness of policies addressing nature-related risks.</li> </ul> <p><b>6. Disclosure Metrics:</b></p> <ul style="list-style-type: none"> <li><b>Transparency:</b> Quality and frequency of disclosures related to nature-related risks.</li> <li><b>Alignment with Standards:</b> Compliance with frameworks like the Task Force on Nature-related Financial Disclosures (TNFD).</li> </ul>	<p><b>2. Climate-Nature Nexus Data:</b></p> <ul style="list-style-type: none"> <li><b>Climate Change Impacts:</b> Data on how climate change affects natural systems, such as shifts in species distributions and changes in ecosystem productivity.</li> <li><b>Carbon Sequestration:</b> Information on the capacity of forests, oceans, and other ecosystems to absorb carbon dioxide.</li> </ul> <p><b>3. Geospatial Data:</b></p> <ul style="list-style-type: none"> <li><b>Land Use and Land Cover:</b> Satellite imagery and other geospatial data showing changes in land use and land cover over time.</li> <li><b>Natural Disaster Risk Maps:</b> Data on the frequency and severity of natural disasters like floods, hurricanes, and wildfires.</li> </ul> <p><b>4. Economic and Financial Data:</b></p> <ul style="list-style-type: none"> <li><b>Natural Capital Accounting:</b> Metrics that quantify the economic value of natural resources and ecosystem services.</li> <li><b>Environmental, Social, and Governance (ESG) Ratings:</b> Ratings that assess the environmental performance of companies and their exposure to nature-related risks.</li> </ul> <p><b>5. Regulatory and Supervisory Data:</b></p> <ul style="list-style-type: none"> <li><b>Policy and Regulatory Changes:</b> Information on new regulations and policies aimed at protecting biodiversity and ecosystems.</li> <li><b>Disclosure Requirements:</b> Data on the extent to which companies and financial institutions are required to disclose their nature-related risks.</li> </ul> <p><b>6. Case Studies and Illustrative Examples:</b></p> <ul style="list-style-type: none"> <li><b>Forest and Freshwater Systems:</b> Specific case studies, such as the Amazon Rainforest and the Colorado River Basin, which illustrate the application of risk assessment frameworks to these ecosystems.</li> </ul>	<p><b>Interconnectedness and Spillover Models:</b></p> <p>Network models capture the interconnectedness of financial institutions (banks, insurers, pension funds) and their exposure to nature-related risks. For example, banks may be exposed to sectors like agriculture or forestry, which are highly vulnerable to biodiversity loss or climate change. If these sectors experience significant losses, it could lead to liquidity issues or defaults that impact other financial institutions in the network.</p> <p><b>Leverage and Contagion Effects:</b></p> <p>Models of financial contagion, where a shock to one institution or sector (e.g., agriculture, forestry) causes a ripple effect through the financial system. For example, the collapse of a large agribusiness due to biodiversity loss or climate risk could lead to broader systemic instability.</p> <p><b>Key Data Inputs:</b></p> <p><b>Sectoral Exposure Data:</b> Data on financial institutions' exposure to sectors highly dependent on biodiversity and natural resources (e.g., forestry, agriculture, fisheries).</p> <p><b>Correlation Analysis:</b> Examining correlations between environmental shocks (e.g., deforestation, habitat loss) and financial performance across sectors.</p> <p><b>Contagion and Interconnectedness Networks:</b> Data on the exposure of financial institutions to nature-related risks in various sectors and geographic regions.</p> <p><b>Examples of Tools:</b></p> <p>Global Systemic Risk Models (e.g., G-SIBs, Financial Stability Board (FSB) assessments).</p> <p><b>Stress Testing and Scenario Analysis:</b> Scenario models assessing the effects of biodiversity and environmental shocks on asset prices, liquidity, and solvency.</p> <p><b>Dynamic Stochastic General Equilibrium (DSGE) Models:</b> Incorporating environmental variables into traditional DSGE models, which can simulate the broader economic effects of nature-related shocks.</p> <p><b>2. Macro-Financial Stress Testing Models</b></p> <p>Stress testing is a core tool for macroprudential supervision. It involves simulating hypothetical scenarios, including extreme environmental or biodiversity-related shocks, to understand how these shocks could affect the entire financial system.</p>

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2. Macro-Prudential for Financial Stability				<p><b>Nature-Related Scenario Analysis:</b></p> <p>Macroprudential stress tests incorporate nature-related stress scenarios that include physical risks (e.g., extreme weather events, sea-level rise, loss of agricultural productivity due to biodiversity loss) and transition risks (e.g., policy changes, carbon pricing, shifts in consumer preferences).</p> <p>For example, a scenario could simulate the financial impact of a severe drought that leads to reduced agricultural output, which in turn affects financial institutions' exposure to farming-related loans and insurance products.</p> <p><b>Key Data Inputs:</b></p> <p><b>Climate and Biodiversity Scenarios:</b> Scenarios incorporating nature-related risks, such as extreme weather, biodiversity loss, or policy changes (e.g., carbon taxes, deforestation policies).</p> <p><b>Sectoral Exposure:</b> Data on sectors like agriculture, energy, construction, and insurance, which may be vulnerable to nature-related risks.</p> <p><b>Macro-Financial Linkages:</b> Data on how environmental risks affect macroeconomic variables (e.g., GDP, inflation, unemployment) and financial stability indicators (e.g., asset prices, credit spreads).</p> <p><b>Examples of Tools:</b></p> <p><b>EU-wide Stress Testing Models:</b> The European Central Bank (ECB) and Bank of England conduct stress tests that assess the resilience of financial institutions to climate and environmental risks, including biodiversity impacts.</p> <p><b>NGFS Climate Scenarios:</b> The Network for Greening the Financial System (NGFS) provides climate-related scenarios for financial stress testing, which can be adapted to include nature-related impacts on financial stability.</p> <p><b>3. Capital Buffer Models and Risk Weights Adjustment</b></p> <p>This model adjusts capital adequacy requirements for financial institutions based on their exposure to nature-related risks, ensuring that institutions have sufficient capital to absorb potential losses from nature-related shocks, especially systemic biodiversity losses or environmental events.</p>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
2. Macro-Prudential for Financial Stability				<p><b>Nature-Related Capital Buffers:</b></p> <p>Adjusting capital buffers based on sectoral and geographical exposure to biodiversity risks. For example, banks with large portfolios in agriculture or industries dependent on natural resources may face higher capital requirements to absorb potential biodiversity-related risks.</p> <p><b>Biodiversity-Adjusted Risk Weights:</b></p> <p>Assigning higher risk weights to assets exposed to biodiversity loss or natural resource depletion. For example, investments in regions with high deforestation rates or endangered ecosystems may require higher capital provisions.</p> <p><b>Key Data Inputs:</b></p> <p><b>Sectoral Exposure:</b> Data on financial institutions' exposure to high-risk sectors like agriculture, forestry, or fisheries, where biodiversity loss could significantly impact asset values.</p> <p><b>Natural Capital Valuation:</b> Estimating the financial impact of nature-related risks (e.g., through Natural Capital Protocol).</p> <p><b>Biodiversity Impact Metrics:</b> Using biodiversity indicators (e.g., Biodiversity Intactness Index) to assess the risk of financial exposure to regions or sectors heavily reliant on natural ecosystems.</p> <p><b>Examples of Tools:</b></p> <p><b>Basel III Capital Framework:</b> Capital buffer adjustments based on sectoral exposure to environmental and biodiversity-related risks, integrated into the broader financial stability framework.</p> <p><b>Sustainable Finance Taxonomy:</b> Tools like the EU Taxonomy provide guidance on green investment, which could be integrated into financial supervision models to adjust capital requirements based on environmental performance.</p> <p><b>4. Macroeconomic Impact Models with Nature-Related Data</b></p> <p>These models aim to assess the broader macroeconomic impact of nature-related risks on the financial system, including how environmental degradation, biodiversity loss, and climate change can affect GDP, inflation, and other key economic variables, which, in turn, can influence financial system stability.</p>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
2. Macro-Prudential for Financial Stability				<p><b>Dynamic Simulation Models:</b></p> <p>Integrating nature-related shocks (such as biodiversity collapse or climate-related disasters) into traditional macroeconomic models to assess their impact on broader economic stability. For example, a sudden loss of ecosystem services (e.g., pollination, water availability) could lead to productivity losses in agriculture, which would depress GDP and affect the financial stability of institutions heavily invested in those sectors.</p> <p>These models can help identify feedback loops where economic downturns exacerbate environmental degradation, leading to further financial instability.</p> <p><b>Key Data Inputs:</b></p> <p><b>Environmental GDP Impact Data:</b> Estimating the impact of biodiversity loss on economic productivity, particularly in sectors directly dependent on natural resources.</p> <p><b>Biodiversity and Ecosystem Service Data:</b> Data on ecosystem services and their economic value, which can help model the broader economic impact of biodiversity degradation.</p> <p><b>Sectoral Sensitivity to Environmental Shocks:</b> Data on how sensitive key sectors (e.g., agriculture, tourism, fisheries) are to environmental disruptions.</p> <p><b>Examples of Tools:</b></p> <p><b>Integrated Assessment Models (IAMs):</b> These models combine economics, climate, and environmental science to evaluate long-term impacts of biodiversity and environmental risks on macroeconomic variables. E3 (Energy-Economy-Environment) and CGE (Computable General Equilibrium) models could incorporate biodiversity risks.</p> <p><b>Dynamic Stochastic General Equilibrium (DSGE) Models:</b> Can be modified to integrate environmental shocks and their long-term impacts on economic stability.</p> <p><b>5. Systemic Stress Testing and Biodiversity Impact Metrics</b></p> <p>Stress testing can also incorporate systemic risks from biodiversity loss, looking at how an ecosystem-wide collapse or the depletion of natural resources can affect the broader financial system. This model assesses the cascading effects of nature-related risks on the stability of financial markets, asset prices, and institutions.</p>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
2. Macro-Prudential for Financial Stability				<p><b>Biodiversity Risk Transmission Models:</b></p> <p>These models simulate how environmental shocks (e.g., biodiversity collapse) can lead to market distortions (e.g., asset devaluation in biodiversity-sensitive sectors) and liquidity crises (e.g., flight to safer assets). The models focus on how biodiversity degradation affects asset prices, credit risk, and market confidence.</p> <p><b>Key Data Inputs:</b></p> <p><b>Market and Asset Price Sensitivity:</b> Data on how asset classes (e.g., real estate, bonds, stocks) are affected by environmental and biodiversity shocks.</p> <p><b>Risk Transmission Paths:</b> Identifying the channels through which biodiversity loss can impact financial markets and institutions (e.g., through insurance payouts, loan defaults, or shifting investment preferences).</p> <p><b>Examples of Tools:</b></p> <p>Biodiversity Intactness Index and other biodiversity risk metrics to assess financial institutions' exposure to biodiversity risk.</p> <p>Bank of England's Climate Stress Testing Framework, which could be adapted to include biodiversity risks alongside climate-related shocks.</p>
3. Monetary Policy	Uses data to inform policy decisions affecting the economy's overall monetary conditions.	<p>Metrics reflecting broader economic impacts of nature related changes (e.g., inflation, employment).</p> <p>When linking nature-related metrics to monetary policy, the focus is on assessing environmental sustainability and integrating the economic impacts of nature degradation or protection into policy decisions. Here are some key metrics and use cases for incorporating nature-related considerations into monetary policy:</p> <p><b>1. Natural Capital Accounting Metrics</b></p> <ul style="list-style-type: none"> <li>• <b>Use Case:</b> Integrating natural capital into economic policy decisions.</li> <li>• <b>Metrics:</b> <ul style="list-style-type: none"> <li>- <b>Natural Capital Value:</b> The total value of natural resources (e.g., forests, fisheries, wetlands) and ecosystem services.</li> <li>- <b>Ecological Footprint:</b> Measuring the demand placed on natural resources compared to the earth's regenerative capacity.</li> <li>- <b>Biodiversity Index:</b> Tracks changes in biodiversity, which can affect long-term economic stability.</li> </ul> </li> </ul>	<p>Data on nature related-related factors influencing economic variables. To effectively implement nature-related metrics in monetary policy, the following types of data would be needed for each use case. These data would help policymakers assess environmental risks, track sustainability progress, and integrate ecological considerations into economic decisions:</p> <p><b>1. Natural Capital Accounting Metrics</b></p> <ul style="list-style-type: none"> <li>• <b>Data Needed:</b> <ul style="list-style-type: none"> <li>- <b>Natural Resource Stocks:</b> Data on forests, water resources, land use, minerals, and fisheries (e.g., quantity and value of natural resources).</li> <li>- <b>Ecosystem Services Valuation:</b> Economic valuations of services like carbon sequestration, water filtration, and pollination.</li> <li>- <b>Biodiversity Data:</b> Information on species diversity, ecosystem health, and habitats.</li> <li>- <b>Environmental Degradation Indicators:</b> Data on deforestation rates, soil erosion, or water scarcity.</li> </ul> </li> </ul>	<p>Tools to quantify economic impacts of nature related loss on monetary policy objectives.</p> <p>Quantifying the <b>economic impacts of nature-related loss on monetary policy objectives</b> requires tools that can assess how environmental degradation – such as <b>biodiversity loss, climate change, and ecosystem destruction</b> – affects key economic variables that central banks and monetary authorities monitor. These variables include <b>inflation, output (GDP), interest rates, financial stability, and employment</b>.</p> <p>Here are examples of tools and frameworks that can be used to quantify the economic impacts of nature-related loss on monetary policy objectives:</p> <p><b>1. Integrated Assessment Models (IAMs)</b></p> <p><b>Integrated Assessment Models (IAMs)</b> combine knowledge from multiple disciplines (economics, environmental science, and policy) to simulate the interactions between environmental changes, economic activity, and policy responses. These models help estimate the potential economic costs of nature-related risks such as biodiversity loss, ecosystem degradation, or climate change.</p>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
3. Monetary Policy		<ul style="list-style-type: none"> <li>• <b>Example in Monetary Policy:</b> Central banks could use natural capital values to adjust GDP estimates to reflect the depreciation of natural resources or incorporate biodiversity impacts into growth forecasts.</li> <li>2. <b>Environmental Risk Assessment</b></li> <li>• <b>Use Case:</b> Identifying environmental risks to financial stability and ensuring that monetary policy accounts for these.</li> <li>• <b>Metrics:</b> <ul style="list-style-type: none"> <li>- <b>Climate-related Risk Exposure:</b> Metrics such as carbon footprint or climate vulnerability indices to assess the exposure of financial institutions to climate change impacts.</li> <li>- <b>Transition Risk Index:</b> Measures the risk from transitioning to a low-carbon economy (e.g., carbon-intensive industries facing regulatory or market shifts).</li> <li>- <b>Physical Risk Indicators:</b> Identifies risks from climate change impacts like extreme weather events or resource scarcity.</li> </ul> </li> <li>• <b>Example in Monetary Policy:</b> Central banks might stress-test financial institutions for exposure to climate risks, adjusting policy rates or capital buffers accordingly.</li> <li>3. <b>Carbon Pricing and Emission Reduction Metrics</b></li> <li>• <b>Use Case:</b> Incorporating the economic cost of carbon emissions into monetary policy frameworks.</li> <li>• <b>Metrics:</b> <ul style="list-style-type: none"> <li>- <b>Carbon Price per Ton of CO<sub>2</sub>:</b> The economic price of carbon emissions to account for externalities (via carbon taxes or emissions trading systems).</li> <li>- <b>Emission Intensity Metrics:</b> Tracks emissions per unit of GDP or per capita, serving as indicators of economic decoupling from environmental harm.</li> </ul> </li> <li>• <b>Example in Monetary Policy:</b> Central banks could use carbon pricing to influence monetary policy, for example by adjusting interest rates or bond purchases based on the carbon intensity of the economy.</li> </ul>	<ul style="list-style-type: none"> <li>2. <b>Environmental Risk Assessment</b></li> <li>• <b>Data Needed:</b> <ul style="list-style-type: none"> <li>- <b>Climate Risk Data:</b> Climate models forecasting temperature, rainfall, and extreme weather events.</li> <li>- <b>Physical Risk Exposure:</b> Regional vulnerability assessments (e.g., flood zones, drought-prone areas).</li> <li>- <b>Transition Risk Data:</b> Data on carbon emissions, energy intensity, and regulatory risks from transitioning to a low-carbon economy (e.g., emissions data from specific industries).</li> <li>- <b>Environmental Liability Data:</b> Information on environmental damage or ongoing litigation (e.g., oil spills, toxic waste).</li> </ul> </li> <li>3. <b>Carbon Pricing and Emission Reduction Metrics</b></li> <li>• <b>Data Needed:</b> <ul style="list-style-type: none"> <li>- <b>Carbon Emissions Data:</b> National and sectoral emissions data (e.g., from energy production, transport, manufacturing).</li> <li>- <b>Carbon Price Data:</b> Current and projected carbon prices in emissions trading systems (e.g., EU ETS, carbon taxes).</li> <li>- <b>Energy Mix Data:</b> Proportions of energy generated from fossil fuels, renewables, and nuclear energy.</li> <li>- <b>Emission Reduction Targets:</b> Data on national or international GHG reduction goals (e.g., Paris Agreement targets).</li> </ul> </li> <li>4. <b>Sustainable Finance Metrics</b></li> <li>• <b>Data Needed:</b> <ul style="list-style-type: none"> <li>- <b>Green Bond Data:</b> Total value of green bonds issued, types of projects funded, and associated environmental outcomes.</li> <li>- <b>Investment Flows:</b> Data on sustainable investments in sectors like renewable energy, clean tech, and circular economy initiatives.</li> <li>- <b>Environmental, Social, and Governance (ESG) Data:</b> Corporate ESG performance data, including climate-related disclosures (e.g., TCFD reports).</li> <li>- <b>Impact Reporting:</b> Metrics showing the effectiveness of sustainable finance initiatives in reducing environmental harm.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Applications:</b> <ul style="list-style-type: none"> <li>- <b>GDP Impact:</b> IAMs can estimate how ecosystem losses, such as reduced agricultural productivity from pollinator decline or water scarcity, might affect economic output.</li> <li>- <b>Inflation and Interest Rates:</b> IAMs can also model how the degradation of natural capital leads to price instability (e.g., food or energy prices) and how central banks might adjust interest rates to stabilize inflation.</li> </ul> </li> <li>• <b>Examples:</b> <ul style="list-style-type: none"> <li>- <b>MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impacts):</b> A widely used IAM that can incorporate the economic impacts of nature loss alongside climate impacts.</li> <li>- <b>DICE (Dynamic Integrated Climate-Economy Model):</b> A global model that helps quantify the costs of environmental damage and can be used to assess the economic impacts of biodiversity loss on macroeconomic stability.</li> <li>- <b>NIERM (National Integrated Economic-Environment Model):</b> A model tailored to assess national-level impacts of environmental degradation on GDP and inflation.</li> </ul> </li> <li>2. <b>Computable General Equilibrium (CGE) Models</b></li> <li><b>Computable General Equilibrium (CGE) models</b> simulate how the economy adjusts to shocks in various sectors. These models are widely used for policy analysis because they can evaluate the broad effects of nature-related risks on sectors such as agriculture, forestry, energy, and manufacturing, which are directly impacted by environmental degradation.</li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
3. Monetary Policy		<p><b>4. Sustainable Finance Metrics</b></p> <ul style="list-style-type: none"> <li><b>Use Case:</b> Ensuring the financial sector supports sustainable investments and risk management.</li> <li><b>Metrics:</b> <ul style="list-style-type: none"> <li><b>Green Bond Issuance:</b> The total amount of green bonds issued, signalling the shift of capital to environmentally sustainable projects.</li> <li><b>Sustainable Investment Index:</b> Proportion of investments in industries aligned with sustainability goals (e.g., renewable energy, circular economy).</li> </ul> </li> <li><b>Example in Monetary Policy:</b> Central banks could purchase green bonds as part of quantitative easing programs or use sustainable finance metrics to guide financial stability decisions.</li> </ul> <p><b>5. Social and Economic Resilience to Environmental Change</b></p> <ul style="list-style-type: none"> <li><b>Use Case:</b> Protecting vulnerable populations and economies from the impacts of environmental degradation.</li> <li><b>Metrics:</b> <ul style="list-style-type: none"> <li><b>Environmental Equity Indicators:</b> Assessing how environmental policies impact different socio-economic groups, especially marginalized communities.</li> <li><b>Environmental Debt to GDP Ratio:</b> Measures the long-term liabilities of the economy due to environmental degradation or mitigation efforts.</li> </ul> </li> <li><b>Example in Monetary Policy:</b> Adjusting policy tools (like interest rates or liquidity support) to safeguard vulnerable sectors or regions from environmental shocks.</li> </ul> <p><b>6. Ecosystem Service Valuation</b></p> <ul style="list-style-type: none"> <li><b>Use Case:</b> Incorporating the value of ecosystem services (e.g., water purification, carbon sequestration) into monetary policy frameworks.</li> <li><b>Metrics:</b> <ul style="list-style-type: none"> <li><b>Ecosystem Service Contributions to GDP:</b> Quantifies the contribution of ecosystem services to national economic output.</li> <li><b>Sustainability-adjusted GDP:</b> GDP adjusted to reflect the depletion or degradation of natural assets, providing a more accurate representation of economic wellbeing.</li> </ul> </li> </ul>	<p><b>5. Social and Economic Resilience to Environmental Change</b></p> <ul style="list-style-type: none"> <li><b>Data Needed:</b> <ul style="list-style-type: none"> <li><b>Vulnerability Indicators:</b> Data on how environmental degradation impacts different socioeconomic groups (e.g., poverty rates, access to water, health impacts from pollution).</li> <li><b>Displacement and Migration Data:</b> Data on climate-induced migration or displacement due to environmental disasters (e.g., floods, droughts).</li> <li><b>Economic Impact of Environmental Shocks:</b> Data on past natural disasters and their impact on GDP, inflation, employment, and public debt.</li> </ul> </li> </ul> <p><b>6. Ecosystem Service Valuation</b></p> <ul style="list-style-type: none"> <li><b>Data Needed:</b> <ul style="list-style-type: none"> <li><b>Ecosystem Service Data:</b> Quantitative and qualitative data on ecosystem services, such as air and water purification, soil fertility, and carbon storage.</li> <li><b>Land Use Data:</b> Information on land cover and land-use changes, including agriculture, forestry, and urbanization.</li> <li><b>Valuation of Ecosystem Services:</b> Data on the economic value of ecosystem services based on studies and models (e.g., water purification costs, the value of pollination).</li> </ul> </li> </ul> <p><b>7. Circular Economy Indicators</b></p> <ul style="list-style-type: none"> <li><b>Data Needed:</b> <ul style="list-style-type: none"> <li><b>Material Flows:</b> Data on the flow of materials through the economy, including extraction, use, recycling, and disposal (e.g., the amount of waste generated per unit of GDP).</li> <li><b>Recycling and Reuse Rates:</b> Statistics on recycling rates for different materials (e.g., plastics, metals, e-waste).</li> <li><b>Product Life Cycle Data:</b> Information on the environmental impacts of products throughout their life cycle (e.g., carbon footprint, resource consumption).</li> <li><b>Circularity Indices:</b> Data on the circularity of sectors or industries (e.g., the percentage of materials in the economy that are reused or recycled).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><b>Applications:</b> <ul style="list-style-type: none"> <li><b>Economic Growth and Output:</b> CGE models can estimate the knock-on effects of biodiversity or environmental loss on national output and GDP. For example, the depletion of fisheries or loss of pollination could reduce agricultural yields, affecting national economic performance.</li> <li><b>Monetary Policy Implications:</b> CGE models can also evaluate how environmental risks affect inflation and monetary transmission mechanisms (e.g., via higher prices for food and raw materials), influencing central bank policy decisions.</li> </ul> </li> <li><b>Examples:</b> <ul style="list-style-type: none"> <li><b>GTAP (Global Trade Analysis Project):</b> A widely used CGE model that can incorporate environmental factors and assess their impacts on global trade, GDP, and inflation.</li> <li><b>ENVISAGE:</b> A CGE model specifically designed to assess environmental policies and their economic impacts, including biodiversity and ecosystem service losses.</li> </ul> </li> </ul> <p><b>3. Environmental Impact Valuation Tools</b></p> <p>These tools estimate the monetary value of ecosystem services and biodiversity, helping policymakers understand the economic costs of nature loss.</p> <ul style="list-style-type: none"> <li><b>Applications:</b> <ul style="list-style-type: none"> <li><b>Cost of Inaction:</b> These tools help quantify the <b>economic costs of inaction</b> in preserving biodiversity and ecosystems. For example, if forests are cleared at a rapid rate, the lost services (e.g., carbon sequestration, water filtration) could exacerbate climate risks and economic instability.</li> <li><b>Sectoral Impacts:</b> Tools can evaluate how environmental degradation impacts specific sectors like agriculture, tourism, or fisheries, which in turn affects the broader economy.</li> </ul> </li> <li><b>Examples:</b> <ul style="list-style-type: none"> <li><b>The Natural Capital Protocol:</b> This framework helps businesses and policymakers measure and value natural capital, which includes ecosystems and biodiversity, in financial terms. It can be used to estimate the cost of ecosystem service loss and its implications for economic growth and inflation.</li> </ul> </li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
3. Monetary Policy		<ul style="list-style-type: none"> <li><b>Example in Monetary Policy:</b> Adjusting inflation targets or national savings metrics by factoring in the degradation or restoration of ecosystem services, influencing long-term policy decisions.</li> </ul>	<p>8. Sustainable Development Goals (SDG) Alignment</p> <ul style="list-style-type: none"> <li><b>Data Needed:</b> <ul style="list-style-type: none"> <li><b>SDG Progress Data:</b> Official data from national governments and international organizations tracking progress on SDG indicators, especially those related to climate action, biodiversity, and sustainable consumption.</li> <li><b>Financial Flows to SDG Projects:</b> Data on investments and funding aligned with SDG targets, including green finance and sustainable infrastructure projects.</li> <li><b>Impact Data:</b> Metrics showing the social and environmental outcomes of SDG-related policies or investments (e.g., reductions in poverty, improved access to clean water, improved air quality).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><b>The TEEB (The Economics of Ecosystems and Biodiversity):</b> A widely used methodology for valuing the economic benefits of biodiversity and ecosystem services. It helps quantify how the loss of biodiversity may affect national income or sectoral performance.</li> </ul>
		<p>7. Circular Economy Indicators</p> <ul style="list-style-type: none"> <li><b>Use Case:</b> Promoting economic activities that reduce waste and increase the reuse of materials.</li> <li><b>Metrics:</b> <ul style="list-style-type: none"> <li><b>Material Circularity Index (MCI):</b> Measures how much of a product or service is recyclable or reusable.</li> <li><b>Waste-to-GDP Ratio:</b> Tracks the economic output relative to the amount of waste generated.</li> </ul> </li> </ul>	<p>9. Greenhouse Gas (GHG) Emission Reduction Targets</p> <ul style="list-style-type: none"> <li><b>Data Needed:</b> <ul style="list-style-type: none"> <li><b>GHG Emissions Data:</b> National and sectoral emissions data, broken down by industry (e.g., energy, transport, agriculture).</li> <li><b>Carbon Intensity of Economic Output:</b> Data on emissions per unit of GDP or other economic output measures.</li> <li><b>Reduction Potential:</b> Data on potential emission reduction opportunities, including renewable energy capacity, energy efficiency improvements, and carbon capture technologies.</li> <li><b>Regulatory Data:</b> Information on carbon reduction regulations and policies (e.g., emissions trading systems, carbon taxes).</li> </ul> </li> </ul>	<p>4. Dynamic Stochastic General Equilibrium (DSGE) Models</p> <p>DSGE models are used by central banks and monetary authorities to model the economy and the behaviour of macroeconomic variables over time. These models can incorporate nature-related risks, such as environmental shocks, and evaluate their impact on the key monetary policy objectives, including inflation, GDP growth, and employment.</p> <ul style="list-style-type: none"> <li><b>Applications:</b> <ul style="list-style-type: none"> <li><b>Inflation and Employment:</b> DSGE models can be modified to account for environmental shocks (e.g., biodiversity loss leading to higher food prices) and their impact on inflation and employment. For example, a loss of pollination services might lead to an agricultural price shock, affecting inflation.</li> <li><b>Interest Rates:</b> DSGE models can help central banks analyse how environmental disruptions affect output gaps and the potential need for adjustments in interest rates to stabilize the economy.</li> </ul> </li> <li><b>Examples:</b> <ul style="list-style-type: none"> <li><b>The Euro Area DSGE Model (EAGLE):</b> Used by the European Central Bank, this model can incorporate shocks from climate and biodiversity-related risks and estimate their effects on inflation and GDP growth.</li> <li><b>FED DSGE Models:</b> The Federal Reserve uses DSGE models to assess how climate risks (and by extension, biodiversity and ecosystem-related risks) could affect U.S. economic stability and monetary policy decisions.</li> </ul> </li> </ul>
		<p>8. Sustainable Development Goals (SDG) Alignment</p> <ul style="list-style-type: none"> <li><b>Use Case:</b> Aligning monetary policy with global sustainability goals (e.g., UN SDGs).</li> <li><b>Metrics:</b> <ul style="list-style-type: none"> <li><b>SDG Integration Score:</b> A metric for tracking the alignment of financial and monetary policies with the SDGs, especially those related to climate action, life on land, and water conservation.</li> <li><b>SDG Impact on Inflation and Growth:</b> Analysing how SDG-related investments (e.g., clean energy or social infrastructure) can affect long-term economic growth or inflation trends.</li> </ul> </li> <li><b>Example in Monetary Policy:</b> Shaping long-term interest rates or bond market interventions to promote SDG-related projects, boosting investments in renewable energy or sustainable agriculture.</li> </ul>	<p>Common Data Sources</p> <p>For most of these use cases, the following data sources would be important:</p> <ul style="list-style-type: none"> <li><b>National Statistical Offices:</b> For GDP, environmental, and social data (e.g., population statistics, industry data, emissions).</li> <li><b>International Organizations:</b> Data from the UN, World Bank, OECD, and other institutions that track climate, economic, and social metrics.</li> <li><b>Environmental Monitoring Networks:</b> Data on biodiversity, ecosystem services, and environmental health (e.g., Global Biodiversity Information Facility, UN Environment Programme).</li> </ul>	<p>5. Environmental Risk Premium and Discount Rate Models</p> <p>These models estimate the <b>risk premium and discount rate</b> adjustments required to account for nature-related risks, which can influence financial asset pricing, investment decisions, and overall economic growth. Changes in biodiversity and ecosystem health affect long-term economic forecasts, which can be captured through these models.</p>
		<p>9. Greenhouse Gas (GHG) Emission Reduction Targets</p> <ul style="list-style-type: none"> <li><b>Use Case:</b> Promoting policies that drive GHG reduction efforts across sectors.</li> <li><b>Metrics:</b> <ul style="list-style-type: none"> <li><b>GHG Emission Reduction Goals:</b> Tracking progress toward national or global emission reduction targets.</li> <li><b>Carbon Intensity of Economic Output:</b> Measures the amount of carbon emitted per unit of GDP.</li> </ul> </li> </ul>		

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
3. Monetary Policy	<p>By incorporating these nature-related metrics into monetary policy, policymakers can promote long-term economic stability while addressing environmental challenges, transitioning towards a more sustainable, resilient economy.</p>	<ul style="list-style-type: none"> <li><b>Example in Monetary Policy:</b> Adjusting monetary policy levers to support sectors or technologies that can significantly reduce GHG emissions, aligning fiscal support with emission targets.</li> </ul>	<ul style="list-style-type: none"> <li><b>Corporate Disclosures:</b> ESG data from companies, particularly in relation to carbon footprints, environmental risks, and sustainability practices.</li> <li><b>Satellite Data and Remote Sensing:</b> For monitoring land use, deforestation, carbon sequestration, and other environmental changes.</li> <li><b>Climate Models and Forecasts:</b> From agencies like the IPCC and national meteorological agencies, providing future projections of climate impacts.</li> </ul>	<ul style="list-style-type: none"> <li><b>Applications:</b> <ul style="list-style-type: none"> <li>- <b>Investment and Discounting:</b> These models estimate the <b>economic value of nature-related risks</b> in long-term financial decision-making. For example, the degradation of a coral reef system can affect the long-term profitability of the tourism industry, which in turn impacts investment and discount rates used by central banks.</li> <li>- <b>Economic Stability:</b> Nature-related risks are factored into broader macroeconomic projections, with adjustments made for the increased uncertainty or risk associated with climate change or biodiversity loss.</li> </ul> </li> <li><b>Examples:</b> <ul style="list-style-type: none"> <li>- <b>Discounted Cash Flow (DCF) Analysis</b> with environmental risk premiums: Used in project finance and investment appraisals to adjust for risks arising from nature-related degradation.</li> <li>- <b>Carbon Pricing Models:</b> These models estimate the cost of biodiversity and ecosystem service loss by calculating the cost of carbon emissions or environmental harm, which can influence central banks' economic modelling.</li> </ul> </li> </ul> <p><b>6. Environmental Stress Testing for Financial Stability</b></p> <p>Central banks and financial regulators are increasingly using stress testing tools to assess the potential impacts of environmental and nature-related risks on the financial sector and broader economy.</p> <ul style="list-style-type: none"> <li><b>Applications:</b> <ul style="list-style-type: none"> <li>- <b>Financial Sector Resilience:</b> Stress tests can simulate how biodiversity loss, climate change, or natural resource depletion might affect financial institutions' balance sheets, asset prices, and the economy at large. This information can help adjust monetary policy tools (such as interest rates) to maintain economic stability.</li> <li>- <b>Monetary Policy Adjustment:</b> Stress tests that incorporate nature-related risks can highlight vulnerabilities in the financial system, prompting central banks to adjust monetary policy, such as increasing interest rates to curb inflation in response to supply chain disruptions caused by environmental shocks.</li> </ul> </li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
3. Monetary Policy				<ul style="list-style-type: none"> <li>• <b>Examples:</b> <ul style="list-style-type: none"> <li>- <b>Bank of England's Climate Stress Tests:</b> These tests evaluate the resilience of UK banks and insurers to climate-related risks, and similar models can be adapted to assess the impact of biodiversity loss and ecosystem degradation on the broader economy.</li> <li>- <b>ECB Climate Stress Tests:</b> The European Central Bank uses climate-related stress testing, and this framework could be extended to assess nature-related risks on financial stability and macroeconomic outcomes like inflation.</li> </ul> </li> <li><b>7. Sectoral Simulation Models</b> <p>These models focus on specific sectors (e.g., agriculture, fisheries, forestry, tourism) that are directly impacted by nature-related loss and simulate their effects on broader economic variables such as employment, GDP, and inflation.</p> <ul style="list-style-type: none"> <li>• <b>Applications:</b> <ul style="list-style-type: none"> <li>- <b>Sectoral Shocks:</b> These models can simulate how specific sectors that rely on biodiversity and ecosystem services (e.g., fisheries or agriculture) are affected by environmental losses, and how these shocks affect inflation and economic output.</li> <li>- <b>Monetary Policy Implications:</b> Central banks can use these models to forecast the potential need for interest rate adjustments or other policy responses to mitigate sector-specific disruptions.</li> </ul> </li> <li>• <b>Examples:</b> <ul style="list-style-type: none"> <li>- <b>Agri-Economic Models:</b> Models that assess the impacts of biodiversity loss on agricultural yields, food prices, and supply chains, which in turn affect inflation and monetary policy.</li> <li>- <b>Fisheries Economic Models:</b> Models that assess the economic impact of overfishing or ecosystem collapse on the fisheries sector, which can influence export revenues, GDP, and inflation.</li> </ul> </li> </ul> </li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
4. Statistical Indicators	Provides data for general economic analysis and reporting.	<p>Accepted indicators for benchmarking and longitudinal studies (e.g., nature related indexes, ecosystem service valuations).</p> <p>When integrating nature-related considerations into statistical indicators, the aim is to create a set of metrics that reflect the health of ecosystems, the sustainable use of natural resources, and the economic and social implications of environmental changes. These indicators can help inform policies, monitor progress, and guide decision-making related to environmental sustainability and its link to the economy.</p> <p>Here are key <b>nature-related metrics for statistical indicators</b>, categorized according to specific use cases:</p> <p><b>1. Natural Capital and Ecosystem Health</b></p> <ul style="list-style-type: none"> <li>• <b>Indicators:</b> <ul style="list-style-type: none"> <li>- <b>Natural Capital Index:</b> A composite indicator that measures the stock and value of natural capital (e.g., forests, water bodies, biodiversity, minerals).</li> <li>- <b>Biodiversity Index:</b> Tracks species diversity within ecosystems. Examples include the <b>Living Planet Index (LPI)</b> or the <b>Red List Index</b> (which tracks species risk of extinction).</li> <li>- <b>Ecosystem Service Valuation:</b> Measures the economic value of ecosystem services (e.g., water purification, pollination, carbon sequestration). This could be quantified in monetary terms per hectare or in terms of impact on GDP.</li> <li>- <b>Land Degradation Index:</b> Measures the extent of land degradation, including desertification, deforestation, and soil erosion, using satellite data and ground-level assessments.</li> <li>- <b>Water Quality and Availability Index:</b> Tracks the availability of clean water and the quality of water resources (e.g., water stress indicators, freshwater ecosystem health).</li> </ul> </li> </ul> <p><b>2. Climate and Environmental Risks</b></p> <ul style="list-style-type: none"> <li>• <b>Indicators:</b> <ul style="list-style-type: none"> <li>- <b>Greenhouse Gas (GHG) Emissions by Sector:</b> Measures carbon dioxide (CO<sub>2</sub>) and other GHGs emitted by major sectors (e.g., energy, transportation, agriculture). This is often expressed in tons of CO<sub>2</sub> equivalent (CO<sub>2</sub>e) per unit of GDP or per capita.</li> </ul> </li> </ul>	<p>Data supporting trend analysis and comparisons over time.</p> <p>To implement and track nature-related use cases in <b>statistical indicators</b>, various types of data are required across environmental, economic, and social domains. This data can be sourced from national statistical offices, international organizations, scientific studies, and real-time monitoring systems. Below is an outline of the key <b>data needed</b> for each of the nature-related statistical indicators:</p> <p><b>1. Natural Capital and Ecosystem Health</b></p> <ul style="list-style-type: none"> <li>• <b>Natural Resource Stocks Data:</b> <ul style="list-style-type: none"> <li>- Quantity and value of natural resources (forests, water bodies, minerals, fisheries, etc.).</li> <li>- Forest cover, soil quality, biodiversity hotspots, and land use.</li> <li>- Data on ecosystems such as wetlands, coral reefs, forests, and grasslands.</li> </ul> </li> <li>• <b>Ecosystem Service Valuation Data:</b> <ul style="list-style-type: none"> <li>- Monetary and non-monetary value of ecosystem services (e.g., carbon sequestration, water purification, pollination, soil fertility).</li> <li>- Surveys and studies quantifying the contribution of ecosystems to human wellbeing and economic activity.</li> </ul> </li> <li>• <b>Biodiversity Data:</b> <ul style="list-style-type: none"> <li>- Species richness, population densities, and conservation status of key species.</li> <li>- Data from organizations like the <b>IUCN Red List</b> or <b>World Conservation Monitoring Centre (WCMC)</b>.</li> <li>- Monitoring of biodiversity through satellite imagery, camera traps, or ground surveys.</li> </ul> </li> <li>• <b>Land Degradation Data:</b> <ul style="list-style-type: none"> <li>- Soil erosion, deforestation rates, desertification, and wetland degradation.</li> <li>- Remote sensing data and geographical information systems (GIS) on land use changes.</li> </ul> </li> <li>• <b>Water Quality and Availability Data:</b> <ul style="list-style-type: none"> <li>- Water quality indicators (e.g., chemical pollution levels, pH, turbidity, and biological oxygen demand).</li> <li>- Freshwater availability and usage data from national and international sources (e.g., <b>FAO</b>, <b>UN Water</b>).</li> </ul> </li> </ul>	<p>Statistical tools to analyse correlations between nature-related changes and economic variables.</p> <p>To analyse correlations between nature-related changes and variables, several statistical tools and techniques are available. These methods help to quantify the relationships between environmental factors (e.g., temperature, precipitation, habitat loss) and changes in natural systems (e.g., species population dynamics, biodiversity, ecosystem health). Below are some of the key statistical tools and methods:</p> <p><b>1. Pearson's Correlation Coefficient (r)</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Measures the strength and direction of the linear relationship between two continuous variables.</li> <li>• <b>Use:</b> Commonly used to analyse the relationship between two environmental variables (e.g., temperature vs. species abundance, precipitation vs. crop yield).</li> <li>• <b>Range:</b> Ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation), with 0 indicating no linear correlation.</li> </ul> <p><b>2. Spearman's Rank Correlation</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Measures the strength and direction of the monotonic relationship between two ranked (ordinal) or continuous variables.</li> <li>• <b>Use:</b> Used when the relationship between variables is not linear but still monotonic (i.e., consistently increasing or decreasing), such as the correlation between temperature and the timing of seasonal events (e.g., blooming or migration).</li> <li>• <b>Range:</b> Similar to Pearson's correlation but for ordinal data, ranging from -1 to +1.</li> </ul> <p><b>3. Multiple Linear Regression</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Models the relationship between a dependent variable and multiple independent variables.</li> <li>• <b>Use:</b> Often used to predict or understand how various environmental factors (e.g., temperature, precipitation, land use change) affect a natural system (e.g., species distribution, ecosystem health). For instance, predicting biodiversity in relation to climate variables, land use, and pollution.</li> </ul> <p><b>4. Generalized Linear Models (GLM)</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> A flexible extension of linear regression that allows for the response variable to have a distribution other than normal (e.g., binomial, Poisson).</li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
4. Statistical Indicators		<ul style="list-style-type: none"> <li>- <b>Carbon Intensity of the Economy:</b> The amount of CO<sub>2</sub> emissions per unit of GDP, reflecting the carbon efficiency of economic activity.</li> <li>- <b>Climate Vulnerability Index:</b> Assesses the exposure of regions or sectors to climate risks such as extreme weather events (floods, droughts, wildfires).</li> <li>- <b>Physical Risk Exposure:</b> Quantifies the exposure of assets, infrastructure, and populations to physical climate risks, such as sea-level rise, temperature extremes, or flooding.</li> <li>- <b>Climate Change Impact Index:</b> An overall measure of the cumulative effects of climate change on natural systems and human societies, including the frequency of extreme events, loss of biodiversity, and changes in ecosystem functioning.</li> </ul>	<p><b>2. Climate and Environmental Risks</b></p> <ul style="list-style-type: none"> <li>• <b>GHG Emissions Data:</b> <ul style="list-style-type: none"> <li>- National GHG emissions by sector (energy, transportation, agriculture, industry) from sources like national inventories, UNFCCC reports, or EPA emissions data.</li> <li>- Carbon intensity metrics (emissions per unit of GDP, emissions per capita).</li> </ul> </li> <li>• <b>Climate Risk Data:</b> <ul style="list-style-type: none"> <li>- Data from IPCC climate models predicting temperature changes, sea-level rise, and extreme weather patterns.</li> <li>- Regional vulnerability data (e.g., physical risks from extreme heat, drought, flooding).</li> </ul> </li> <li>• <b>Transition Risk Data:</b> <ul style="list-style-type: none"> <li>- Emission reduction policies, carbon pricing data, and energy transition plans (e.g., decarbonisation strategies).</li> <li>- Economic exposure to carbon-intensive industries and the potential impact of climate regulations.</li> </ul> </li> <li>• <b>Physical Risk Exposure:</b> <ul style="list-style-type: none"> <li>- Physical risks from climate change such as extreme weather events, flooding, and heatwaves, as well as their impact on infrastructure and communities.</li> <li>- Data from global climate risk platforms such as <b>The Climate Risk Index (CRI)</b> or <b>World Bank's Climate Data API</b>.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Use:</b> Used to model the relationship between predictors and outcomes that do not fit a normal distribution. For example, GLMs are used to model species occurrence (binomial) or count data (Poisson), such as the number of species found in different habitat types.</li> <li>• <b>5. Canonical Correlation Analysis (CCA)</b> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Examines the relationship between two sets of multiple variables.</li> <li>• <b>Use:</b> Often applied in ecology and environmental science to understand the correlation between two different sets of variables, such as the relationship between environmental variables (e.g., temperature, rainfall, soil type) and ecological community structure (e.g., species abundance, diversity).</li> </ul> </li> <li>• <b>6. Principal Component Analysis (PCA)</b> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> A dimensionality reduction technique that transforms correlated variables into a smaller set of uncorrelated variables called principal components.</li> <li>• <b>Use:</b> Often used when dealing with multivariate environmental data, such as weather variables or land cover types, to identify patterns and reduce the complexity of large datasets. PCA can help determine how different environmental factors collectively influence natural changes (e.g., forest health, species distributions).</li> </ul> </li> <li>• <b>7. Partial Correlation Analysis</b> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Measures the correlation between two variables while controlling for the effect of other variables.</li> <li>• <b>Use:</b> Used to understand the direct relationship between two variables by removing the influence of other potentially confounding variables. For example, examining the relationship between species abundance and temperature while controlling for land use.</li> </ul> </li> <li>• <b>8. Cross-Correlation</b> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Measures the time-lagged relationship between two time series datasets.</li> <li>• <b>Use:</b> Applied to analyse the delayed or leading correlations between nature-related variables and other factors. For instance, the impact of rainfall patterns on the population size of a species in subsequent months or years.</li> </ul> </li> </ul>
		<p><b>3. Sustainable Resource Use</b></p> <ul style="list-style-type: none"> <li>• <b>Indicators:</b> <ul style="list-style-type: none"> <li>- <b>Ecological Footprint:</b> Measures the demand on natural resources and ecosystems in relation to the Earth's capacity to regenerate them. It includes factors like carbon footprint, land use, and water usage.</li> <li>- <b>Resource Efficiency:</b> Metrics like <b>Energy Intensity</b> (energy consumption per unit of GDP) and <b>Material Intensity</b> (material consumption per unit of GDP) assess how efficiently resources are used in the economy.</li> <li>- <b>Water Footprint:</b> Measures total water consumption by sector and by population, accounting for both direct and indirect water use (virtual water).</li> <li>- <b>Sustainable Fisheries Index:</b> Measures the sustainability of fisheries based on catch rates, ecosystem health, and fisheries management practices.</li> <li>- <b>Renewable Energy Share:</b> Tracks the proportion of energy generated from renewable sources (e.g., wind, solar, hydro) as a share of total energy production.</li> </ul> </li> </ul>	<p><b>3. Sustainable Resource Use</b></p> <ul style="list-style-type: none"> <li>• <b>Ecological Footprint Data:</b> <ul style="list-style-type: none"> <li>- Consumption data on resources such as land, water, and energy, and their corresponding environmental impacts.</li> <li>- Data on the ecological footprint per capita, including metrics from the <b>Global Footprint Network</b>.</li> </ul> </li> <li>• <b>Resource Efficiency Data:</b> <ul style="list-style-type: none"> <li>- Energy intensity (energy consumption per unit of GDP), material intensity (material consumption per unit of GDP).</li> <li>- Data on the recycling rate of materials and the resource efficiency of key industries.</li> </ul> </li> <li>• <b>Water Footprint Data:</b> <ul style="list-style-type: none"> <li>- Water usage data by industry, region, and sector.</li> <li>- Data on freshwater withdrawals, consumption, and the virtual water trade.</li> </ul> </li> </ul>	
		<p><b>4. Economic Impacts of Nature Loss</b></p> <ul style="list-style-type: none"> <li>• <b>Indicators:</b> <ul style="list-style-type: none"> <li>- <b>GDP Adjusted for Natural Capital Depletion:</b> A variation of GDP that subtracts the depletion of natural resources (e.g., timber, minerals) and degradation of ecosystems (e.g., loss of wetlands, forests).</li> <li>- <b>Environmental Debt to GDP Ratio:</b> Measures the economic cost or liability of environmental degradation compared to national economic output.</li> </ul> </li> </ul>		

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
4. Statistical Indicators		<ul style="list-style-type: none"> <li>- <b>Cost of Ecosystem Loss:</b> The economic impact of the loss of ecosystem services on national and regional economies (e.g., declines in agricultural productivity due to soil erosion, or reduced tourism due to coral reef degradation).</li> <li>- <b>Environmental Shock Resilience Index:</b> A composite measure of how resilient an economy or region is to environmental shocks, such as natural disasters or climate-related events.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Sustainable Fisheries Data:</b> <ul style="list-style-type: none"> <li>- Fisheries catch data, stock assessments, fishing mortality rates, and sustainability of marine ecosystems.</li> <li>- Data from organizations such as the <b>FAO, Global Fishery Resources</b> database, and national fisheries monitoring systems.</li> </ul> </li> <li>• <b>Renewable Energy Share Data:</b> <ul style="list-style-type: none"> <li>- Energy production data by source (e.g., solar, wind, hydro, geothermal).</li> <li>- National and regional data on the share of renewables in the energy mix, energy subsidies, and renewable energy infrastructure.</li> </ul> </li> </ul>	<p>9. Granger Causality Test</p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Determines whether one time series can predict another.</li> <li>• <b>Use:</b> Used in environmental studies to test if changes in one environmental variable (e.g., temperature, CO<sub>2</sub> levels) can help predict changes in another variable (e.g., plant growth, fish migration), accounting for time lags.</li> </ul> <p>10. Mann-Kendall Trend Test</p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> A non-parametric test for identifying trends (increasing or decreasing) in time-series data.</li> <li>• <b>Use:</b> Commonly applied in environmental sciences to detect trends in data like temperature, precipitation, river flow, or species abundance over time, without assuming a specific distribution of the data.</li> </ul> <p>11. Distance-based Redundancy Analysis (db-RDA)</p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> A variation of redundancy analysis that incorporates distance measures for analysing multivariate data.</li> <li>• <b>Use:</b> Applied in ecology to assess how environmental gradients (e.g., soil pH, temperature, and moisture) explain variations in community composition or species distributions.</li> </ul> <p>12. Structural Equation Modelling (SEM)</p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> A multivariate technique used to analyse complex relationships between multiple variables, including direct and indirect effects.</li> <li>• <b>Use:</b> Used to model direct and indirect effects of multiple environmental variables on natural processes. For example, examining how temperature, soil moisture, and land use influence species diversity through indirect pathways.</li> </ul> <p>13. Bayesian Inference and Bayesian Networks</p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Provides a probabilistic approach to understanding uncertainty in environmental data and models.</li> <li>• <b>Use:</b> Bayesian methods are used to model complex relationships between variables in uncertain or sparse data environments. They are particularly useful in predicting species distributions or ecosystem changes under different environmental scenarios.</li> </ul>
5. Environmental Equity and Social Impact		<ul style="list-style-type: none"> <li>- <b>Environmental Justice Index:</b> Measures how environmental impacts (e.g., pollution, exposure to hazardous waste) are distributed across different social groups, including vulnerable populations (e.g., low-income or minority communities).</li> <li>- <b>Access to Environmental Services Index:</b> Tracks the proportion of the population with access to clean water, sanitation, and clean air, as well as access to green spaces.</li> <li>- <b>Health Impact of Pollution:</b> Indicators measuring the public health burden due to environmental factors, including air and water pollution, and exposure to hazardous chemicals.</li> <li>- <b>Climate Migration Index:</b> Tracks migration patterns driven by environmental factors such as rising sea levels, droughts, or extreme weather events.</li> </ul>	<p>4. Economic Impacts of Nature Loss</p> <ul style="list-style-type: none"> <li>• <b>GDP Adjusted for Natural Capital Depletion:</b> <ul style="list-style-type: none"> <li>- Data on economic output adjusted for the depletion of natural resources, ecosystem services loss, and environmental degradation.</li> <li>- National accounting data, such as the <b>System of Environmental-Economic Accounting (SEEA)</b>.</li> </ul> </li> <li>• <b>Environmental Debt to GDP Data:</b> <ul style="list-style-type: none"> <li>- Estimates of the economic liability arising from environmental degradation and natural capital depletion.</li> <li>- Data on costs of restoring ecosystems or mitigating climate impacts.</li> </ul> </li> <li>• <b>Cost of Ecosystem Loss:</b> <ul style="list-style-type: none"> <li>- Economic data showing the financial impacts of environmental loss (e.g., loss of agricultural productivity, reduced tourism from biodiversity loss, healthcare costs from pollution).</li> </ul> </li> <li>• <b>Environmental Shock Resilience Data:</b> <ul style="list-style-type: none"> <li>- Data on past environmental shocks and their economic impact, including recovery time and costs.</li> <li>- Risk modelling and resilience data from institutions like the <b>World Bank</b> or <b>OECD</b>.</li> </ul> </li> </ul>	
6. Sustainable Finance and Investment		<ul style="list-style-type: none"> <li>- <b>Green Finance Proportion:</b> The share of total financial investments allocated to green bonds, sustainable infrastructure, or low-carbon technologies.</li> <li>- <b>ESG (Environmental, Social, Governance) Investment Ratio:</b> Measures the proportion of investments directed toward companies or projects with high ESG scores, signalling sustainable business practices.</li> <li>- <b>Green Bond Market Growth:</b> Tracks the volume and growth rate of green bond issuance, which finances environmentally sustainable projects.</li> <li>- <b>Sustainable Investment Fund Size:</b> Total capital invested in funds that target sustainable or impact-driven projects, such as renewable energy or conservation initiatives.</li> </ul>	<p>5. Environmental Equity and Social Impact</p> <ul style="list-style-type: none"> <li>• <b>Environmental Justice Data:</b> <ul style="list-style-type: none"> <li>- Data on the geographic distribution of environmental hazards (e.g., pollution, waste sites) and vulnerable populations.</li> <li>- Data on health disparities and exposure to environmental risks, especially in marginalized communities.</li> </ul> </li> </ul>	

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
4. Statistical Indicators		<p><b>7. Circular Economy and Waste Management</b></p> <ul style="list-style-type: none"> <li>• <b>Indicators:</b> <ul style="list-style-type: none"> <li>- <b>Material Circularity Index (MCI):</b> Measures the degree to which materials in an economy or industry are reused, recycled, or repurposed, contributing to a circular economy.</li> <li>- <b>Waste-to-GDP Ratio:</b> Tracks the amount of waste generated relative to economic output, assessing the efficiency of waste management systems and the potential for recycling and reuse.</li> <li>- <b>Recycling Rate:</b> Percentage of waste materials that are recycled, indicating the effectiveness of circular economy policies and waste management systems.</li> <li>- <b>Electronic Waste (E-Waste) Management Index:</b> Measures the collection, recycling, and proper disposal of electronic waste, which is a growing environmental challenge.</li> </ul> </li> </ul> <p><b>8. Global and National Environmental Policy Alignment (SDG Indicators)</b></p> <ul style="list-style-type: none"> <li>• <b>Indicators:</b> <ul style="list-style-type: none"> <li>- <b>SDG 12 – Responsible Consumption and Production:</b> Measures the degree to which consumption patterns and production methods are aligned with sustainability goals, including the decoupling of economic growth from resource use.</li> <li>- <b>SDG 13 – Climate Action:</b> Tracks progress on climate action goals, such as GHG emissions reduction targets, adaptation strategies, and financing for climate resilience.</li> <li>- <b>SDG 14 &amp; 15 – Life Below Water and Life on Land:</b> Metrics that assess the health of marine and terrestrial ecosystems, including biodiversity, ecosystem restoration efforts, and sustainable resource use.</li> <li>- <b>SDG 6 – Clean Water and Sanitation:</b> Measures the availability and quality of freshwater resources, as well as progress toward achieving universal access to clean water and sanitation.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Access to Environmental Services Data:</b> <ul style="list-style-type: none"> <li>- Access to clean water, sanitation, and green spaces, often tracked by government health or infrastructure agencies.</li> <li>- Data from <b>World Health Organization (WHO), UNICEF,</b> or national health ministries.</li> </ul> </li> <li>• <b>Health Impact of Pollution Data:</b> <ul style="list-style-type: none"> <li>- Public health data, including the number of premature deaths or illnesses related to air and water pollution.</li> <li>- Data on exposure to chemicals and particulate matter, from national health surveys or the <b>Global Burden of Disease Study.</b></li> </ul> </li> <li>• <b>Climate Migration Data:</b> <ul style="list-style-type: none"> <li>- Data on migration patterns linked to environmental factors such as sea-level rise, extreme weather events, and resource scarcity.</li> <li>- Data from international migration organizations like <b>IOM (International Organization for Migration)</b> or <b>UNHCR.</b></li> </ul> </li> </ul> <p><b>6. Sustainable Finance and Investment</b></p> <ul style="list-style-type: none"> <li>• <b>Green Finance Data:</b> <ul style="list-style-type: none"> <li>- Data on green bond issuance, green investment funds, and financing for sustainable projects.</li> <li>- Reports from financial institutions, such as the <b>International Finance Corporation (IFC)</b> or <b>Climate Bonds Initiative.</b></li> </ul> </li> <li>• <b>ESG Investment Data:</b> <ul style="list-style-type: none"> <li>- Corporate disclosures on environmental, social, and governance (ESG) performance from databases like <b>MSCI, S&amp;P Global,</b> or <b>Sustainalytics.</b></li> <li>- Data on the growth of ESG funds, investments aligned with the <b>UN Principles for Responsible Investment (PRI),</b> or climate-related financial disclosures (e.g., <b>TCFD</b> reports).</li> </ul> </li> <li>• <b>Green Bond Market Data:</b> <ul style="list-style-type: none"> <li>- Green bond issuance volumes, coupon rates, types of projects funded, and geographic distribution.</li> <li>- Market reports from organizations like the <b>Climate Bonds Initiative</b> or <b>World Bank.</b></li> </ul> </li> </ul>	<p><b>14. Geospatial Statistics (e.g., Moran's I, Geary's C)</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Analyses spatial autocorrelation (the degree to which a variable at one location is similar to neighbouring locations).</li> <li>• <b>Use:</b> Applied to spatially distributed environmental data, such as vegetation cover, disease spread, or species occurrence, to assess how spatially clustered or dispersed these variables are and how they relate to environmental factors.</li> </ul> <p><b>15. Time Series Analysis (e.g., ARIMA, Exponential Smoothing)</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Analyses and forecasts data that are collected over time, accounting for trends, seasonality, and noise.</li> <li>• <b>Use:</b> Used to model environmental time series data such as temperature, precipitation, or species population dynamics over time. These models can help understand cyclical patterns and predict future changes based on historical data.</li> </ul> <p><b>16. Random Forests and Machine Learning Models</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Non-parametric, data-driven methods that use decision trees to model complex relationships.</li> <li>• <b>Use:</b> These techniques are particularly useful when dealing with large, high-dimensional environmental datasets. For instance, they can predict species distribution based on environmental predictors, or model ecosystem responses to climate change.</li> </ul> <p><b>17. Spatial Autoregressive Models (SAR)</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Used to model spatial dependencies in data, considering the influence of nearby observations on each other.</li> <li>• <b>Use:</b> Applied in ecology and environmental sciences to analyse spatially distributed data, such as the impact of land use or habitat fragmentation on biodiversity.</li> </ul> <p><b>18. Ecological Network Analysis (ENA)</b></p> <ul style="list-style-type: none"> <li>• <b>Purpose:</b> Examines the flow of energy, nutrients, or species within ecosystems.</li> <li>• <b>Use:</b> Often used to analyse how environmental changes, such as the introduction of pollutants or habitat loss, affect ecosystem structure and function.</li> </ul>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
4. Statistical Indicators			<ul style="list-style-type: none"> <li>• <b>Sustainable Investment Fund Data:</b> <ul style="list-style-type: none"> <li>- Data on the size and growth of funds dedicated to sustainable infrastructure or environmental projects.</li> <li>- Investment flows into renewable energy, low-carbon technologies, or conservation projects.</li> </ul> </li> <li>• <b>7. Circular Economy and Waste Management</b></li> <li>• <b>Material Flow Data:</b> <ul style="list-style-type: none"> <li>- Data on the extraction, use, and recycling of materials across sectors (e.g., metals, plastics, and electronics).</li> <li>- National statistics on raw material consumption, recycling rates, and material recovery.</li> </ul> </li> <li>• <b>Recycling and Reuse Data:</b> <ul style="list-style-type: none"> <li>- Data on the recycling rates of key materials (e.g., paper, plastic, metals, electronics).</li> <li>- National waste management data from environmental protection agencies or waste management associations.</li> </ul> </li> <li>• <b>Circularity Indices:</b> <ul style="list-style-type: none"> <li>- Data on how much of a product or material is reused or recycled, including life cycle assessment (LCA) data.</li> </ul> </li> <li>• <b>Electronic Waste (E-Waste) Data:</b> <ul style="list-style-type: none"> <li>- Data on the volume and management of electronic waste, including collection, recycling, and disposal.</li> <li>- Reports from organizations like <b>WEEE Forum</b>, <b>UNU</b> (United Nations University), or <b>International Telecommunication Union (ITU)</b>.</li> </ul> </li> <li>• <b>8. Global and National Environmental Policy Alignment (SDG Indicators)</b></li> <li>• <b>SDG Data:</b> <ul style="list-style-type: none"> <li>- National and global progress data on Sustainable Development Goals (SDGs), particularly those related to <b>SDG 13 (Climate Action)</b>, <b>SDG 6 (Clean Water)</b>, and <b>SDG 12 (Responsible Consumption)</b>.</li> <li>- Data on government policies and actions aimed at achieving SDG targets (e.g., emissions reduction commitments, water access goals, waste reduction programs).</li> </ul> </li> </ul>	

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
<b>5. Non-Supervisory Engagement</b>	Uses data to engage stakeholders outside regulatory frameworks.	<p>Understandable metrics for public communication and stakeholder engagement.</p> <ol style="list-style-type: none"> <li><b>Biodiversity Index</b> <ul style="list-style-type: none"> <li>A measure of the variety of species in a particular area.</li> </ul> </li> <li><b>Carbon Sequestration</b> <ul style="list-style-type: none"> <li>The amount of carbon dioxide captured and stored by forests, wetlands, and other ecosystems.</li> </ul> </li> <li><b>Water Quality Index</b> <ul style="list-style-type: none"> <li>A composite measure of water quality based on various parameters like pH, dissolved oxygen, and contaminants.</li> </ul> </li> <li><b>Air Quality Index (AQI)</b> <ul style="list-style-type: none"> <li>A measure of air pollution levels.</li> </ul> </li> <li><b>Green Space Coverage</b> <ul style="list-style-type: none"> <li>The percentage of land area covered by parks, gardens, and other green spaces.</li> </ul> </li> <li><b>Endangered Species Count</b> <ul style="list-style-type: none"> <li><b>Description:</b> The number of species in a given area that are classified as endangered.</li> </ul> </li> <li><b>Tree Canopy Coverage</b> <ul style="list-style-type: none"> <li>The proportion of an area covered by tree canopies.</li> </ul> </li> <li><b>Pollinator Population</b> <ul style="list-style-type: none"> <li>The number of pollinators, such as bees and butterflies, in a given area.</li> </ul> </li> <li><b>Habitat Restoration Area</b> <ul style="list-style-type: none"> <li>The area of land restored to its natural state.</li> </ul> </li> <li><b>Public Engagement in Conservation Activities</b> <ul style="list-style-type: none"> <li>The number of people participating in conservation activities.</li> </ul> </li> </ol>	<p>Data supporting narratives on nature related's societal and economic importance.</p> <p>Supporting narratives on the societal and economic importance of nature-related risks and opportunities involves data that highlights the critical role of ecosystems, biodiversity, and natural resources in driving human well-being, economic growth, and long-term sustainability. These narratives often focus on the interdependencies between human societies, economies, and the environment, emphasizing the value of natural capital, the cost of environmental degradation, and the benefits of preserving natural systems.</p> <p>Here's a breakdown of the key data needed to support these narratives:</p> <ol style="list-style-type: none"> <li><b>Economic Valuation of Ecosystem Services</b> <p>Ecosystem services refer to the benefits humans derive from nature, which include provisioning, regulating, cultural, and supporting services. These services are critical to both societal well-being and economic activity.</p> <p><b>Key Data:</b></p> <ul style="list-style-type: none"> <li><b>Global and National Valuation Studies:</b> Studies that estimate the total economic value of ecosystem services, often measured in monetary terms. These can include: <ul style="list-style-type: none"> <li>- Provisioning services (e.g., food, water, raw materials) that support industries such as agriculture, forestry, and fisheries.</li> <li>- Regulating services (e.g., climate regulation, water purification, flood control) that underpin sectors like agriculture, real estate, insurance, and infrastructure.</li> <li>- Cultural services (e.g., tourism, recreation, spiritual benefits) that support sectors such as tourism, leisure, and the arts.</li> <li>- Supporting services (e.g., soil formation, pollination, nutrient cycling) essential for agricultural productivity and food security.</li> </ul> </li> <li><b>The Economics of Biodiversity Report (Dasgupta Review):</b> A landmark report that quantifies the economic dependence of societies on nature, providing data on how environmental degradation impacts GDP and long-term economic growth.</li> </ul> </li> </ol>	<p>Metrics demonstrating nature related's value to non-financial stakeholders.</p> <p><b>Health and Well-being Metrics</b>  <i>Metric: Reduction in Stress Level</i>  <i>Metric: Physical Activity Levels</i></p> <p><b>Educational and Cultural Value</b>  <i>Metric: Environmental Education Participation</i>  <i>Metric: Cultural Heritage Sites</i></p> <p><b>Community Engagement and Social Cohesion</b>  <i>Metric: Volunteer Participation</i>  <i>Metric: Community Events</i></p> <p><b>Biodiversity and Ecosystem Health</b>  <i>Metric: Species Richness</i>  <i>Metric: Habitat Restoration Success</i></p> <p><b>Climate and Environmental Resilience</b>  <i>Metric: Urban Heat Island Effect Reduction</i>  <i>Metric: Flood Mitigation</i></p> <p><b>Pollution Reduction</b>  <i>Metric: Water Quality Improvement</i>  <i>Metric: Air Quality Improvement</i></p>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
5. Non-Supervisory Engagement			<ul style="list-style-type: none"> <li>• <b>National and Regional Ecosystem Service Valuation:</b> Localized data, like those from the Natural Capital Project or The Economics of Ecosystems and Biodiversity (TEEB) initiative, which estimate the value of ecosystem services at the national or regional level.</li> <li><b>2. Biodiversity and Economic Dependency</b></li> </ul> <p>Biodiversity, the variety of life on Earth, underpins ecosystem functioning and resilience. A loss of biodiversity can directly affect economic sectors dependent on natural resources.</p> <p><b>Key Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Biodiversity Indexes and Species Richness:</b> Data on species diversity, including the number of species in a region or ecosystem, and how this diversity impacts ecosystem services. For example, pollination services are essential for agriculture and food production.</li> <li>• <b>Ecosystem-based Economic Dependency:</b> Data showing how industries such as agriculture, fisheries, forestry, and tourism rely on specific biodiversity hotspots or ecosystems. For instance: <ul style="list-style-type: none"> <li>- <b>Agricultural Productivity:</b> The economic contribution of pollination and soil health to crop yields.</li> <li>- <b>Fisheries:</b> The economic value of fisheries in regions that depend on healthy marine biodiversity.</li> <li>- <b>Forestry:</b> The contribution of forest ecosystems to timber production, non-timber forest products, and carbon sequestration.</li> </ul> </li> <li>• <b>Global and Regional Biodiversity Loss Data:</b> Information on the rate of biodiversity loss, such as the Living Planet Index (LPI) or the Global Biodiversity Outlook (GBO), which measures trends in species populations and the decline of ecosystems.</li> <li>• <b>Biodiversity and the Global Economy:</b> Studies on how biodiversity loss impacts GDP, food security, and employment, such as those by The World Bank and UN Environment Programme.</li> </ul> <li><b>3. Natural Capital and Economic Growth</b></li> <p>Natural capital refers to the world's stocks of natural resources and environmental assets, which are essential for economic activities.</p>	

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
5. Non-Supervisory Engagement			<p><b>Key Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Natural Capital Accounting:</b> Data from natural capital accounting frameworks (e.g., the System of Environmental-Economic Accounting (SEEA)) that quantify the value of natural assets and ecosystem services. This can show the economic importance of forests, fisheries, minerals, water resources, and land.</li> <li>• <b>Contribution of Natural Resources to GDP:</b> Sectoral contributions to GDP from industries directly reliant on natural resources (e.g., agriculture, mining, forestry, energy). For example, the percentage of GDP dependent on fossil fuels, timber, or agricultural production.</li> <li>• <b>Economic Impact of Resource Depletion:</b> Estimates of the economic cost of resource depletion and the degradation of natural capital, such as the loss of soil fertility, forest degradation, or freshwater scarcity.</li> <li>• <b>Natural Capital and Job Creation:</b> Data showing how the sustainable use of natural capital creates jobs, especially in sectors like green energy, eco-tourism, sustainable agriculture, and conservation.</li> </ul> <p><b>4. Climate Change and Economic Impacts</b></p> <p>Climate change poses significant risks to societal and economic systems, with impacts on infrastructure, agriculture, health, and financial stability.</p> <p><b>Key Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Cost of Climate Change:</b> Data on the economic cost of climate change, including: <ul style="list-style-type: none"> <li>- <b>Losses from extreme weather events (e.g., hurricanes, floods, droughts)</b> and their financial impacts on industries and infrastructure.</li> <li>- <b>Health Costs:</b> Data on the economic burden of climate-related health impacts, including increased healthcare costs from heatwaves, pollution, and climate-sensitive diseases.</li> <li>- <b>Agricultural Losses:</b> Economic data on crop yield reductions due to changing weather patterns, droughts, and floods.</li> <li>- <b>Insurance Losses:</b> Historical data on claims and damages from climate-related events, showing the cost to the insurance sector and how these costs are passed on to businesses and consumers.</li> <li>- <b>Sectoral Vulnerabilities:</b> Economic models and projections showing how sectors like agriculture, construction, tourism, and energy are vulnerable to climate impacts.</li> </ul> </li> </ul>	

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
5. Non-Supervisory Engagement			<ul style="list-style-type: none"> <li>• <b>Adaptation and Mitigation Costs:</b> Data on the costs of climate adaptation (e.g., flood defences, drought-resistant crops) and mitigation efforts (e.g., transitioning to renewable energy, energy efficiency investments).</li> <li>• <b>5. The Role of Ecosystems in Disaster Risk Reduction</b> Ecosystems play a critical role in reducing the impacts of natural disasters. Healthy ecosystems can serve as natural buffers, preventing or mitigating damage from floods, storms, and droughts. <b>Key Data:</b></li> <li>• <b>Natural Infrastructure for Disaster Risk Reduction:</b> Data on the role of ecosystems in reducing the cost of disaster response, including: <ul style="list-style-type: none"> <li>- <b>Wetlands:</b> The role of wetlands in flood mitigation and water filtration.</li> <li>- <b>Mangroves:</b> The protection mangroves provide against coastal storm surges and erosion.</li> <li>- <b>Forests:</b> The role of forests in stabilizing soils and preventing landslides, particularly in mountainous regions.</li> <li>- <b>Coral Reefs:</b> The protection coral reefs offer against storm damage in coastal areas.</li> </ul> </li> <li>• <b>Economic Savings from Ecosystem Protection:</b> Data on the avoided costs of disaster recovery due to the presence of natural infrastructure, as well as the economic benefits of investing in ecosystem restoration.</li> <li>• <b>6. Social and Health Impacts</b> Nature-related risks also have direct implications for human health and social equity. Data supporting this narrative focuses on how environmental degradation disproportionately impacts vulnerable populations. <b>Key Data:</b></li> <li>• <b>Health Impacts of Environmental Degradation:</b> Data on the economic cost of diseases linked to environmental degradation, including: <ul style="list-style-type: none"> <li>- <b>Respiratory Diseases:</b> The costs associated with air pollution and respiratory illnesses (e.g., asthma, bronchitis).</li> <li>- <b>Waterborne Diseases:</b> The economic burden of diseases resulting from water contamination or water scarcity.</li> </ul> </li> </ul>	

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
5. Non-Supervisory Engagement			<ul style="list-style-type: none"> <li>- <b>Heat-related Illnesses:</b> Data on the costs of healthcare associated with heatwaves, particularly in vulnerable communities.</li> <li>• <b>Social Vulnerability:</b> Data on how marginalized communities (e.g., low-income populations, indigenous groups) are disproportionately affected by environmental risks, such as displacement from natural disasters or loss of access to natural resources.</li> <li>• <b>Food Security:</b> Data on how ecosystem degradation and climate change threaten food security, affecting agricultural yields and access to affordable, nutritious food, with direct social and economic consequences.</li> </ul> <p><b>7. Investment in Nature and Green Economy</b></p> <p>The transition to a green economy offers new investment opportunities and job creation, as well as potential cost savings through sustainability practices.</p> <p><b>Key Data:</b></p> <ul style="list-style-type: none"> <li>• <b>Green Investment Growth:</b> Data on the rise of green investments, including investments in renewable energy, green bonds, sustainable agriculture, and clean technology.</li> <li>• <b>Job Creation in Green Sectors:</b> Employment data showing how sectors like renewable energy, sustainable agriculture, eco-tourism, and nature-based solutions contribute to economic growth and job creation.</li> <li>• <b>Cost Savings from Sustainable Practices:</b> Data on how businesses can reduce costs through energy efficiency, waste reduction, water conservation, and sustainable sourcing.</li> </ul>	

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
<b>6. Portfolio Management</b>	Helps investors manage risk and optimize returns, considering nature related impacts.	<p>Indicators of nature related risks and opportunities associated with investments.</p> <p><b>Nature-Related Risks</b></p> <p><b>1. Physical Risks:</b></p> <ul style="list-style-type: none"> <li>• <b>Climate Change:</b> Increased frequency and severity of extreme weather events (e.g., hurricanes, floods, droughts) can damage assets and disrupt supply chains.</li> <li>• <b>Biodiversity Loss:</b> Degradation of ecosystems can affect industries reliant on natural resources (e.g., agriculture, fisheries, forestry).</li> <li>• <b>Water Scarcity:</b> Limited water availability can impact operations in water-intensive industries (e.g., mining, manufacturing).</li> </ul> <p><b>2. Regulatory Risks:</b></p> <ul style="list-style-type: none"> <li>• <b>Environmental Regulations:</b> Stricter environmental laws and regulations can increase compliance costs and operational constraints.</li> <li>• <b>Carbon Pricing:</b> Implementation of carbon taxes or cap-and-trade systems can increase costs for carbon-intensive industries.</li> </ul> <p><b>3. Market Risks:</b></p> <ul style="list-style-type: none"> <li>• <b>Changing Consumer Preferences:</b> Growing demand for sustainable products can affect market share for companies not aligned with these preferences.</li> <li>• <b>Reputation Risk:</b> Negative publicity related to environmental practices can damage a company's brand and customer loyalty.</li> </ul> <p><b>4. Transition Risks:</b></p> <ul style="list-style-type: none"> <li>• <b>Technological Changes:</b> Shifts towards greener technologies can render existing assets obsolete or require significant capital investment.</li> <li>• <b>Policy Shifts:</b> Changes in government policies towards sustainability can impact business models and profitability.</li> </ul> <p><b>Nature-Related Opportunities</b></p> <p><b>1. Resource Efficiency:</b></p> <ul style="list-style-type: none"> <li>• <b>Energy Efficiency:</b> Investments in energy-efficient technologies can reduce operational costs and improve margins.</li> <li>• <b>Waste Reduction:</b> Implementing circular economy practices can lower waste disposal costs and create new revenue streams from recycled materials.</li> </ul>	<p>Scenario-based risk assessments integrating nature related factors.</p> <p><b>Integrating Nature-Related Considerations in Portfolio Management</b></p> <p><b>1. ESG Integration:</b></p> <ul style="list-style-type: none"> <li>• Incorporate Environmental, Social, and Governance (ESG) criteria into investment analysis and decision-making processes.</li> <li>• Use ESG ratings and data to assess the environmental performance of potential investments.</li> </ul> <p><b>2. Thematic Investing:</b></p> <ul style="list-style-type: none"> <li>• Focus on themes such as renewable energy, water management, sustainable agriculture, and biodiversity conservation.</li> <li>• Invest in funds or companies that align with these themes.</li> </ul> <p><b>3. Engagement and Stewardship:</b></p> <ul style="list-style-type: none"> <li>• Engage with portfolio companies to encourage better environmental practices and transparency.</li> <li>• Use shareholder voting rights to influence corporate behaviour towards sustainability.</li> </ul> <p><b>4. Risk Assessment Tools:</b></p> <ul style="list-style-type: none"> <li>• Utilize tools and frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD) and the Taskforce on Nature-related Financial Disclosures (TNFD) to assess and report on nature-related risks and opportunities.</li> </ul> <p><b>5. Scenario Analysis:</b></p> <ul style="list-style-type: none"> <li>• Conduct scenario analysis to understand the potential impacts of different environmental scenarios on portfolio performance.</li> <li>• Use these insights to inform strategic asset allocation and risk management.</li> </ul>	<p>Quantitative metrics for evaluating financial performance against nature-related risks.</p> <ol style="list-style-type: none"> <li><b>1. Carbon Footprint:</b> Measures the total greenhouse gas emissions (GHG) associated with the portfolio. It is usually expressed in tons of CO<sub>2</sub> equivalent per million dollars invested.</li> <li><b>2. Water Usage:</b> Quantifies the amount of water used by the companies in the portfolio. This can be measured in cubic meters per million dollars invested.</li> <li><b>3. Biodiversity Impact:</b> Assesses the impact of the portfolio on biodiversity and the effect of biodiversity dependency on portfolio, often through metrics like the Mean Species Abundance (MSA) or the Biodiversity Intactness Index (BII).</li> <li><b>4. Environmental, Social, and Governance (ESG) Scores:</b> Aggregated scores that reflect the environmental, social, and governance performance of the companies in the portfolio. These scores are often provided by third-party rating agencies and can be distinguished into risk management score and impact score.</li> <li><b>5. Climate Value-at-Risk (Climate VaR):</b> Estimates the potential financial loss in the portfolio due to climate-related risks, such as extreme weather events or regulatory changes.</li> <li><b>6. Stranded Asset Risk:</b> Evaluates the risk of assets becoming obsolete or devalued due to environmental regulations or shifts in market preferences towards more sustainable options.</li> <li><b>7. Green Revenue Percentage:</b> The proportion of revenue generated from environmentally sustainable products or services (e.g. green taxonomy-aligned activity revenue) within the portfolio.</li> <li><b>8. Energy Intensity:</b> Measures the amount of energy consumed per unit of economic output, typically expressed in megajoules per dollar of revenue.</li> <li><b>9. Waste Generation:</b> Quantifies the amount of waste produced by the companies in the portfolio, often measured in tons per million dollars invested.</li> </ol>

Use cases of Nature-related data	Description	Targeted Metrics	Scenario Construction	Type of Analysis/Purpose
6. Portfolio Management		<p><b>2. Sustainable Products and Services:</b></p> <ul style="list-style-type: none"> <li>• <b>Green Products:</b> Developing and marketing eco-friendly products can capture growing consumer demand and open new markets.</li> <li>• <b>Renewable Energy:</b> Investing in renewable energy projects can provide stable returns and reduce exposure to fossil fuel volatility.</li> </ul> <p><b>3. Innovation:</b></p> <ul style="list-style-type: none"> <li>• <b>Sustainable Technologies:</b> Investing in companies developing innovative solutions for sustainability challenges (e.g., clean tech, biotech) can offer high growth potential.</li> <li>• <b>Nature-Based Solutions:</b> Supporting projects that restore or protect natural ecosystems can provide long-term benefits and enhance resilience.</li> </ul> <p><b>4. Regulatory Incentives:</b></p> <ul style="list-style-type: none"> <li>• <b>Subsidies and Grants:</b> Governments may offer financial incentives for investments in sustainable practices and technologies.</li> <li>• <b>Tax Benefits:</b> Tax credits and deductions for environmentally friendly investments can improve financial performance.</li> </ul> <p><b>5. Enhanced Resilience:</b></p> <ul style="list-style-type: none"> <li>• <b>Risk Mitigation:</b> Companies that proactively manage nature-related risks can be more resilient to environmental shocks and stresses.</li> <li>• <b>Long-Term Value Creation:</b> Sustainable practices can lead to long-term value creation and stability, attracting long-term investors.</li> </ul>		<p><b>10. Natural Capital Depletion:</b> Assesses the extent to which the portfolio's activities deplete natural resources, such as forests, minerals, or fisheries.</p> <p><b>11. Transition Risk Exposure:</b> Evaluates the portfolio's exposure to risks associated with the transition to a low-carbon economy, including regulatory changes, market shifts, and technological advancements.</p> <p><b>12. Physical Risk Exposure:</b> Measures the portfolio's exposure to physical risks from climate change, such as rising sea levels, increased frequency of extreme weather events, and temperature changes.</p> <p><b>13. Sustainable Investment Ratio:</b> The proportion of the portfolio invested in companies or projects that meet specific sustainability criteria, such as those aligned with the United Nations Sustainable Development Goals (SDGs).</p> <p><b>14. Environmental Impact Reduction Targets:</b> The extent to which companies in the portfolio have set and are meeting targets for reducing their environmental impact, such as emissions reduction targets.</p> <p><b>15. Green Bond Allocation:</b> The proportion of the portfolio allocated to green bonds, which are specifically earmarked to fund projects that have positive environmental benefits.</p>



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