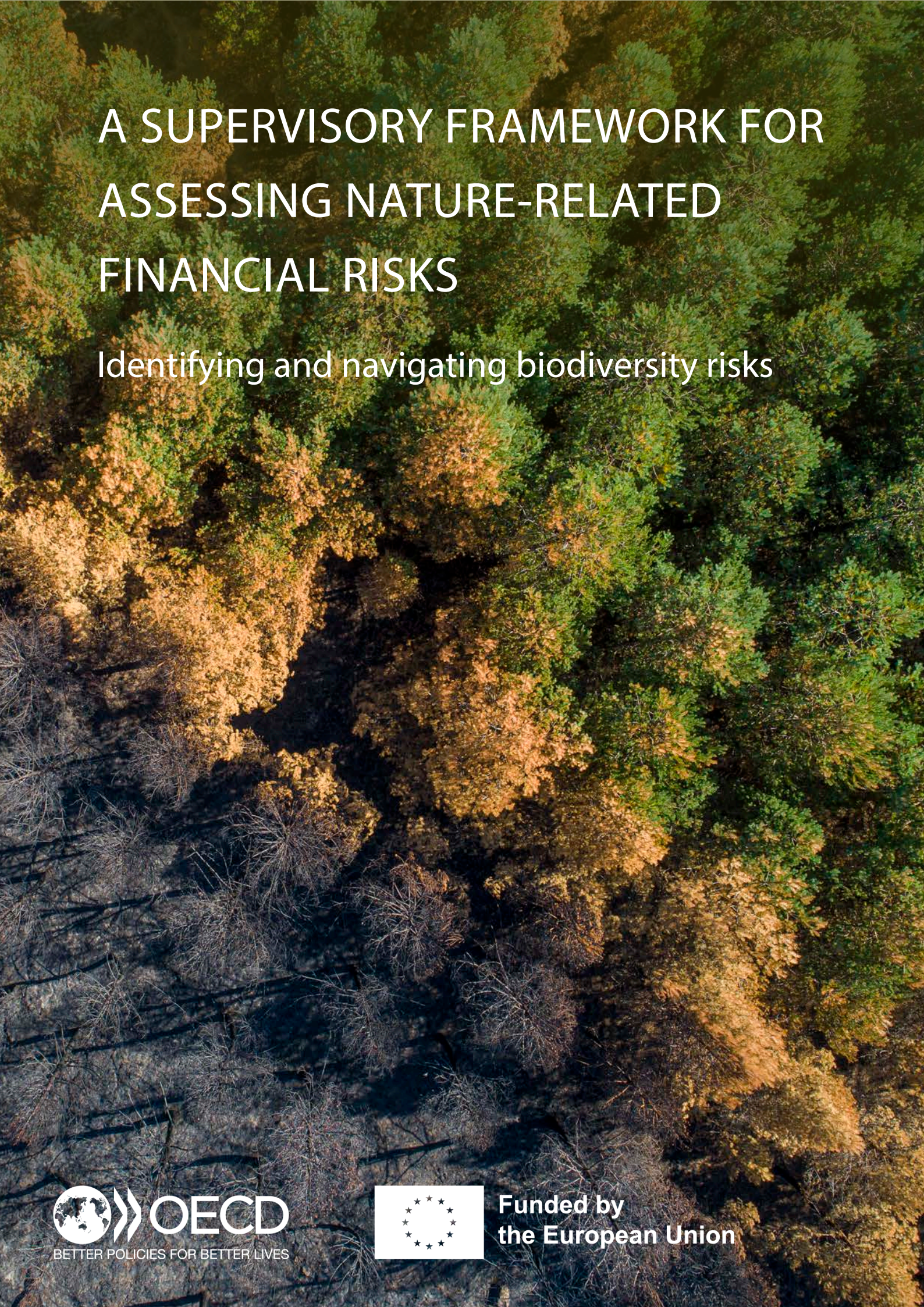

A SUPERVISORY FRAMEWORK FOR ASSESSING NATURE-RELATED FINANCIAL RISKS

Identifying and navigating biodiversity risks

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OECD (2023), *A supervisory framework for assessing nature-related financial risks: Identifying and navigating biodiversity risks, OECD Business and Finance Policy Papers.*

This paper presents a methodological supervisory framework to help central banks and financial supervisors assess biodiversity-related financial risks, impacts and dependencies in the financial sector, including transmission channels for physical and transition risks. This framework is designed to translate biodiversity risks into financial risks. It draws on a previous mapping of existing approaches, while also accounting for broader nature-related financial risks. While acknowledging different national circumstances, this methodological framework is designed to be applicable broadly for central banks, supervisors and commercial banks across different countries.

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Executive summary

Biodiversity – the variety of life on Earth – plays a critical role for human well-being and economic activities through the provision of a range of ecosystem services. Yet humanity is destroying biodiversity at an unprecedented rate and biodiversity loss already imposes costs on our economies. Through transmission channels stemming from physical and transition risks, these losses may also have an effect on financial assets and the financial institutions holding them, with possible implications for financial and price stability. In response to this, several central banks have already started analysing the exposure of their financial systems to biodiversity loss through impacts and dependency assessments.

This report builds on an OECD mapping of existing and emerging approaches to measure these nature-related financial risks carried out in 2022 as part of a Project on "Developing a Supervisory Framework for Financial Risks Stemming from Biodiversity-related Losses", launched in September 2022 by the European Commission, together with the OECD as the implementing partner, with funding from the European Union. While recognising that national circumstances and mandates differ, the **framework consists of a four-step approach** to help financial authorities, as well as commercial banks, identify and prioritise, conceptualise, and assess nature-related financial risks**: (i) Risk identification and prioritisation; (ii) Economic risk assessment; (iii) Financial risk assessment (iv) Considerations for supervisors**.

Although the report focuses primarily on biodiversity, the term "nature" is used throughout the report to refer not just to biodiversity but also to all aspects of the natural world (both biotic and abiotic) to capture any risk which may be considered financially material. The framework offers guidance for financial authorities to assess nature-related financial risks (sources of potential losses for market participants associated with the deterioration of nature), **overviewing the interlinkages between nature and the economic and financial systems.** The framework starts with the **risk identification and prioritisation** assessment, to help users identify the potential for nature-related risk to become a financial risk. Within the prioritisation process, financial exposures are split between direct and indirect risks from nature loss to better understand the sectoral differences in ecosystem service dependency and impact, incorporating geolocation factors to understand the domestic and foreign exposure to nature-related risks.

The conceptualisation of both the direct and indirect economic risks, with respect to exposure of the financial system is part of the **second step of the framework** on **economic risk assessment**. This is to help convey the differences in economic impact between economic activities which directly interact with ecosystems and those who depend on or impact ecosystem services through their value chain. To provide an understanding of the impacts of direct and indirect economic risks' consequences on the financial system, different financial risk transmission channels are explored as part of the **third step of the framework** on **financial risk assessment**. Finally, a number of considerations for financial supervisors to **incorporate these risks into financial risk management are provided in a fourth step**. These suggestions outline possible avenues for financial authorities to consider these risks in their operations but are not recommending any single approach to be undertaken by financial regulators and supervisors. This reflects the emerging context in understanding of nature-related financial risks, and the considerations outlined offer flexibility to regulatory authorities to pursue alternative interpretations and avenues to incorporate these risks into supervisory practices.

1 Introduction

1.1. Background and context

Biodiversity – the variety of life on Earth – plays a fundamental role for human well-being and economic activities through the provision of a range of ecosystem services, including food provisioning and clean water, flood protection, nutrient cycling and pollination. Yet, biodiversity is currently declining at an unprecedented rate, with almost a 50 per cent decline in natural ecosystems relative to their originally estimated state. Global wildlife populations continue to decline, and many ecosystems are being degraded, raising concerns about the threat this poses to human well-being (IPBES, 2019[1]). The global decline in biodiversity is also compromising ecosystem services. For instance, the IPBES Global Assessment (IPBES, 2019[1]) finds that 14 out of 18 assessed categories of ecosystem services have declined since 1970. Biodiversity loss and climate change are closely interlinked and perceived by business leaders and policymakers among the top global risks to society (WEF, 2023[2]).

Biodiversity loss presents risks to economic activities through declining services that ecosystems provide. Biodiversity loss already imposes economic costs through physical and transition risk channels. Subsequently, financial assets associated with these economic activities, and the financial institutions holding these assets, may in turn be subject to financial risks, with potential systemic risks and possible implications for financial stability (NGFS - INSPIRE, 2022[3]). Furthermore, there are relationships between biodiversity and price stability but are yet to be explored quantitatively. For example, the loss of ecosystem services such as pollination can lead to a decline of crop yields, with subsequent increased commodity prices and costs along the agri-food value chain, if these costs can be passed through the value chain. Hence, the risks presented by biodiversity loss and the mitigating action required to prevent the materialisation of physical risks are relevant to the mandate of central banks.

There has been a recent increase in the recognition of transition risks related to nature degradation. The CBD Kunming-Montreal Global Biodiversity Framework (GBF)[1] at the 15th Conference of the Parties (COP15) of the Convention on Biological Diversity (CBD) (CBD, 2022[4]) in December 2022 and the UN High Seas Treaty[2] (UN, 2023[5]) signalled policymakers' strong commitment to halt and reverse biodiversity loss and reduce the impact of economic activities on biodiversity. The actions necessary to achieve these commitments imply significant economic shifts which might be a challenge to enact, particularly for certain regions and sectors. Better assessing biodiversity-related financial risks is particularly timely in the context

[1] The Global Biodiversity Framework replaces the 2011-2020 Strategic Plan for Biodiversity and the associated Aichi Targets. The mission of this post-2020 framework is "to take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery for the benefit of people and planet by conserving and sustainably using biodiversity, and ensuring the fair and equitable sharing of benefits from the use of genetic resources, while providing the necessary means of implementation."

[2] The "*Draft agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*" emphasises the need for conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction (BBNJ) on the basis of the best available science and scientific information.

of the goals and targets (for 2050 and 2030 respectively) adopted under the Global Biodiversity Framework). In particular, Target 15 calls on governments to take measures "to encourage large and transnational companies and financial institutions to regularly monitor, assess and transparently disclose their risks, dependencies and impacts on biodiversity."

In response to the increasing awareness of biodiversity loss as a material economic and financial risk, financial actors and international initiatives are undertaking work to understand, conceptualise, and assess these risks. The central banks of France, the Netherlands, Malaysia, and Brazil have already published the assessments of exposure of their financial systems to biodiversity loss through impacts and dependency assessments (Svartzman et al., 2021[6]; DNB, 2020[7]; Calice, Kalan and Miguel, 2021[8]; World Bank & BNM, 2022[9]). In addition, international initiatives are building momentum for improved assessment, reporting and management of biodiversity-related financial risks, impacts, dependencies and opportunities:

- The Network of Central Banks and Supervisors for Greening the Financial System (NGFS) has acknowledged that nature-related risks could have significant macroeconomic and financial implications, and subsequently has established a Taskforce on Nature-related Risks (NGFS, 2022[10]; NGFS - INSPIRE, 2022[3]). The NGFS, through its Nature Taskforce, has developed a conceptual framework to create a common language and understanding of nature-related financial risks (NGFS, 2023[11]). While aligned with the NGFS conceptual framework, adjustments might be needed to reflect future work and relevant developments on this topic.
- The Taskforce on Nature-related Financial Disclosures (TNFD) is a global, market-led, science-based and government-supported initiative to help companies and financial institutions factor nature into decision making. The Taskforce has developed a risk management and disclosure framework for organisations to report and act on evolving nature-related issues. The TNFD has followed an 'open innovation' approach, which involved the release of four prototype 'beta' frameworks for feedback and pilot testing over the past two years and released its final set of disclosure recommendations and suite of additional guidance in September 2023.
- In addition, the European Commission has contracted a study for a methodological framework and assessment of potential financial risks associated with biodiversity loss and ecosystem degradation. This work aims to develop a methodological framework tailored for financial institutions. The study focusses on biodiversity loss and ecosystem degradation, to understand and map the transmission channels as well as to identify the potential risks for financial market participants. Specifically, the project focuses on mapping adverse impacts of biodiversity loss and nature degradation on the economy and the financial domains, identifying the most affected economic sectors. The project will develop a methodological framework that enables the assessment of potential financial risks on industry sectors and the broader financial landscape. The outcomes will offer a guidance on integrating the framework into financial institutions practices, complementing climate-related financial risk approaches. The results are expected to be published in the first quarter of 2024.

Against this background, the OECD's proposed supervisory methodological framework offers technical guidance to central banks and financial supervisors (hereafter referred to as 'financial authorities') on how to prioritise, conceptualise, and assess biodiversity-related financial risks with respect to their financial system. Where possible, the OECD will align with the NGFS with regards to the conceptualisation of risks. Likewise, the framework developed as part of the technical support project implemented by the OECD in cooperation with the European Commission and the MNB, and the European Commission's study are complementary. While the project funded by the European Union and implemented by the OECD focuses on central banks and supervisors, the European Commission's study places its emphasis on financial institutions.

Currently, both micro- and macro-level measurement approaches for risks, impacts and dependencies of the economy and the financial sector to nature exist (OECD, 2023[12]). However, these risks are yet to be integrated into a methodological framework for financial authorities to assess nature-related financial risks.

1.2. Overview of the Project and the proposed methodological supervisory framework

Recognising this need, the European Commission is supporting the Hungarian central bank Magyar Nemzeti Bank (MNB), at MNB's initiative, and launched in September 2022, together with the OECD, project on "Developing a Supervisory Framework for Financial Risks Stemming from Biodiversity-related Losses". This project is financed by the European Union through the Technical Support Instrument (TSI) and implemented by the OECD, in cooperation with the European Commission's Directorate-General for Structural Reform Support (DG REFORM).

As part of the Project, the OECD is developing a methodological supervisory framework to help the Hungarian central bank (MNB) assess nature-related financial risks in the financial system. The Project aims to help MNB and banks with retail activities in Hungary become more informed about their exposures, impacts and dependencies to biodiversity-related financial risks, to improve biodiversity-related risk management. The Project is being undertaken in two phases:

- Phase I aims to develop a methodological framework designed to translate biodiversity risks to financial risks, drawing on a mapping of existing tools, practices, definitions, transmission channels, metrics and indicators in a published report. (OECD, 2023[12])
- Phase II aims at collection of available data, providing options for bridging data gaps, development of a software-based tool to implement the methodological framework to analyse the biodiversity-related financial risks, impacts and dependencies of the Hungarian financial system, and report on applicability.

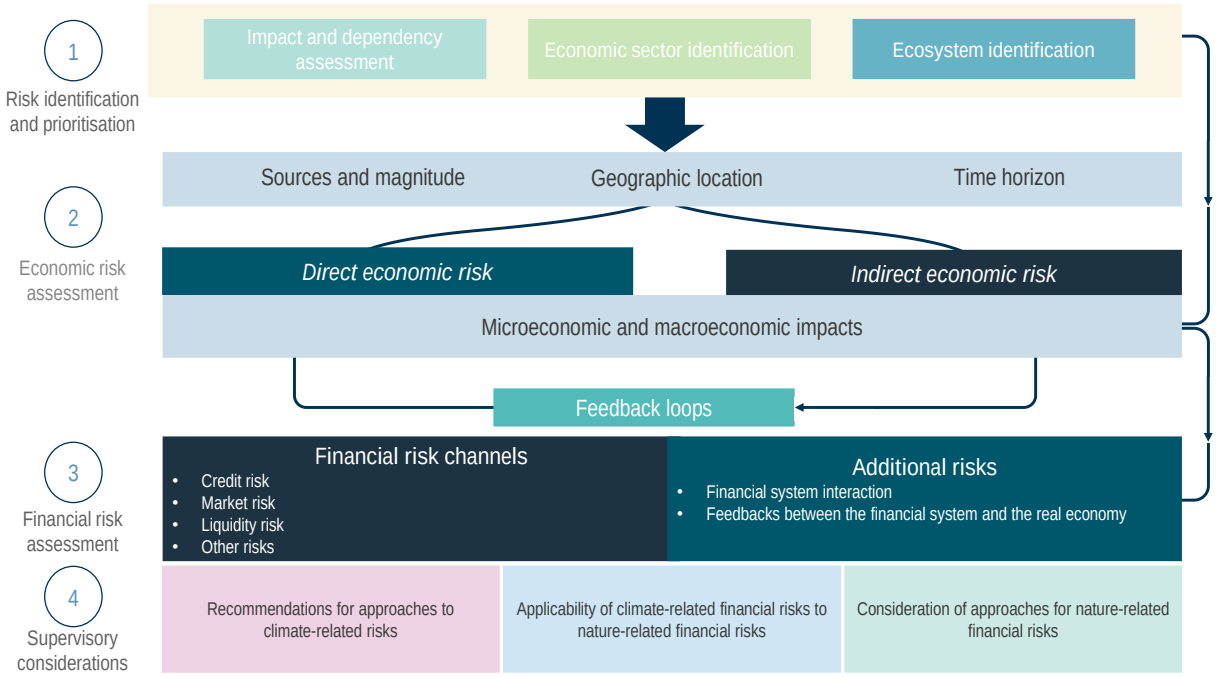
Building on a mapping of existing and emerging approaches to measure biodiversity-related financial risks (OECD, 2023[12]), this report presents a methodological supervisory framework for assessing nature-related financial risks (under Phase I of the Project). While recognising that national circumstances matter, including different mandates of financial authorities, the framework aims to offer technical guidance that can be applicable to nature-related risks, but primarily focuses on risks stemming from biodiversity-related losses. Given the mandate of financial authorities, the framework opts for a financial materiality approach. However, the framework is flexible to also include environmental materiality to be applicable in jurisdictions where this is suitable.

Following a **four-step approach, the framework aims to enable financial authorities to identify, conceptualise, and assess nature-related financial risks** by providing the tools to undertake technical assessments of the economic and financial implications stemming from biodiversity loss: **(i) Risk identification and prioritisation; (ii) Economic risk assessment; (iii) Financial risk assessment (iv) Considerations for supervisors**.

The main body of this framework therefore provides a conceptualisation of the highlighted steps, providing an overview of how assessments could be implemented, including key concepts and characteristics and offers considerations for financial authorities to incorporate these risks into financial risk management. Additionally, annexes highlight possible tools to assess the economic and financial materiality stemming from nature loss, guidance on bridging data gaps for technical assessments, case studies to understand

the implications of the materialisation of these risks and a practical approach for commercial banks' use of the framework[3]

Figure 1.1. Overview of steps for methodological framework



Source: OECD authors' illustration.

[3] See technical annex, https://www.oecd.org/finance/A-supervisory-framework-for-assessing-nature-related-financial-risks-annexes.pdf.

Box 1.1. The use of terms in this report: nature, biodiversity, and ecosystems

Nature

The term nature is used in different ways, depending on the context within which it is applied. Both the Taskforce for Nature-related Financial Disclosures (TNFD) and the Network for Greening the Financial System (NGFS) closely follow the definition provided by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): "The nonhuman world, including coproduced features, with particular emphasis on living organisms, their diversity, their interactions among themselves and with their abiotic environment." The Dasgupta Review uses the term 'nature' in a similar manner, but additionally uses it synonymously with other terms, including for example, natural capital, the natural environment, and the biosphere. In this report, the term 'nature' refers to all physical aspects of the natural world (both biotic and abiotic)[4], including species, the landscape and other features and products of the earth, including geology, atmosphere, soil, and water. References to 'broader nature' refer only to the abiotic components of nature. Biodiversity is an integral component of nature. Some may opt for the term 'environment' instead of nature as an encompassing term to cover this array of risks. For example, the OECD Guidelines for Multinational Enterprises define environmental risks as "significant changes in the environment or biota which have harmful effects on the composition, resilience, productivity or carrying capacity of natural and managed ecosystems, or on the operation of socio-economic systems or on people". However, this report uses the term 'nature' to align with the terminology of the NGFS.

Biodiversity

According to the Convention on Biological Diversity (CBD), biological diversity (biodiversity) "means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

Ecosystems

According to the CBD, an ecosystem means "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit".

How the terms are used in the report

Chapter 1 of the report primarily focuses on an overview of biodiversity and the interlinkages with the economy. This is to reflect biodiversity's complexity and crucial role into providing ecosystem services, which warrants this specific focus to understand it. However, to properly understand the full range of risks for the financial system, it is necessary to broaden the focus to include abiotic risk sources within the scope of assessments. Therefore, chapters 2 to 5 use the term 'nature-related' risk as an encompassing term to refer to risks stemming from both biotic and abiotic sources. The term 'biodiversity' is only used in chapters 2 to 5 when it is specifically referring to the biotic component of nature or is citing a reference which uses this terminology.

Source: The Convention on Biological Diversity (1992[13]); Taskforce on Nature-related Financial Disclosure (TNFD); NGFS (2020[14]), *Guide for Supervisors on integrating climate-related and environmental risks into prudential supervision*, https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_for_supervisors.pdf; IPBES (2019[1]), *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, https://10.5281/zenodo.3831673*; OECD (2023[15]), *Guidelines for Multinational Enterprises on Responsible Business Conduct,* https://doi.org/10.1787/81f92357-en.

2 Biodiversity, and the interlinkages with economic and financial risk

This chapter reviews how biodiversity loss impacts the economy, financial authorities and the wider financial system, and the key aspects that need to be understood to assess the subsequent economic and financial risks. The chapter also explores the interlinkages between biodiversity, climate- and broader nature-related risks, which is important as the combination and interaction of these risks may magnify the economic and financial risks beyond the "sum-of-the-parts".

Additionally, the chapter highlights the primary transmission channels through which different nature-related risks transmit through the economy via physical and transition risk channels, and finally into the financial system. Transmission channels are closely related, as either physical or transition risks could eventually directly or indirectly affect economic actors' capacity to operate. These risks can be accentuated by the limited substitutability, uncertain time horizons, and geographical aspects of biodiversity.

2.1. The interlinkages between biodiversity and the economy: the role of ecosystem services

Ecosystems are connected to the economy through ecosystem services, provided by biodiversity and the interactions with their non-living environment. Ecosystem services refer to the benefits obtained from ecosystems, which can be categorised as ***provisioning, regulating, cultural, and supporting services*** (Millenium Ecosystem Assessment, 2005[16]) (see Table 2.1). These can be viewed as the 'flow' of goods and services which stem from ecosystems and underpin economic activity in the global economy, either direct or indirectly (IPBES, 2019[1]; Millenium Ecosystem Assessment, 2005[16])While economic activities depend on these services, they can also impact the underlying ecosystems that underpin these services (IPBES, 2019[1]). Biodiversity is critical for the productivity and resilience of ecosystems. These impacts and dependencies can be considered as the exposure of the global economy to biodiversity and broader nature.

Table 2.1. List of ecosystem services

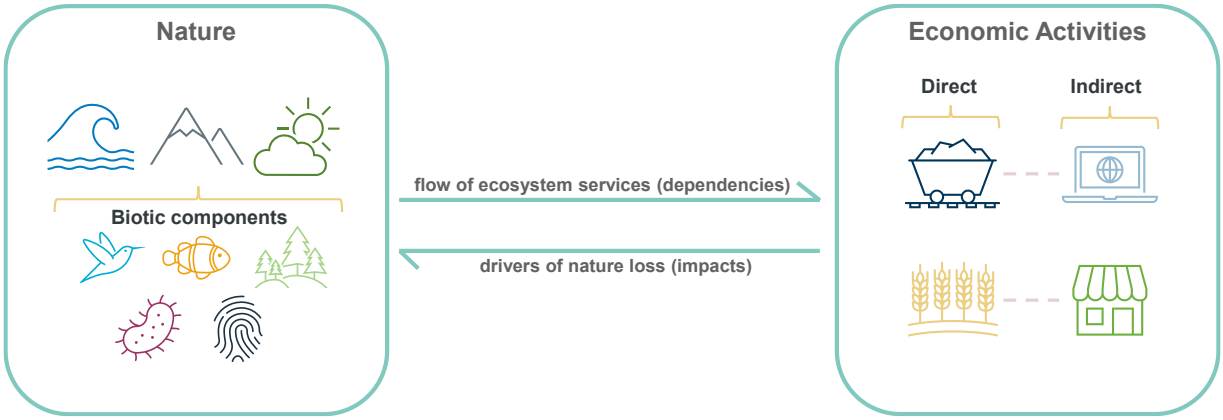
Categories	MEA	CISL	IPBES	ENCORE	TNFD (from UN SEEA EA)
Provisioning services	• Food • Fiber (wood, cotton, etc.) • Fuel • Genetic resources • Biochemicals • Ornamental resources • Fresh water	• Food and other goods provision	• Food and feed • Energy • Materials and assistance • Medicinal, biochemical, and genetic resources	• Fibers and other materials • Animal based energy • Genetic materials • Ground water • Surface water	• Biomass provisioning • Genetic material • Water supply • Other provisioning services

Categories	MEA	CISL	IPBES	ENCORE	TNFD (from UN SEEA EA)
Regulating Services	• Air quality regulation • Climate regulation • Water regulation • Erosion regulation • Water purification and waste treatment • Disease regulation • Pest regulation • Pollination • Natural hazard regulation	• Air quality and local climate • Water security • Hazard regulation • Habitat intactness	• Regulation of air quality • Regulation of climate • Pollination and dispersal of seeds • Regulation of ocean acidification • Regulation of hazards and extreme events • Regulation of organisms detrimental to humans • Regulation of freshwater quantity, location and timing • Regulation of freshwater and coastal water quality	• Ventilation • Climate regulation • Filtration (air) • Filtration (water) • Pollination • Disease control • Pest control • Water flow maintenance • Bio-mediation • Dilution by atmosphere and ecosystems • Mass stabilisation and erosion control	• Air filtration • Local/Global climate regulation • Pollination • Flood/storm mitigation • Rainfall pattern regulation • Biological control • Noise attenuation • Soil quality • Water flow regulation • Water purification • Other regulating and maintenance services • Soil and sediment retention Solid waste remediation
Cultural Services	• Cultural diversity • Spiritual/religious values • Knowledge systems • Educational values • Inspiration • Aesthetic values • Social relations • Cultural heritage value • Recreation/ecotourism	• Habitat intactness	• Habitat creation and maintenance • Learning and inspiration • Physical and psychological experiences • Supporting identities • Maintenance of options	• Maintain nursery habitats • Dilution by atmosphere and ecosystems	• Nursery population and habitat maintenance • Recreation-related services • Visual amenity services • Education, scientific and research services • Spiritual, artistic and symbolic services • Other cultural services
Supporting Services	• - Soil formation • - Photosynthesis • - Primary production • - Nutrient cycling • - Water cycling	• Habitat intactness	• Formation, protection, and decontamination of soils • Habitat creation and maintenance	• Soil quality • Buffering and attenuation of mass flows Mediation of sensory impacts • Water quality Flood and storm protection	

Source: Adapted from NGFS (2023[11]), *Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors,* https://www.ngfs.net/sites/default/files/medias/documents/ngfs_conceptual-framework-on-nature-related-risks.pd ; originally from Millenium Ecosystem Assessment (2005[16]), *Ecosystems and Human Well-being: Synthesis,* http://www.millenniumassessment.org/documents/document.356.aspx.pdfhttp://www.millenniumassessment.org/documents/document.356.aspx.pdf; CISL (2021[17]), *Handbook for Nature-related Financial Risks: key concepts and a framework for identification,* https://www.cisl.cam.ac.uk/system/files/documents/handbook-for-nature-related-financial.pdf; IPBES (2019[1]), *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services,* https://10.5281/zenodo.3831673; UNEP-WCMC (2023[18]), *Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE),* https://encore.naturalcapital.finance/en; TNFD (2022[19]), *The TNFD Nature-Related Risk and Opportunity Management and Disclosure Framework Beta v0.2,* https://framework.tnfd.global/wp-content/uploads/2022/06/TNFD-Framework-Document-Beta-v0-2.pdf

Economic activities are underpinned by the flow of ecosystem services provided by biodiversity, either directly or indirectly, through their interaction with the abiotic components of nature. For example, the value of pollination services for crops is estimated to be more than USD 200 billion annually and 84 per cent of crop species cultivated in Europe depend on animal pollination (Gallai et al., 2009[20]; Klein et al., 2007[21]). These services support the agricultural economic sector and the agri-food downstream supply chain. Most ecosystem services are not fully substitutable, and some contributions of biodiversity are irreplaceable (IPBES, 2019[1]).

Figure 2.1. The connection between nature and the economy



Source: OECD authors' illustration.

2.2. Drivers of biodiversity loss and associated indicators

2.2.1. Direct drivers of biodiversity loss

Globally, the five primary direct drivers of biodiversity loss are (in order of greatest impact); land and sea use change; resource extraction; climate change; pollution; and the invasion of alien species. Climate change is projected to become increasingly important as a direct driver (IPBES, 2019[1]). The relative importance of these different primary drivers varies both regionally and by ecosystem. For example, direct exploitation (resource extraction) is the greatest driver of biodiversity loss in Africa, whereas land/sea-use change is the primary driver for Europe and Central Asia. Similarly, direct exploitation is a greater relative driver within marine realms, compared to terrestrial and freshwater biogeographic realms, which face greater impacts from land/sea use change (Ibid).

Within each of these direct drivers, there are several types of impacts which need to be considered to understand the aggregated impact on biodiversity (and nature more broadly). For example, pollution includes pollutants into the atmosphere, carried by water (including nitrogen and phosphorous), and the

disposal of solid waste (IPBES, 2019[1]). These impacts contribute towards biodiversity loss through different avenues and determine the type of risk and industries most affected by their materialisation.

Several economic sectors are identified to be highly impactful for and dependent on biodiversity, and directly link the economy to the aggregated impacts of biodiversity loss. These sectors include – fisheries; agriculture; forestry (logging for wood and biofuels); harvesting (wild plants and animals from sea and landscapes); mining; infrastructure (dams, cities, roads); tourism; transportation (of goods and people); and illegal activities (IPBES, 2019[1]). These sectors are of primary importance to understand, assess, and monitor biodiversity- and broader nature-related financial risks.

2.2.2. Indicator Classes

Recognising the complexity of biodiversity, the framework of Essential Biodiversity Variables (EBVs) defines the minimum necessary measurements to capture changes in the primary components of biodiversity (Dasgupta, 2021[22]; Pereira, 2013[23]). IPBES, which is one of the key authorities on biodiversity loss, uses EBVs are used by IPBES to assess the trends in relative impact of the direct drivers of biodiversity loss for each component of biodiversity (IPBES, 2019[1]). Under the framework, indicators are captured under six broad classes to measure the different components:

- **Ecosystem structure** – the structural complexity and fragmentation of ecosystems, measured using habitat or biome extent.
- **Ecosystem function** – the interactions between the biotic and abiotic aspects within ecosystems which enable the flow of energy through systems.
- **Community composition** – the diversity of organisms which constitute the ecosystem. These depend on a variety of variables, including temperature, soil type, water availability, and evolutionary time.
- **Species populations** – the abundance and distribution of species
- **Species traits** – the structural, physiological, and chemical characteristics of organisms.
- **Genetic composition** – the genetic diversity which determines the variation within and across species, as well as provides resilience to environmental change.

2.3. Ecosystem services interaction, regime shifts and tipping points

2.3.1. Ecosystem service interaction and trade-offs

Since ecosystem services do not operate in isolation but interact in complex and sometimes unpredictable manners (Agard et al., 2005[24]), assessments on individual ecosystem services in isolation are likely to lead to an underestimation of economic impact. This is because the loss or decline of any single ecosystem service, stemming from the degradation or reduction in the stock of biodiversity, is likely to reduce the productivity of other ecosystem services. For example, differences in land-use change for floodplains and agroecosystems[5] alter the provision of multiple ecosystem services, including climate regulation, soil stability, nutrient regulation, and habitat quality (Felipe-Lucia, Comín and Bennett, 2014[25]). Furthermore, there are trade-offs between the provision of certain ecosystem services, which is determined by the land-use of an area. The extraction of raw materials cannot be supplied at the same time as food production, for instance (Felipe-Lucia, Comín and Bennett, 2014[25]). Hence, when considering land-use change and

[5] Agroecosystems are cultivated ecosystems that are modified to produce ecosystem services which are valued in the form of agricultural goods and services.

other drivers of biodiversity loss, there are trade-offs and interactions between different ecosystem services.

2.3.2. Regime shifts and tipping points

The term 'regime shifts' refers to substantial, abrupt, unexpected, and persistent changes in ecosystem function and structure, which affect the flow of ecosystem services (Biggs et al., 2012[26]; Biggs, Peterson and Rocha, 2015[27]). Regime shifts can occur in terrestrial, freshwater and marine ecosystems. Coral reefs for example, can be subject to regime shifts, where the system shifts from coral dominance to macroalgal dominance. Proximal triggers, such as mass bleaching or severe hurricanes, kill off living coral and open space for algal colonisation (Biggs et al., 2012[26]). These shifts can be difficult to reverse due to strong feedback, such as the growth of algal dominants in the ecosystem, their interaction with remaining coral increases, hampering coral growth rates and recovery of coral tissue (Ibid). The drivers of regime shifts are diverse and strongly co-occur, which indicates that continued global change may increase the risk of multiple regime shifts. Additionally, the occurrence of a single regime shift can exacerbate the drivers of other regime shifts, which increases the risk of cascading regime shifts (Rocha, Peterson and Biggs, 2015[28]). On a global scale, these regime shifts may lead to greater tipping points in nature, leading to a substantially and permanently altered ecosystem. For example, some research indicates the Amazon rainforest to be close to a critical threshold whereby it is losing its resilience and may not recover from dieback (Boulton, Lenton and Boers, 2022[29]).

2.4. Nexus between biodiversity, broader nature, climate change and the environment

Biodiversity loss and climate change interact and exacerbate each other, leading to greater overall impacts on the economy than the 'sum-of-the-parts' approach (IPCC-IPBES, 2021[30]). Hence, specific impacts of biodiversity loss on economic risks may not be considered in isolation, due to the close interlinkages with broader nature- or climate-related risks and their potentially compounding effects. For example, climate change is the third primary direct driver of biodiversity degradation, with 47 per cent of threatened terrestrial mammals (excluding bats) and 23 per cent of threatened bird species potentially already negatively affected by climate change (IPBES, 2019[31]).

Within the interaction between climate change, biodiversity and nature more broadly, there are four key interactions to be considered: (i) climate change as a driver of biodiversity loss and broader nature degradation; (ii) unintended consequences of climate change mitigation or adaptation as a potential driver of biodiversity loss and broader nature degradation; (iii) biodiversity loss and broader nature degradation as a driver of climate change; and (iv) biodiversity and broader nature restoration as a solution for climate change mitigation and adaption[6] (NGFS, 2023[11]). Hence, biodiversity loss, climate change, and broader nature degradation are inherently interlinked. The effects of climate change and biodiversity loss may reinforce one another, leading to compounding aggregated impacts on the global economy (Pörtner, 2021[32]).

Policies aiming to conserve, sustainably use and restore biodiversity and the ecosystem services that stem from it may help mitigate the physical risks of climate change. For example, insurance-related research showed that coastal wetlands reduced storm surge-related property damages in the northeast US by 20 percent on average during Superstorm Sandy (Colgan, M.W Beck and S. Narayan, 2017[33]). In this

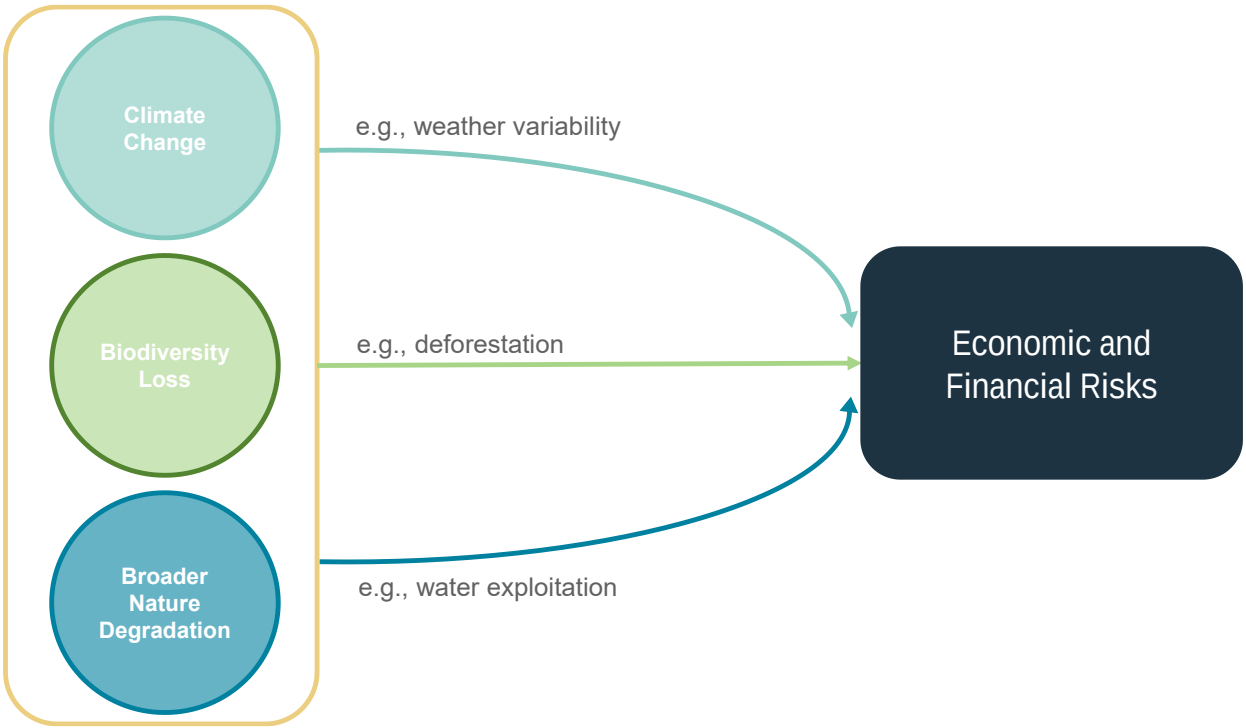
[6] The NGFS describes the nature-climate change nexus, rather than here where biodiversity loss and broader nature degradation are separated out.

respect, assessments that incorporate interactions with other environmental can better capture the full economic impact.

An integrated perspective can better inform the sectoral and regional location of economic risk materialisation from biodiversity and broader nature-related risks. This does not entail quantitatively disaggregating their respective impacts on the economy, but rather ensuring current frameworks to capture environmental risks include each of these risk types and their interaction factors. Hence, financial authorities may consider these risks together in tandem to accurately assess the potential financial risks (see

Figure 2.2)

Figure 2.2. Integrated approach to biodiversity-, broader nature-, and climate-related risks



Note: Biodiversity loss, climate change, and broader nature degradation are presented to be distinct, but this is just to illustrate the additionality of each component in this conceptualisation. In reality, it may not be possible to quantitatively distinguish between the economic impacts stemming from each type of risk due to their strong interlinkages
Source: OECD authors' illustration.

2.5. Transmission channels from biodiversity and nature to economic and financial risks

Biodiversity- and broader nature-related losses are expected to lead to significant economic risk, which in turn could result in financial risks that erode the resilience of individual financial institutions and, potentially, financial systems and markets. Initial estimates by the World Bank indicate global decline in ecosystem services could lead to a loss of USD 2.7 trillion in global GDP in 2030, with the relative impacts on low-income countries being the most pronounced, where falls in GDP may exceed 10 per cent (Johnson et al., 2021[34]). In response to increased awareness, several central banks have undertaken impact and dependency studies to assess their financial systems' exposure to biodiversity- and broader nature-related financial risks (hereafter referred to as 'nature-related financial risks'). The results from various jurisdictions

reveal between 36 percent and 54 percent of financial assets and loans portfolios are highly or very highly dependent on one or more ecosystem services (Svartzman et al., 2021[6]; DNB, 2020[7]; World Bank & BNM, 2022[9]; Calice, Kalan and Miguel, 2021[8]).

Nature-related financial risks can enter the economy through two main channels: **physical and transition risks** (please see Section Sources and magnitude of impact for more examples):

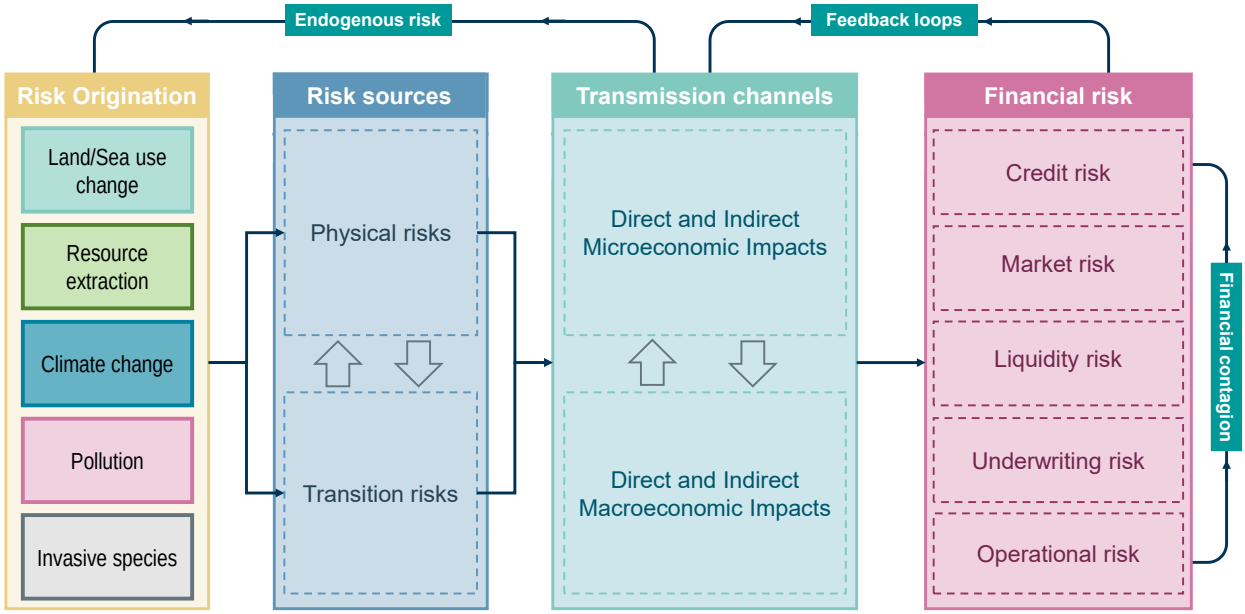
- **Physical risks** stem from the degradation or disruption of ecosystems on which economic sectors depend. These can be either chronic (e.g., gradual reduction in pollinators leading to reduced crop yields) or acute (e.g., pests wiping out a harvest due to the disappearance of natural predators), or both (e.g., disruption of microclimates from deforestation (NGFS - INSPIRE, 2022[3]).
- **Transition risks** may stem from misalignment between companies' business model and strategy, and actions related to the restoration, conservation, or sustainability of nature. Specifically, actions driven by changes in climate and environmental policy, technology advancements, and changes in consumer and investor sentiment. These may lead to economic and financial risk to both corporate and financial institutions. Transition risks may additionally occur from policies implemented in response to the materialisation of physical risks, which may not directly or indirectly serve to preserve nature.
- Furthermore, **liability risks,** which may be considered as a subset of physical and transition risks, refer to legal action arising from nature loss, the transition to a sustainable economy, or the misrepresentation of biodiversity risks or impacts (Barker, Mulholland and Onifade, 2020[35]). Liability risks arise as a consequence of one of the other two primary risk channels. Due to the locality and greater attributability of nature-related risks than climate-related risks[7], this subset channel may have greater relevance in this context.

These risk types may interact and reinforce one another, compounding the aggregate economic impact (NGFS, 2023[11]). For example, water curtailment or restriction measures which are introduced in response to a water stress event may create compounding impacts for water dependent economic sectors. These regulatory measures may further restrict companies' production which may have already been impacted from water scarcity in their water-dependent operations, leading to an overall greater impact on companies' operations (Figure 2.3 offers an overview of the transmission channels).

These risks may propagate through the economy, initially through the sectors that directly depend on and/or impact nature, and their associated value chains, which may lead to aggregate fluctuations and more systemic risks. This may lead to the materialisation of microeconomic (e.g., business disruption and lower profitability) and macroeconomic impacts (e.g., inflationary pressures and changes in trade flows). These microeconomic impacts are more related to the initial idiosyncratic shock, i.e. the indirect impacts, whereas the macroeconomic impacts are closely related to the broader indirect impacts. Subsequently, these economic risks may spill over into the financial sector to create financial risks, including – credit, market, underwriting, liquidity, and operational risks (Svartzman et al., 2021[6]). Furthermore, feedback loops exist between the economy and nature, within the economy, and between the financial sector and the real economy. The interconnectedness of the financial systems means there is a possibility of financial contagion between financial institutions (please also see Figure 2.3 for more details).

[7] Attribution science studies the relationship between climate change and weather events and impacts, i.e. the extent to which a particular event is attributable to anthropogenic climate change. It remains difficult to attribute a specific cause (such as increase in GHG emissions) to individual extreme events.

Figure 2.3. Overview of climate-, biodiversity, and broader nature-related financial risks

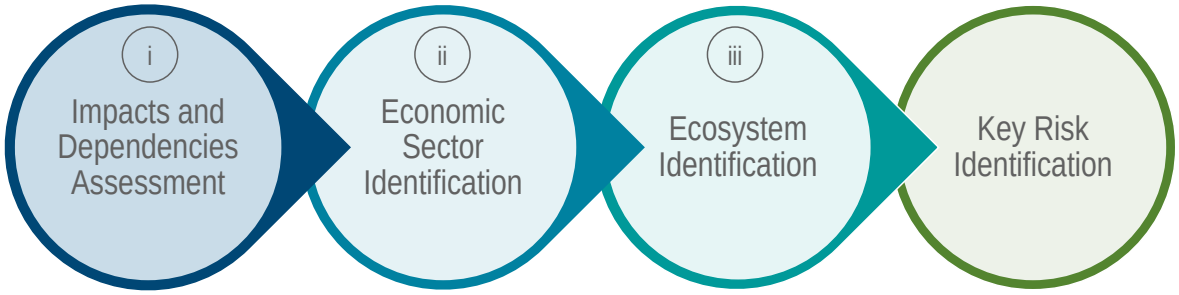


Note: Additionally, liability risk can be considered a subset of both physical and transition risk.
Source: OECD authors' illustration adapted from Svartzman et al, (2021[6]), *A "Silent Spring" for the Financial System? Exploring Biodiversity-Related Financial Risks in France*, https://publications.banque-france.fr/sites/default/files/medias/documents/wp826_0.pdf; NGFS (2023[11]), *Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors*, https://www.ngfs.net/sites/default/files/medias/documents/ngfs_conceptual-framework-on-nature-related-risks.pdf.

3 Risk identification and prioritisation

The risk **identification and prioritisation** approach is the first step of the methodological framework. It assists financial authorities to identify nature-related risks with the greatest relevance for financial materiality. This aims to help financial authorities, in particular supervisors, select the most relevant risks to assess nature-related financial risks. However additional considerations need to be given with respect to the level of engagement with environment ministries, supervised institutions and other relevant stakeholders needed, given the complexity of analysing nature-related risks, which requires expertise beyond the financial domain. The risk identification process consists of a three-phase approach: (i) impacts and dependencies assessment; (ii) economic sector identification; and (iii) ecosystem identification (Figure 3.1).

Figure 3.1. A three-phase approach to identify and prioritise nature-related risks



Source: OECD authors' illustration.

The approach offers financial authorities a list of prioritisation questions (presented in Box 3.1, Box 3.2, Box 3.3, Box 3.4) to understand how to apply the methodological framework in each of the phases. This chapter also proposes methodological approaches, as well as sample metrics that financial authorities may use as guidance to answer the proposed questions. Further information on specific methodological tools and data can be found in the annex. Nonetheless, financial authorities may tailor the risk identification and prioritisation process, as well as the preferred assessment tools and metrics, based on their specific needs and data availability. Likewise, acknowledging the complexity and non-linearity of nature, financial authorities could consider working together with relevant agencies and institutions with more expertise and availability of nature-related data to complete the risk identification and prioritisation process.

The proposed methodological framework builds upon developments including by the NGFS Nature Task Force and the draft risk management and disclosure framework of the Taskforce on Nature-related Financial Disclosures (TNFD). As a result, the proposed approach aligns to existing methodologies and current global practices to ensure synergies and avoid overlaps.

The framework primarily opts to complete the risk identification and prioritisation process by first analysing the relevance of economic activities based on asset-level data (bottom-up approach). This approach enables the inclusion of greater granularity, capturing the complexity and geographic specificity of nature, and may be more appropriate to identify some risks, including concentration risk. However, the framework also offers an alternative to complete the risk identification and prioritisation process by focusing on aggregated sectorial data (top-down approach). To this end, relevant clarification is provided at the end of each component to offer financial authorities flexibility in the type of assessment undertaken.

Financial authorities may undertake an evaluation of all three components:

- **Phase 1: Impacts and dependencies assessment:** The initial phase identifies to which extent the financial system is related to economic activities that impact and/or depend on nature. This phase will also allow to determine the degree of materiality of economic activities (the extent to which economic activities represent a risk to nature and vice versa). The analysis will focus on financial assets with links to economic activities, which will translate into further understanding of where physical and transition risks may interact.
- **Phase 2: Economic sector identification:** The second phase focuses on prioritising the economic sectors that may incur the most adverse economic impacts from nature-related losses. The analysis focuses on two aspects: first, identifying the relevant direct and indirect economic activities based on their materiality of their impact/dependence on ecosystems services and their overall importance for the economy. Second, analysing the implications of the geographic location of where the prioritised economic activities take place, which entails an analysis of domestic/foreign exposure to physical and transition risks.
- **Phase 3: Ecosystem identification:** The last phase identifies the main ecosystems that can represent a source of financial risks stemming from impacts and dependencies. The analysis delves into three distinct aspects: (i) the current and forecasted state of these ecosystems; (ii) their geographical location; and (iii) their functioning and interlinkages to provide ecosystem services.

3.1. Phase 1: Impacts and dependencies assessment

The first phase aims to identify the exposure of the financial sector, both in terms of impacts and dependencies, to ecosystem services (see question 1 in Box 3.1). This is a necessary first step for financial authorities to understand the financial system's exposure to nature-related risks.

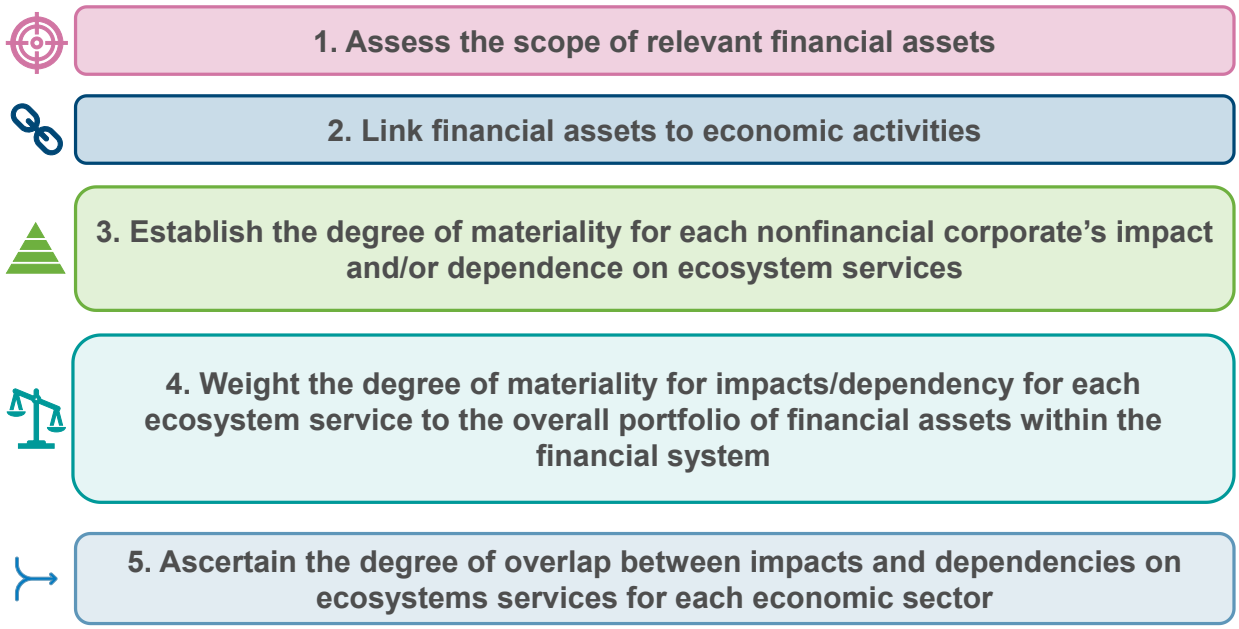
From the assessment, financial authorities can identify relevant sources of risk for the financial system. For instance, if the assessment shows a high dependence on nature, then the identification of physical risks can be prioritised through the 3-phase approach. This result indicates that the financial system is dependent on the availability of ecosystem services, meaning that the deterioration and shocks of nature will likely translate into financial losses. Conversely, if the financial system is exposed to economic activities which substantially impact the state of nature, then it may be exposed to transition risks. The introduction of possible new regulation and actions to address nature loss can also lead to financial losses.

While financial authorities may determine their own approach to perform an impacts and dependencies assessment based on available resources, data, and technical expertise, the following steps can be undertaken to assess impacts and dependencies (see Figure 3.2). For step 3, where nonfinancial corporates span multiple economic activities with differing degrees of materiality for impacts and/or dependencies, financial authorities may either take the average or the highest degree of materiality. This can be informed by the level of substitutability foreseen to mitigate the risk.

Previous studies have used varying methodologies to understand the exposure of the financial sector to nature (Calice, Kalan and Miguel, 2021[8]; DNB, 2020[7]; Svartzman et al., 2021[6]; World Bank & BNM, 2022[9]) . As mentioned in the Drivers of biodiversity loss and associated indicators section, nature loss

may materialise with differentiated impacts depending on the underlying drivers. Financial authorities' assessment of impacts and dependencies may reflect this heterogeneity within their analysis. Given the complexity of ecosystems, the assessment of the financial system's exposure to ecosystem services in terms of impacts and dependencies requires multiple indicators and approaches.

Figure 3.2. Proposed methodological steps to assess impacts and dependencies



Note: Financial authorities may determine the most appropriate method for establishing overlap; however, the purpose is to identify areas which may be exposed to both physical and transition risks.
Source: OECD authors' illustration.

Significant overlap between impacts and dependencies from specific sectors indicates that these sectors are exposed to both transition and physical risks stemming from nature-related losses. In such instances, financial authorities could consider both risk sources concurrently due to their potentially interacting and compounding effects. This means that no additional efforts are needed while prioritising risks through the three-phase approach (See question 2 in Box 3.1).

If the impacts and dependencies assessment reveals significant discrepancies between the ecosystem services depended on and those impacted, financial authorities will need to conduct additional analyses to complete the risk identification process. Consequently, it is recommended to conduct the identification process and answering the guiding questions twice. First, by focusing on the impacted sectors and placing a stronger emphasis on transition risks. Then, the same process may be repeated for the nature-dependent sectors, with a focus on physical risks.

The methodology outlined above focuses on a bottom-up approach to link different financial assets to economic activities which directly or indirectly depend and/or impact upon ecosystem services. If financial authorities opt for a top-down approach, the following steps are suggested: (i) scope the relevant economic sectors to be included in the assessment; (ii) link economic sectors to different ecosystem service impacts and dependencies; (iii) establish the degree of materiality for each economic sector's impact and/or dependence on different ecosystem services; (iv) weight the degree of materiality for each ecosystem

service with the size of economic sectors to rank relevant sectors[8]; (v) assess the degree of overlap between impacts and dependencies for each economic sector. Whilst the present report offers the above approaches, financial authorities may explore alternative methodologies which may be more appropriate to the specific context of their jurisdiction.[9]

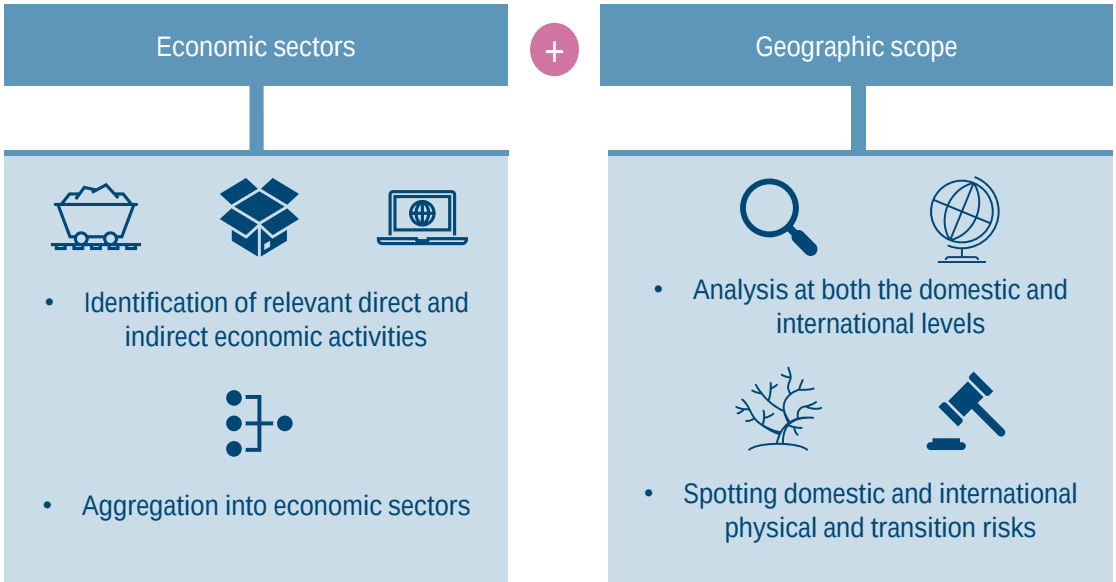
Box 3.1. Guiding questions for the impacts and dependencies assessment

1. What is the exposure of the financial system, in terms of impacts and dependencies, to nature through ecosystem services?
2. Do the ecosystem services which are impacted differ from those depended on?

3.2. Phase 2: Economic sector identification and prioritisation

The second phase of the prioritisation process focuses on identifying the key economic sectors exposed to nature-related risks. As illustrated in Figure 3.3, the scope of the analysis will consider two aspects: an assessment on relevant economic sectors and the analysis on their geographic location. The former will focus on prioritising economic sectors based on the materiality of their impact/dependence on ecosystem services (identified in phase 1), as well as their overall economic importance. Likewise, it provides a first differentiation regarding relevant direct and indirect economic risks. The latter, on the other hand, will delve into the exposure of physical and transition risks at the international and domestic levels.

Figure 3.3. Phase 2. Economic sector identification



Source: OECD authors' illustration.

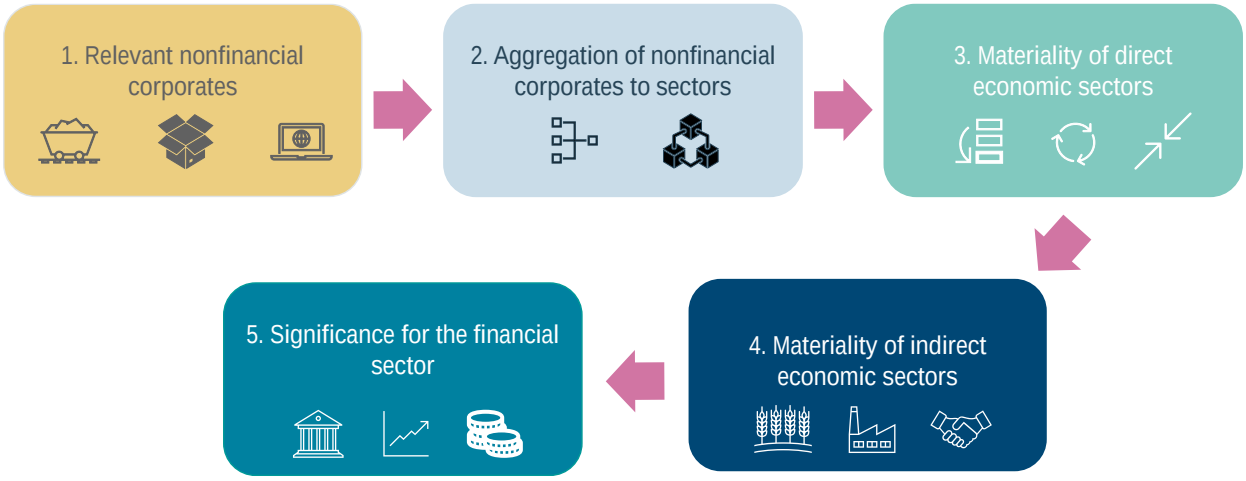
[8] It is the responsibility of the financial authority to determine the most appropriate metrics to determine the size and importance of different sectors, depending on the focus and objective of their assessment.

[9] Several central banks have followed similar methodologies to undertake an impacts and dependencies assessment (Svartzman et al., 2021[6]), (DNB, 2020[7]), (World Bank & BNM, 2022[9]).

3.2.1. Economic sectors

The second phase begins by identifying the most relevant economic sectors that financial authorities can prioritise to address and understand nature-related risks. This requires an evaluation of the direct and indirect economic sectors of the economy. Financial authorities can filter relevant economic sectors based on different considerations proposed below (see Figure 3.4).

Figure 3.4. Prioritisation steps to identify relevant economic sectors



Source: OECD authors' illustration.

The impacts and dependency assessment informs financial authorities of the nonfinancial corporates with the highest degree of materiality regarding impacts and/or dependencies, and the number of ecosystem services which are impacted and/or depended upon. Subsequently, nonfinancial corporates can be aggregated into economic sectors using commonly considered classification systems, such as Nomenclature of Economic Activities (NACE), Global Industry Classification Standard (GICS), or others. Where the materiality rating between nonfinancial corporates in the same sectors differs, financial authorities may either assign the weighted-average or the highest materiality rating to the sector. Alternatively, financial authorities may prefer to rely on company-level metrics to understand the intra-industry risk differentials for nature-related financial risks.

The selection of direct economic sectors (primary economic sectors) may be based on: (i) the aggregate financial exposure to economic sectors; (ii) the degree of materiality for impacts and dependencies; (iii) the number of ecosystem services impacted and/or depended on (see question 1, 1.1, 1.2, and 1.3 Box 3.2). From this, financial authorities can identify the highly-material sectors and their relevance for the financial system. If possible, financial authorities may prioritise direct sectors based on these three components to identify the key economic sectors for the analysis. Financial authorities could analyse the relevance of primary economic sectors (e.g. agriculture, extractive industries) given their necessary input into the rest of economy and include the analysis in their consideration of relevant sectors (see question 2 Box 3.2). For example, the role of agricultural production in maintaining labour productivity through accessibility to food.

For indirect economic sectors (secondary and tertiary economic sectors), financial authorities may consider three aspects: (i) the economic and financial relevance of indirect sectors; and (ii) the materiality of value chain impacts and/or dependencies on ecosystem services; (iii) the number of ecosystem services which each sector impacts and/or depends upon (see questions 3, 3.1, 3.2, and 3.3 Box 3.2).

Within this, financial authorities can analyse the value chains of profiled indirect economic sectors and consider the share of imported commodities compared to domestic production (see question 4 in Box 3.2). This indicates the degree of exposure to imported risks, as well as the information needed to proceed with the analysis on the Geographic scope. Finally, financial authorities could consider the aggregated financial relevance for the identified economic sectors as well as the sectoral concentration (see question 5 in Box 3.2).

If a top-down assessment approach is chosen, financial authorities may not need to follow steps 1 and 2 in the identification of relevant economic sectors. Additionally, the value chain analysis for indirect sectors may not be necessary as a sector-based approach may be taken to ascertain materiality. Under this approach, it might be more relevant for financial authorities to consider the economic relevance of different sectors as opposed to their financial significance. At this point, the assessing financial authority can preliminarily identify both the key direct and indirect economic sectors exposed to nature-related financial risks.

Box 3.2. Guiding questions for economic activities

Economic activities

Direct economic sectors

1. Which are the most relevant direct economic sectors?
    - 1.1 What is the financial relevance (in terms of aggregate financial exposure) of highly-material sectors?
    - 1.2 Which are the highest-material economic sectors?
    - 1.3 Which economic sectors depend on and/or impact the highest number of ecosystem services?
2. Independent of the impacts and dependency assessment, what is the economic relevance of primary economic sectors?

Indirect economic sectors

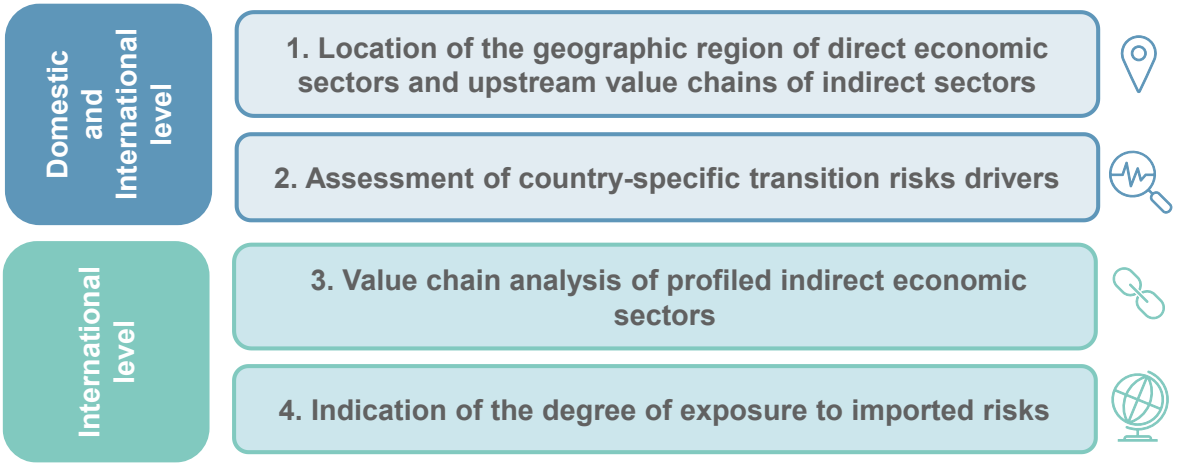
3. Which are the most relevant indirect economic sectors?
    - 3.1 Which are the most financially and economically relevant sectors without a direct interface with nature, and why have they been assessed as having no direct interface with nature?
    - 3.2 What is the degree of materiality, in terms of impacts and dependencies on ecosystem services, for their associated value chains?
    - 3.3 Which sectors indirect depend on and/or impact the highest number of ecosystem services?
4. What is the share of imported commodities compared to domestic production?
5. What is the aggregate financial relevance of identified economic sectors and the sectoral concentration?

3.2.2. Geographic scope

Once financial authorities identify the key direct and indirect economic sectors, they may assess the possible sources of risks given the geographic location of the economic activities. For both foreign and domestic exposures, financial authorities can: (i) locate the geographic region of their direct economic sectors; and then (ii) locate the geographic location of upstream value chains for indirect economic sectors

to understand the origination of the risk (see question 7 in Box 3.3). Once financial authorities have identified the geographic location of all relevant direct and indirect economic sectors these could be aggregated based on location to understand the regional concentration. This endeavour may require engagement with environmental ministries and relevant agencies, given their expertise with nature-related topics.

Figure 3.5. Geographic location of identified economic sectors



Source: OECD authors' illustration.

Financial authorities could consider the geographic location for direct and indirect economic sectors, particularly the country in which they are domiciled (question 6 in Box 3.3). The country context will greater determine the physical and transition risks, based on the state of nature and the policy environment, for example. For indirect sectors, financial authorities may consider the geographic location of their upstream value chains (question 7 in Box 3.3).

At the domestic level, financial authorities can consider the domestic policy environment, regulatory changes, technological advancements, changes in consumer preferences and public sentiment to identify possible transition risks for both direct and indirect economic sectors (see question 8 in Box 3.3). Likewise, financial authorities could consider relevant liability risks associated with such transition (see question 8.1 in Box 3.3). This analysis can be undertaken at the sectoral level to understand the sector-specific policies which may create adverse impacts for nonfinancial corporates. Additionally, the analysis may adopt an integrated approach to nature-related risks and the nexus between biodiversity loss, climate change, and broader nature to consider cumulative transition risks.

At the international level, financial authorities may undertake a similar assessment. This transboundary assessment is relevant for financial authorities to ascertain possible imported impacts from nature degradation occurring beyond their national jurisdictions. To this end, it is important to be conscious of the exposure to foreign regions through both direct and indirect sectors. For example, it could be relevant to consider the geographic concentration for imported impacts both for direct and indirect economic sectors (see questions 9 in Box 3.3). Financial authorities may therefore prioritise regions with greater concentrations of economic and financial exposure. Subsequently, financial authorities can examine the economic relevance of transition risk drivers in these key partner countries (see questions 9.1 and 9.2 and in Box 3.3). Again, this may be undertaken at the sectoral level and adopt an integrated approach to nature-related risks. The geographic concentration of imported impacts may help indicate the level of economic disruption from transition risks materialising in response to physical risks. For example, the imposition of exports bans in response to resource scarcity due to a physical nature shock.

Following this step, financial authorities may have a clear understanding of the key direct and indirect economic sectors, at both the international and domestic levels, that may be exposed to nature-related financial risks.

If a top-down approach is adopted, financial authorities may want to primarily focus on domestic sectors and regulatory environment; however, this is dependent on the country context, as national circumstances and mandates differ. Mapping 'imported impacts' from indirect sectors with upstream dependencies abroad may be possible with trade databases. Concentration of imports can be considered to identify and prioritise different geographies, complemented by an assessment of the country-specific transition risk drivers.

Box 3.3. Guiding questions for the economic sector identification

Geographic scope

1. Where are direct and indirect economic activities located?
2. For indirect economic activities, where are their upstream value chains located?

Domestic level

3. How is the domestic policy environment, technological availability, consumer preferences and public sentiment towards nature (transition risks)?
4. Are there relevant legal local disputes or non-judicial cases that concern the conservation of nature and could represent a source of risk (litigation risk)?

International level

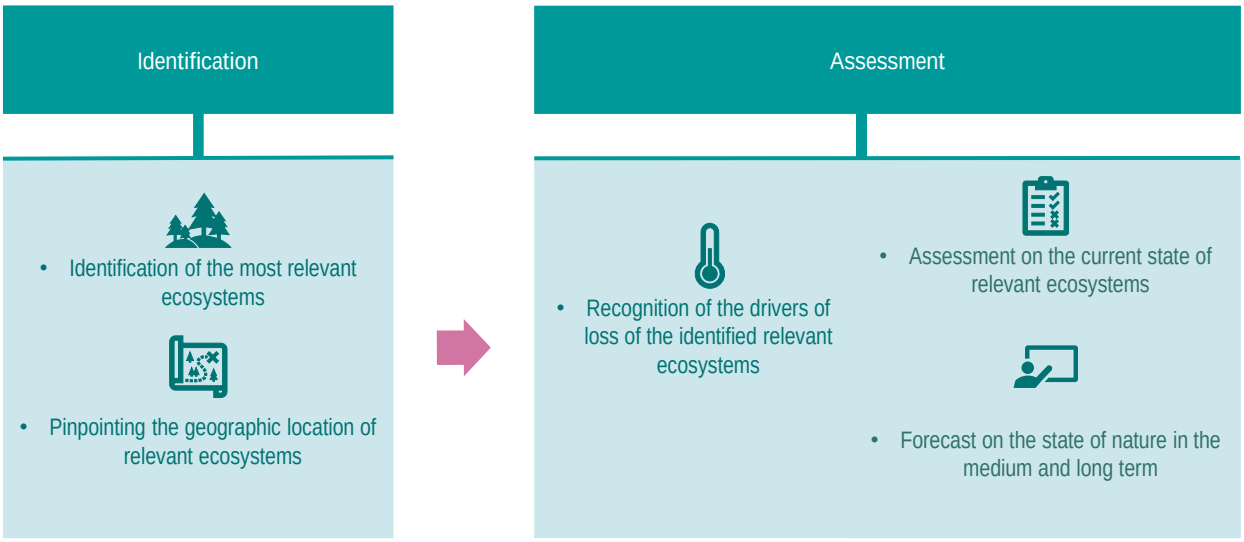
5. What is the geographic concentration for imported impacts, per country? (Consider both sectors and commodities)
6. What are the regional/sectoral policies relevant for nature, technological availability, consumer preferences and public sentiment towards nature (transition risks) in other countries?
7. Are there relevant legal disputes or non-judicial cases in other countries that concern the conservation of nature and could represent a source of risk (litigation risk)?

3.3. Phase 3: Ecosystem identification

The identification and prioritisation of ecosystems focuses on three components: i) identify the most relevant ecosystems services using the results of the impacts and dependencies assessment; ii) identify the main drivers of nature loss and general threats to the integrity of the key ecosystem services; iii) perform an assessment of the current and forecasted state of nature.

It is important to note that financial authorities may encounter difficulties to complete Phase 3 of the risk identification process by themselves due to divergent mandates and expertise. For this reason, it could be beneficial to involve environmental agencies, who already undertake such analyses and may have the capacity to complete the ecosystem identification and assessment steps outlined below. Similarly, where mandates permit, financial authorities could consider the creation of specialised departments within their institutions for nature-related assessments.

Figure 3.6. Phase 3: Ecosystem Identification



Source: OECD authors' illustration.

3.3.1. Identification

Financial authorities can identify first the most relevant ecosystem services with regards to financial materiality. Based on the findings of the impacts and dependencies assessment, financial authorities could consider the aggregation of the financial system's exposure, as well as the number of economic activities which impact and/or depend on a specific service, as the main indicators to filter relevant ecosystem services. Likewise, financial authorities may further profile these services based on the key economic sectors identified in the previous phase and their impact and/or dependence on ecosystem services (See questions 1, 1.1, 1.2 in Box 3.4).

If financial authorities have chosen a specific geographic region for their assessment, further analysis is required on the location of ecosystem services within regions (See questions 1.3 in Box 3.4). It would be relevant, for instance, to pinpoint the exact geographic location from where these ecosystem services are obtained. The results from the analysis on relevant direct economic activities, as well as indirect economic activities' value chain may provide the required inputs to pinpoint the geographic location of ecosystem where key ecosystem services are obtained. Hence, financial authorities may wish to use the findings from the analysis on the Geographic scope in phase 2. Financial authorities may pinpoint the exact geographic location of the ecosystem with ecological maps or through asset-level data of nonfinancial corporates.

3.3.2. Assessment

Financial authorities are subsequently expected to recognise the primary drivers of loss of the identified relevant ecosystems, ecosystem services and the differentiated impacts (see Section on Direct drivers of biodiversity loss for primary direct drivers) (See question 2 in Box 3.4). Financial authorities ought to be aware of the main threats to the integrity of the ecosystem which can alter its capacity to provide the services required by the economic activities identified in Phase 2: Economic sector identification. To this end, financial authorities could conduct literature review, as well as consult with experts and relevant ministries to further understand the functioning of relevant ecosystems and their main threats. Reference to IPBES' identified five main drivers of nature loss may be a useful starting point.

Subsequently, financial authorities may undertake an assessment on the current state of such ecosystems and ecosystem services that stem from it to understand the current vulnerability to nature-related risks

(see Question 3 in Box 3.4). Given the complexity of nature, a myriad of existing metrics and indicators may be used to assess the state and vulnerability of ecosystems. The EBVs framework may offer guidance to understand the different aspects of ecosystem which may be degraded (see Section on Indicator Classes for further information).

As part of the assessment of relevant ecosystems, their current capacity to supply services may be considered (See questions 3 and 3.1 in Box 3.4). Financial authorities could work together with national environmental agencies that collect relevant nature-related data to assess the current state of ecosystem services and their current provisioning. This analysis helps determine if key ecosystems are in a stable state or if they are close to their regime shifts, which would indicate significant physical risks for the financial sector. Additionally, where ecosystems are assessed to be in an unstable condition, financial authorities may consider the cascading risks between ecosystem regime shifts.

Additionally, the future state of prioritised ecosystems in the short, medium, and long term may be assessed (See question 3.2 in Box 3.4). Given the complexity of the task, competent authorities might decide the best way to perform the assessment, which could be driven by a specialised department consisting of environmental specialists. However, engagement with national environmental agencies as well as with supervised institutions will remain critical in performing the assessment. This may be conducted by assessing the current rate of decline and nature scenarios. As part of the analysis, financial authorities can consider how the future state of nature will interrupt the functioning (impacts and dependencies) of the ecosystem's capacity to provide services (See question 3.3 in Box 3.4). Hence, financial authorities will have more information to address nature-related financial risks.

If a top-down approach is applied, financial authorities will still need to consider the current and possible future state of ecosystems. The identification of key ecosystem services, as well as the main drivers of nature loss can be taken from the sector-based impact and dependency assessment. To assess the current and future state of relevant ecosystems, financial authorities may rely on available scenarios.

Box 3.4. Guiding questions for the ecosystem identification

1. What are the most important ecosystem services for the economy?

1.1. Which ecosystem services are most relevant for the financial system?

1.2. Which ecosystem services support/impacted by the greatest number of economic activities?

1.3. Where are these ecosystem services located within regions?

2. What are the main drivers for nature loss (focused on impacts and dependencies)?

3. What is the current state of different ecosystems (related to the identified ecosystem services)?

3.1 What is the current supply of provisioning of different ecosystem services?

3.2 What is the forecasted state of nature in the short, medium and long term?

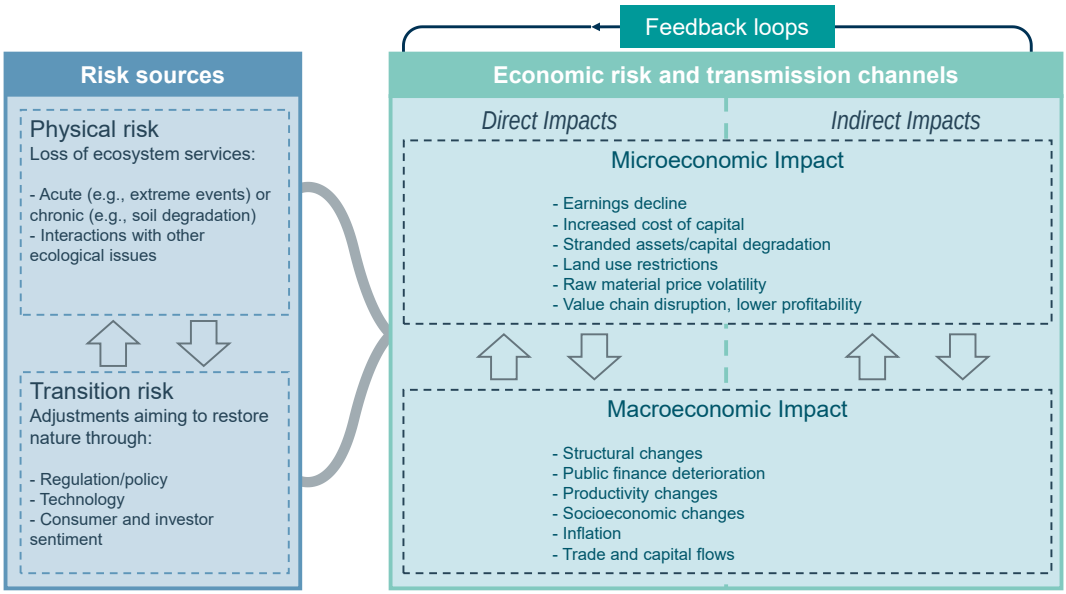
3.3 How will the future state of nature interrupt the functioning (impacts and dependencies) of the ecosystem's capacity to provide regulating and maintenance services)?

4 Economic risk assessment

The chapter on economic risk assessment provides an in-depth conceptualisation of the identified direct and indirect economic impacts stemming physical and transition risk (see Figure 4.1). This includes additional information on how the economic risk originates, starting from the Risk identification and prioritisation assessment, the economic impacts, as well as possible channels of propagation to other parts of the economic system. The purpose is to provide clarity on which type of risks could be considered by financial authorities to design relevant scenarios for their own assessment of financial materiality. The chapter is structured as follows:

- **Economic risk origination**: covers the origin of the risks, their magnitude, and their transmission channels. Additionally, it considers the location of the risk and the relevant time horizon for risk materialisation.
- **Economic risk materialisation**: focuses on the direct and indirect economic impacts of nature losses and how risks may transmit between sectors from those which directly depend on and impacting nature. Both the micro and macro-economic impacts originating from physical and transition risks are included.
- **Economic risk propagation**: explores the linkages and additional source of uncertainty for how these shocks will transmit across markets and economic systems, including effects such as feedback loops and spill overs.

Figure 4.1. Economic risk conceptualisation and transmission channels



Note: Additionally, liability risk can be considered a subset of both physical and transition risk. There is not a clear distinction between the economic impacts stemming from direct and indirect impacts. Direct impacts stem from sectors with a direct interface with nature, whereas indirect impacts stem from impacts in the upstream value chain and the broader economy.
Source: OECD authors' illustration, adapted from NGFS (2023[11]), *Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors,* https://www.ngfs.net/sites/default/files/medias/documents/ngfs_conceptual-framework-on-nature-related-risks.pdf

Financial authorities may decide how best to undertake the assessment, with either a bottom-up or top-down approach, given the micro and macroeconomic risks, and financial institutions' capacity in their jurisdiction to participate in such exercises. Bottom-up approaches assess risk at the granular level, aggregating individual components to provide a consolidated view, but requires greater capacity on the behalf of individual financial institutions. While more granular and possibly complex, this approach can help better understand risks at the individual financial institutions level and aggregate the results to approximate the risk to the wider economic and financial system. Conversely, top-down approaches initially look at a macro-level and then disaggregate the risk at the sectorial level. While requiring a less granular level of data and complexity, this approach may overlook specific risk exposures, such as concentration risk (BIS, 2021[36]).

While the chapter tries to provide clarity on the possible economic consequences of nature loss, several challenges remain, including data availability – particularly regarding location-specific data, underlying assumptions in measurement approaches, and possibilities to overlook potentially relevant key risks. Moreover, given the relatively emerging work on nature, models are still evolving and may not encompass all identified sources of risk. This chapter provides the understanding of the potential economic impacts that may arise from the direct and indirect interactions between economic activities, ecosystem services and nature loss. This serves as a solid base for the last chapter of the framework concerning the financial risk assessment.

4.1. Economic risk origination

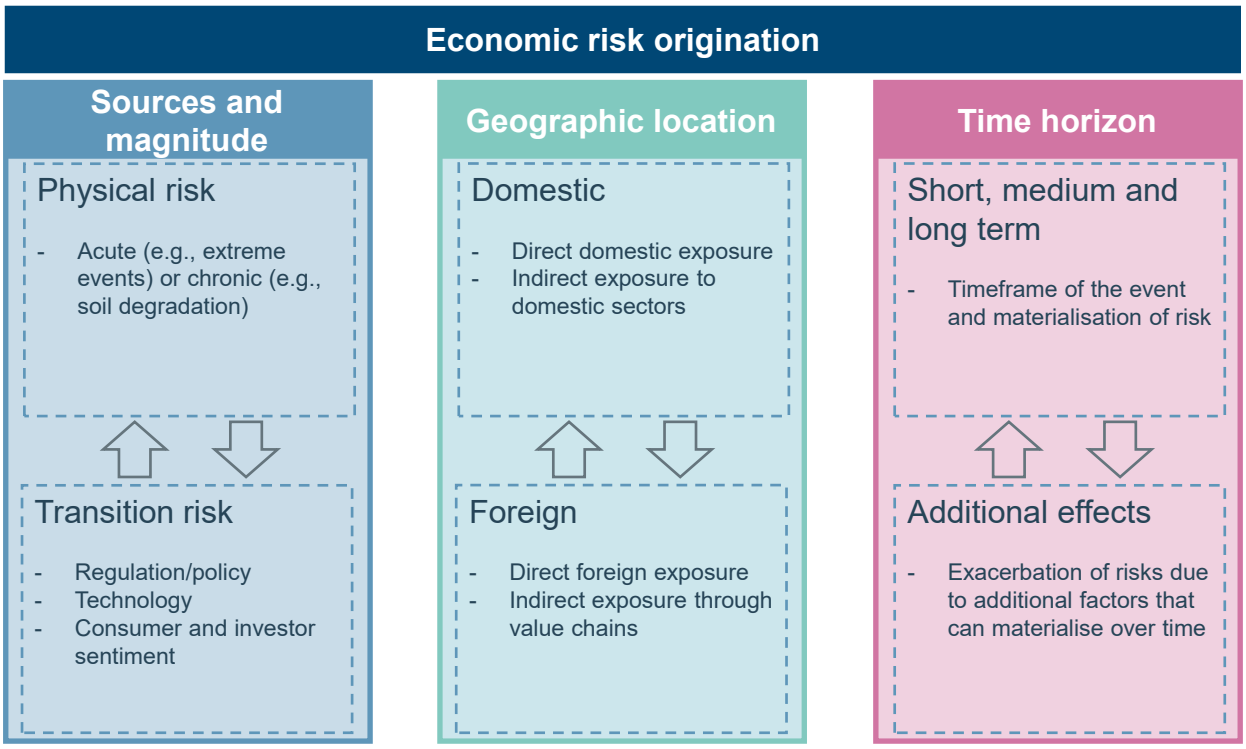
As highlighted in the Risk identification and prioritisation Section of Chapter 2, nature-related financial risks can enter the economy through physical and transition risk channels. The elements identified through the risk identification and prioritisation process can therefore be used as a basis to understand, measure, and assess the sources of risk (see Box 4.1 for list of guiding questions).

These sources of risk are represented by changes in the state of nature and the socio-economic response (through policy, technological change, public sentiment as well as liability and legal) both domestically and abroad. These may result in unexpected impacts on the economy, leading to the materialisation of microeconomic and macroeconomic effects in the short, medium, and long term. Furthermore, these risk sources are subject to uncertainty due to the range of possible events related to nature-related losses as well as the differences in regulations implemented by governments, creating the additional problem of needing to forecast the state of nature in the future.

Analysis on different risk sources is essential to understand how nature loss transmits to the economic system, entailing the need for scenarios which allow to build a forward-looking assessment of the consequences of nature loss. Scenarios describe possible futures in situations of high uncertainty using a set of assumptions, which allows for a better understanding of nature loss dynamics as well as impacts on the economy (IPBES, 2019[1]).

When determining the sources of risk, it is therefore relevant for financial authorities to use the appropriate scenarios. This can be done drawing from the work of relevant bodies or internally, starting from the assessment derived from the risk identification and prioritisation chapter which provides the key ecosystems that are relevant for a proper functioning of economic system. In the latter case, several elements need to be considered when developing the economic risk origination, namely the source and magnitude of risk, the relevant time horizon, and the geographic location (see Figure 4.2).

Figure 4.2. Economic risk origination



Source: OECD authors' illustration.

4.1.1. Sources and magnitude of impact

For analysis on the sources of risk, physical and transition risks need to be taken into account to properly understand how nature loss may affect the economy, and subsequently, the financial sector. These risk drivers can impact economic activities directly or indirectly, through both micro and macro-economic channels, and consequently the financial sector. The extent to which these risk drivers will impact the economic system will vary depending on the severity and frequency of the events as well as whether the transition will be orderly or disorderly and need to be modelled accordingly.

Physical risks stem from the loss of ecosystem services, hence they are the appropriate starting point to identify these risks. The extent to which they impact corporates and other economic actors will partially depend on specific characteristic, such as their resilience and adaptability. Hence, these factors may be considered within the analysis. Conversely, transition risks are likely to occur at the sectoral level, so this may be a more appropriate starting point to identify these risks (although cross-sectoral and intra-sectoral differences in impact should be considered where relevant). When identifying relevant risk sources, financial authorities could consider the potential pervasive impact across the economy to assess the magnitude of risk – i.e., how many sectors will be impacted and what is the overall impact on the economic system.

Some examples of physical risks may include (non-exhaustive):

- Physical acute risks – the spreading of diseases (which may lead to pandemics), crop failure from pest encroachment, irregular rainfall from microclimate disruption, eutrophication (harmful algal blooms from the excess of nutrients such as nitrogen and phosphorous).
- Physical chronic risks – pollinator loss, soil degradation, increased water stress, microclimate disruption.

Some examples of transition risk may include (non-exhaustive):

- Transition policy risk – the Global Biodiversity Framework, including target 2 (at least 30 percent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration), target 14 (ensure full integration of biodiversity into national policy and regulations, including aligning fiscal and financial flows), and target 18 (reduce subsidies for harmful activities to biodiversity by USD 500 billion and scale up positive incentives).
- Transition technology risk – nature beneficial practices, such as regenerative agriculture.
- Transition sentiment risk – increased consumer and investor awareness of nature, which may lead to increased litigation risk and costs of capital for harmful activities.

Additionally, liability risks might stem from both physical and transition risks, for example through the indirect exposure to a supplier in the value chain responsible for nature damages locally which could lead to legal repercussions.

Adding to this, transition risks may occur from policies implemented in response to the materialisation of physical risks, which may not directly or indirectly serve to preserve nature. Sectors will be impacted differently based on the physical and transition nature of the risk and its consequences. Where multiple sectors are affected by physical risk, governments might decide to prioritise some over others, and therefore adding an additional transition risk. These policy responses might exacerbate or mitigate the risks for specific sectors. Consequently, financial authorities may want to create a 'hierarchy of sectors' based on which sectors are likely to be prioritised in the event of physical risk materialisation.

Moreover, interlinkages between physical and transition drivers might compound the risk. For example, the late adoption of policies to limit nature degradation might increase physical risks and the sudden increase in physical risk events might accelerate the adoption of stricter regulations, leading to higher transition risk. Similarly, climate change effects need to be considered during the assessment as risks may interact and exacerbate nature-related risks.

Financial authorities may therefore identify nature-related risks that are relevant for their systems based on the risk identification and prioritisation chapter.

4.1.2. Geographic location – domestic and foreign exposures

The complex and localised characteristics of nature makes it necessary to identify the geographic location of the risks. While a widespread loss of nature and ecosystems would have impacts extending beyond countries' borders, nature is locally very different. Countries may experience differing impacts from nature loss, with emerging and developing economies typically exposed to a higher degree of direct risks. Hence, financial authorities can locate whether their financial counterparties' operations are located domestically or aboard.

Domestic exposures may arise from two sources. First, directly, from financial exposures to counterparties with operations in direct sectors located domestically. Second, indirectly, through exposures whose upstream value chain depends on economic activities undertake in the domestic jurisdiction. Understanding the domestic exposure to nature is necessary to assess the impact of local nature loss, particularly for direct economic effects. Domestic risks have generally larger effects on the home economy than external shocks. However, the magnitude of these risks may be partially determined by the ability of economies to substitute local production for increased reliance on imports through international trade.

Foreign exposures may also arise from two sources. First, directly, from financial exposures to counterparties with operations in direct sectors located in foreign jurisdictions. Second, indirectly, through exposures whose upstream value chain depends on economic activities undertake in a foreign jurisdiction. Cascading impacts through the value chains may have the largest weight when assessing the domestic

economic impact of foreign nature loss. While external shocks have fewer and narrower trade channels to propagate, countries with significant import dependencies may be the most affected.

Financial authorities may consider whether they focus on a scenario assessing domestic, foreign or both exposures based on the aggregated financial exposure to different geographic locations, the potential impacts to the economic system, and the assessed state of nature.

4.1.3. Time horizon

The assessment of nature-related risks may consider the short and medium-term risks, as well as the long-term risks. While the materialisation of these risks will most likely take place in the medium to long term, short-term risks such as acute physical events may materialise as well, making it important for financial authorities to understand the timeframe in which the risks may occur and the different implications.

As outlined in the Risk identification and prioritisation chapter, the factors that impact the assessment include: understanding the main drivers for nature loss, the forecasted state of nature in the short, medium and long term, and how will the future state of nature interrupt the functioning of the ecosystem's capacity to provide services. Additionally, financial authorities could consider the frequency and variability of nature events and distinguish between acute and chronic physical risk differences. Acute and chronic risks can differ depending on the time horizon, with chronic risks becoming more probable in the long term and acute risks in the short term. Over time, additional economic risks might materialise that could further exacerbate environmental risks.

Box 4.1. List of economic risk origination questions

1. What are the relevant risk sources and what is their magnitude? (Magnitude may consider the economic sectors affected and the impact on the entire economic system)
2. Are risks transmitting to the economy through physical or transition channels? Are there relevant interlinkages to consider?
3. Are there relevant climate risks to be taken into account that could amplify the magnitude of the risk?
4. Is the foreign exposure of market participants significant?
5. Are domestic or foreign nature-related risks most relevant to consider?
6. What are the relevant time horizons over which these risks may occur and propagate?
7. Are there any additional risks that could materialise over time and exacerbate environmental risks?

4.2. Economic risk materialisation

Nature-related risk drivers may lead to economic risk materialisation for the economic system via direct and indirect economic impacts. Transition or physical risk drivers may negatively affect market participants, particularly for sectors and activities most directly dependent on and impacting nature, such as all extractive and productive sectors, including mining, fisheries, forestry and agriculture (IPBES, 2019[1]). Additionally, risks may propagate through the economy indirectly through supply chains leading to impacts for a number of other sectors, such as resource conversion and manufacturing, services (such as transportation), as well as consumption (Boston Consulting Group, 2021[37]). Please see Box 4.4 for a list of guiding questions.

The distinction between direct and indirect impacts is important to understand how market participants can be affected and whether additional uncertainties such as substitutability need to be taken into account during the assessment. In this case, indirect impacts might be more challenging to assess, given the possibility of cascading effects for sectors not directly dependent on nature, which could be affected by changes of price inputs and substitutability as nature declines.

Following a physical or transition event, several market participants could be affected. For example, for corporates, the exposure is tied to their economic activities. And the impact may mainly come from earnings decline through increased operating costs or decreases in revenues, businesses disruption, and funding costs increases. For sovereigns, the exposure is tied to macroeconomic factors such as changes in trade flows, changes in currency exchange rates, and inflationary pressures. Households may also be affected through lower wealth such as decreases in property prices and increased costs of consumer staples.

Financial authorities can determine ex-ante the level of granularity and type of analysis required, based on the types of economic impacts which are in scope of the assessment. An analysis at the microeconomic level requires a higher level of granularity but allows a better understanding of risk at the individual level. Macroeconomic analysis requires a less granular level of data and complexity, but may overlook specific risk exposures, such as concentration of risk particularly in the short term when availability of 'fit-for-purpose' data might be scarce. However, it will offer greater insight into the interaction of different sectors and economies, as well as the feedback effects from nature-related shocks.

Therefore, to establish a comprehensive framework to assess nature and nature risks, a key aspect is the inclusion of the type of economic impacts to be assessed. These could include microeconomic factors such as earnings decline, increase in cost of capital as well as stranded assets[10]. Conversely, macroeconomic impacts could include structural changes, inflationary pressures and public finance deterioration.

4.2.1. Direct economic risk

The direct economic impacts are measurable changes in the production and distribution of goods and services occurring in sectors with a direct interface with nature. Changes in the quantity or quality from resources produced in these sectors due to physical or transition risks can affect their availability, quality, and price differently, leading to micro and macro-economic impacts for market participants. Due to the limited substitutability of nature and ecosystem services, sectors with a direct interface with nature will have limited ability to adapt to the decline in nature and substitution (e.g., moving the geographic location of their operations) may create significant costs.

Several sectors will face direct economic impacts due to their strong dependency on nature. These mainly include primary sector activities, such as resources extraction and cultivation activities such as farming, fishing, forestry, and mining and extraction of fossil resources due to their direct exploitation of resources (Boston Consulting Group, 2021[37]).

Farming and agricultural expansion is responsible for more than 90 percent of global deforestation. More specifically, cropland expansion and livestock grazing are the main drivers, causing almost 50 percent and 38 percent of global deforestation respectively. Between 2000 and 2018, the expansion of oil palm cultivation alone caused 7 percent of all deforestation worldwide (FAO, 2022[38]). Additionally, the use of fertilisers can affect plant and animal life (including humans) negatively, leading to soil degradation and water contamination among others (Wiederholt and Johnson, 2022[39]). Mining and extraction of fossil resources also impacts to nature, particularly given the generally valuable ecosystems where some mining

[10] Stranded assets can be broadly defined as assets that suffer an unanticipated or premature write-downs, devaluations, or conversion to liabilities (Caldecott, Howarth and McSharry, 2013[83]).

sites are located. Increases in resources demand and depletion of easily accessible reserves pushes up mining activities in remote areas, including tropical forests and fragile areas (UNEP; International Resource Panel, 2019[40]).

Box 4.2. Case Study: Water scarcity and the economic impact of the mining sector in Chile

Chile is one of Latin America's leading industrial and agricultural exporters. Its central and northern regions hold economic and social significance due to the presence of agricultural and mining ventures. Chile's mining industry is of substantial importance to the Chilean economy, contributing USD 317 billion or 15 percent of Chile's GDP in 2021 and over 62 percent of the country's total exports. However, a prominent issue is the overutilisation of finite water resources. Although the mining industry's water consumption is substantially lower compared to other sectors, notably agriculture, water scarcity presents threats to the viability of the sector, and it continues to face persistent scrutiny from neighbouring communities.

This case study identifies relevant economic activities directly dependent and impacting water ecosystem services with a very high materiality rating in Chile, outlining possible economic and financial consequences of a reduction in ecosystem services.

Direct economic activities include mining activities, agriculture and energy production. Indirect economic activities, whereby industries rely on inputs from the sectors mentioned above could face indirect economic impacts, notable from supply chain disruptions due to water stress, include building construction, infrastructure, manufacturing and the agri-food sector.

Economic impacts can be identified at the micro and macro level, ranging from increases in operational costs and rising capital expenditures needs to GDP decline, reduced government revenue and inflationary pressures. Additionally, the economic risks detailed above may exacerbate, or be exacerbated by alternative sources of risk such as the nexus with climate change and lead to a greater magnitude of impact.

Subsequent financial risks may materialise in the form of credit risk, due to a reduction in profitability and subsequent credit risks if companies are unable to meet the financial obligations to debtholders, market risk for listed companies where volatility could affect market prices and finally liquidity risk due to a sudden reduction in supply of traded commodities, such as copper and lithium, which will likely induce short-term price volatility, with implications for commodity and derivative markets.

Note: See technical annex https://www.oecd.org/finance/A-supervisory-framework-for-assessing-nature-related-financial-risks-annexes.pdf
Source: Stephen et al. (2017[41]), *Using sustainability reporting to assess the environmental footprint of copper mining*, https://10.1016/j.gloenvcha.2017.04.004; Toro, N. et al., (2022[42]), *Use of Alternative Water Resources in Copper Leaching Processes in Chilean Mining Industry – A Review*, https://10.3390/met12030445; Oyarzún, J. (2011[43]), *Sustainable Development Threats, Inter-Sector Conflicts and Environmental Policy Requirements in the Arid, Mining Rich, Northern Chile Territory, https://10.1002/sd.441*; Arratia-Solar, A., & Paredes, D., (2023[44]) , *Commodity price and fatalities in mining – Evidence from copper regions in Chile, https://doi.org/10.1016/j.resourpol.2023.103489*.

4.2.2. Indirect economic risk

Indirect economic impacts (or cascading impacts) are measurable changes in production and consumption in downstream value chains, stemming from the impacts in direct economic sectors. Changes in the quantity or quality of these downstream activities may affect their availability, quality, and price differently, leading to economic impacts. To understand the indirect economic impact of nature loss, how supply chains and their steps are connected to ecosystems need to be assessed.

Key risk factors may include geographic concentration, interconnectivity among suppliers, dependency, and substitutability (McKinsey, 2020[45]). Substitutability is a central consideration to understand indirect economic impact and varies depending on the sector's placement within a value chain. There are two types of substitution that may be considered in the analysis: (i) first, technological substitution, i.e. the ability of firms to substitute different inputs and innovate to reduce their exposure to nature-related risks; and (ii) econd, geographic substitution, i.e. the ability for firms to switch between different suppliers globally to limit their exposure to nature-related risks. Companies closer to the upstream segments of the value chain might be the most affected by a nature-related shock. While companies towards the downstream segments have greater substitutional ability. Moreover, the understanding of cross-border and potential geopolitical risks compounds the complexities regarding import dependencies.

Drivers of nature loss can be identified along major value chains in the global economy, and their effect on nature varies on their position on the value chain.

- Primary sector activities (e.g. agriculture, extractive industries) represent the largest source of impact on nature loss. Unsustainable agriculture, unsustainable fishing, unsustainable forestry practices and unsustainable mining contribute directly to land-use change, land degradation, overexploitation of resources as well as pollution.
- Secondary sector activities (e.g. processing, manufacturing, construction) also contribute significantly to the negative effects on nature. Heavy industries as well as infrastructure development can contribute to land-use change, exploitation of resources such as freshwater and pollution.
- Tertiary sector activities (e.g. services, transportation) can contribute to nature loss through pollution.
- Consumption can also directly impact nature through improper disposal of waste and impacts of durable goods.

While supply chains can be complex and globally interlinked, a limited number of value chains are estimated to account for the majority of pressures on nature, including agrifood, infrastructure and mobility, energy, fashion, among others (pharmaceuticals, cosmetics, and consumer electronics) (Boston Consulting Group, 2021[37]).

Box 4.3. Case Study: The economic and financial implications of deforestation in Indonesia

Covering one of the largest areas of tropical rainforest worldwide, Indonesia's forests are not only essential for global ecosystem integrity and resilience but also a source of significant provisioning and regulating of ecosystem services. These include the provisioning services to the Indonesian palm industry, which is the largest in the world. Yet, between 2000 and 2013, Indonesia was the country with the largest deforestation rate in the world, mostly accounted to the palm oil industry. Given the relevance of the Indonesian rainforests for environmental integrity, including ecosystem protection and restoration, the role of the palm oil industry in the loss of forests, as well as the relevance of this industry for international markets, the case study emphasises on the Hence, this case study aims to delve into the extent to which the financial sector is exposed to nature-related risks based on the Indonesian case.

The generalised loss of forests through the national territory implied an increased likelihood of physical risks, which could interrupt the provisioning of ecosystem services, among other consequences. As a result, since 2011, the Indonesian Government has prioritised the introduction of several policy measures to reduce deforestation rates, including moratoria on logging concessions and licenses, as well as on clearing forests and peatlands.

While the government measures slowed deforestation rates through a strong policy response, by 2016, Indonesia still had one of the highest rates of primary forest loss in the tropics; the country lost almost one million hectares of primary forest loss in 2016 (Jong, 2023[46]) . Even though deforestation can be attributed to myriad of reasons including the extension of agriculture and fires, large-scale palm oil plantations are one of the main drivers of forest loss in the country. For this reason, the Indonesian Government has followed similar policy responses as in previous occasions, introducing moratoria to exploitation contracts, as well as more regulations to control the palm oil trade. It is important to note that the palm oil industry represents around 3.5 percent of the Indonesian GDP. In fact, Indonesia produces around 60 percent of global palm oil, and it is also the largest palm oil exporter of the world.

Direct economic activities include mainly agriculture, while indirect economic activities relying on the outputs from the agriculture include the agri-food, cosmetic and energy sectors.

Economic impacts can be identified at the micro and macro level, such as: decreases in agricultural outputs, increases in operational costs, good prices fluctuations and local community conflicts. At the macro level these could include GDP decline, reduced government revenue and inflationary and employment pressures. Indonesia is expected to export 1.6 million metric tonnes of palm kernel oil in 2023/24, with 70% of exports shipped to the People's Republic of China, the United States, Brazil, and the Netherlands. Indonesia accounts for 56% of the world's palm oil exports, hence the economic risks to the Indonesian economy and abroad may be significant.

Subsequent financial risks may materialise in the form of credit risk, due to a reduction in profitability and subsequent credit risks if companies are unable to meet the financial obligations to debtholders, market risk for listed companies and finally underwriting risk that might lead to refusal to insure agricultural companies if the risk is deemed too high, leading to increased costs for the agriculture sector.

Note: See technical annex https://www.oecd.org/finance/A-supervisory-framework-for-assessing-nature-related-financial-risks-annexes.pdf
Source: UNORCID (2015[47]), *Forest Ecosystem Valuation Study: Indonesia, https://www.unep.org/resources/report/forest-ecosystem-valuation-study-indonesia*; Hansen et al (2013[48]), *High-Resolution Global Maps of 21st Century Forest Cover Change, https://10.1126/science.1244693*; Austin et al. (2019[49]) *What causes deforestation in Indonesia?, https://iopscience.iop.org/article/10.1088/1748-9326/aaf6db/pdf*; Indonesian Palm Oil Association (2021[50]), *Palm Oil Has Irreplaceable Role in Indonesian Economy, https://gapki.id/en/news/20660/palm-oil-has-irreplaceable-role-in-indonesian-economy*; U.S. Department of Agriculture (2023[51]), *Oilseeds and Products Annual, https://apps.fas.usda.gov/psdonline/circulars/oilseeds.pdf*.

4.2.3. Micro and macro-economic impacts

To conceptualise the full extent of the economic risks including direct and indirect impacts, financial authorities may determine the most appropriate type of assessment and identify relevant microeconomic and macroeconomic impacts.

Microeconomic impacts

- Earnings decline: Transition or physical risk drivers may lead to loss of revenues or increasing operational costs due to companies being forced to increase capital expenditures to mitigate and adapt. Examples of transition risk include land use restrictions, whereby regulators might protect or restrict the use of specific lands to preserve nature, which increase land prices and may restrict production. Physical risks may be due to acute or chronic events, where prolonged impacts on nature may lead to decreased availability of raw resources, increasing operating costs.
- Increase in cost of capital: Companies particularly dependent or impactful on nature might be seen as riskier, which could then be reflected in their cost of capital. Companies not taking the appropriate measures to mitigate the impact of nature loss might therefore have lower access to capital, subsequently impacting their investments.
- Physical capital degradation: Companies which directly depend on ecosystem services may see a depreciation in the value of the physical assets (e.g., farmland) due to declines in nature. For example, water stress events and droughts might make previously fertile land less usable, affecting the value of agricultural companies' assets.
- Stranded assets: Transition risk drivers (such as government policy to preserve nature) may cause some assets currently productive to become unproductive and therefore stranded.
- Supply chain disruption: Physical or transition risks may induce commodity supply disruption and force companies switch suppliers. For example, Indonesia's nickel ore export ban in 2020, with implications for supply chains of strategic products (e.g., electric vehicles). Whilst not related to nature degradation, the physical dependence of mining on water provision may lead to similar supply-chain disruptions in future.
- Raw materials price volatility: Supply-side shocks due to resource scarcity or trade restrictions could lead to price volatility which might propagate along supply chains, prompting companies to decide whether to absorb the price difference or pass it on to consumers. Particularly physical commodities' supply chains, where downstream participants may be affected by price spikes.

Macroeconomic impacts

- Structural changes: Physical and transition risks might lead to permanent structural changes to the economic system. For example, changes in resources and subsequently products availability might affect consumer demand, leading to a shift in preferences and consumption patterns. Similarly, a physical event might lead to forced migration, with socio-economic consequences that may affect labour.
- Public finance deterioration: To adapt and mitigate the consequences of eventual shocks, governments might have to increase spending, leading to worsening conditions for public finances, including increased indebtedness. Negative impacts on income could also imply a reduction in government's ability for public spending, including social expenditures and investment.
- Productivity changes: Due to the diversion of investment to mitigation and adaptation of nature-related risks, there is the possibility that productivity might be affected, including higher risk aversion for companies as well as workers in industries closely interlinked with nature issues.

- Changes in trade flows: Physical events and trade restrictions from exporting countries may alter trade flows, with the additional complexity of cross-border transmission of risks making it more difficult to assess. For example, the 2010 droughts in the Russian Federation reduced the grain harvest by around a third, leading to a government-imposed export ban on grain (Hildén et al., 2020[52]).
- Inflationary pressures: Sustained decreases in supply of commodities and higher prices may lead to macroeconomic inflationary pressures. As nature-related losses will differ depending on the location, effects are likely to change depending on the country and its import dependencies as well as substitutability effects. Linking to the aforementioned example, the 2010 export ban in the Russian Federation combined with an excess rainfall in Pakistan, contributed to an increase in international grain prices by over 60 percent.

4.3. Economic risk propagation

An additional source of uncertainty for these shocks relates to feedback loops and cross-market spill overs. These additional risks caused by nature losses can be more significant than the direct and indirect economic impacts as the contagion of one or more sectors can then lead to multiple contagion channels that spread to the wider economic system.

Feedback loops refer to reactions both between economic actors and nature, and between different economic actors. In the event of nature loss, economic actors might alter their activities in response to said shock, which may put additional pressure on nature and further increase the risk. For example, in response to a collapse in agricultural production elsewhere from a nature-related shock, other agricultural companies may increase their production in response to a stronger demand. This could lead to further nature deterioration and increase risks for the economic system. Additionally, indirect sectors may re-align their supply chain dependencies in response to a shock to minimise their risks, which may compound the economic risks for the directly affected sectors.

Spill over effects refer to the cross-market propagation of risk between different sectors, leading to a broader impact on the economy. These risks may reinforce one another, and lead to multiple contagion channels that spread to other sectors of the economy, and which can then further exacerbate the economic risk. For example, losses in the agriculture sector could then spread to the clothing industry which relies on several raw materials for producing textiles.

Box 4.4. Guiding questions for economic risk materialisation

1. What is the level of risk materialisation for direct and indirect impacts?
2. What are the most relevant micro and macro-economic impacts identified for the assessment?
3. What is the time horizon over which identified impacts can occur?
4. Can additional sources of uncertainty be taken into account in the assessment?
5. Are there traditional risks which may amplify or mitigate the economic risks stemming from nature degradation?

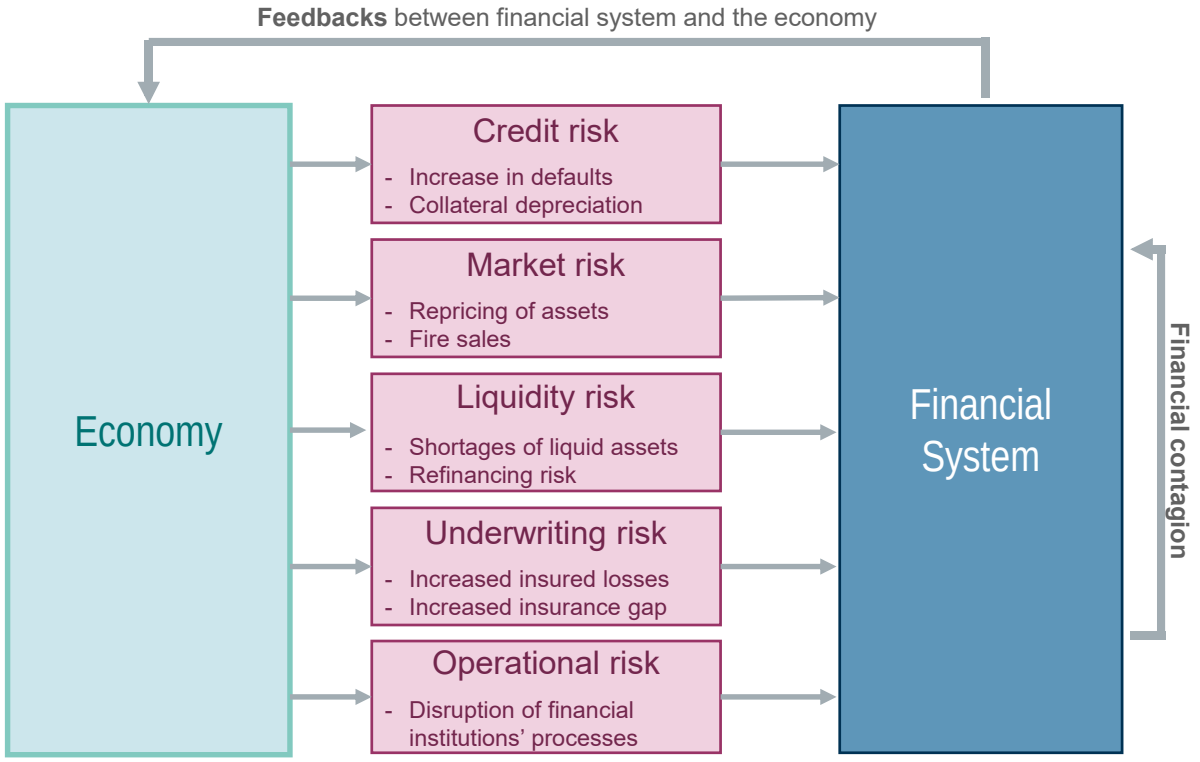
5 Financial risk assessment

Chapter 4 explores and conceptualises the different financial risk channels by which economic risks stemming from nature-related losses may be transmitted in the financial system. The purpose is to provide an understanding of how direct and indirect economic risks identified in the previous chapter can become financial risks channels including the consequent effect on whole financial system as well as individual financial institutions.

The chapter conceptualises different financial risk channels, including credit, market, liquidity and underwriting risks, and reference other possible relevant channels. These are conceptualised through both micro- and macro-financial risk channels, to provide a full understanding of the possible impact of these risks. These risk channels arising from nature-related financial risks may present new risks for the financial system, as well as amplify those stemming from climate-related risks (see Figure 5.1).

Additionally, the chapter provides an overview of risk contagion within the financial system, and possible feedback between the financial sector and the real economy. The conceptualisation offers guidance to financial authorities on how these risks may propagate throughout the financial system and lead to further cascading risks within the real economy.

Figure 5.1. Overview of financial risk transmission channels



Source: OECD authors' illustration.

5.1. Credit risk

Nature risk drivers may lead to credit risks for the financial system via changes in income or changes in wealth that affect the ability of borrowers (public sector, corporates or households) to repay debts. Transition or physical risk drivers may negatively impact debt servicing capacity (income effect) or the ability of banks to react to an increase in non-performing loans if the value of the collateral decreases (wealth effect) (BIS, 2021[53]).

These may arise from chronic or acute impacts from nature loss. Abrupt impacts, such as water stress and subsequent water curtailment, may lead to direct and indirect economic impacts for specific sectors, for example agriculture and clothing. Operational challenges for agricultural companies could then lead to reduced raw materials, impacting the agricultural company's revenues as well as reducing the outputs for the clothing company. If extensive, the impact might lead to difficulties to meet their debt obligations. In the case of a financial institution, if overly exposed to the specific sector, this might lead to an increase in non-performing loans, eroding the asset quality on the lender's balance sheet, which could eventually trigger credit rating downgrades and increases in risk-weighted assets (RWAs) (CISL, 2022[54]). Similarly chronic risks may lead to credit risks over time. For example, deforestation in the Southern Brazilian Amazon, beyond a certain threshold, is linked to reduced rainfall and decreased agricultural yields (Teixeira Leite-Filho et al., 2021[55]).

At a micro-financial level, this reduces agricultural revenues and farmers' ability to service and repay their debts, whilst at the same time, devaluing their land, which may be used as collateral against these debt obligations. At a macro-financial level, food scarcity and increases in agricultural commodities may lead to declines in labour productivity and increased costs along the agri-food business value chains.

More broadly, the linkages between food insecurity and per capita GDP growth have been previously explored at a global level (Wu et al., 2011[56]). However, the severity of impacts is closely tied to regional dynamics and ability of nations to import agricultural commodities in addition to their domestic supply (Ibid). Furthermore, a study by (Johnson et al., 2021[34]) offers initial estimates of the GDP impacts under a nature collapse scenario, indicating a 10 percent decrease in real GDP by 2030 for low-income countries (Johnson et al., 2021[34]). These GDP impacts can heighten credit risks to financial institutions, not only from non-financial corporates but also from potential sovereign rating downgrades (Agarwala et al., 2022[57]).

Additionally, climate change has been previously identified to amplify credit risks through increased surface temperatures (BIS, 2021[53]). These risks may interact and compound nature-related risks to exacerbate credit risks for financial institutions. For example, increases in global temperatures will bring greater rainfall variability in Brazil (Alves et al., 2020[58]). This may further impact agricultural yields, leading to greater credit losses for financial institutions.

5.2. Market risk

Nature risk drivers may lead to market risks for the financial system through volatility in market prices, including for example commodity or equity prices, resulting in the degradation of earnings or the economic value of capital for financial institutions. This might be caused by physical and transition risk events, which may alter economic conditions or the value of real or financial assets (BIS, 2021[53]).

When looking at physical risks, the indirect economic impacts stemming from nature loss may lead to new correlations between assets and sectors, limiting banks' ability to hedge these risks. Initial research on corporate bonds in Australia and Brazil reveal increases in corporate bond spreads in the immediate wake of acute biodiversity events (Cherief, Sekine and Stagnol, 2022[59]). The results indicate that companies operating in the most harmful sectors to biodiversity, face more significant spreads following acute biodiversity events. For example, paper products (40 percent), steel (33 percent), and commodity

chemicals (13 percent) saw the greatest spread increases in Brazil, with the results suggestive of a possible biodiversity premium (Ibid). However, these results cannot fully distinguish biodiversity from other physical environmental dimensions, with periods of high correlation. Other analysis on the performance of synthetically constructed hedging portfolios for biodiversity risk, finds positive correlations between portfolios returns and a biodiversity risk index. These results indicate that biodiversity risk may already be initially priced into financial markets (Giglio et al., 2023[60]; Garel et al., 2023[61]; Coqueret and Giroux, 2023[62]). However, greater awareness, identification and measurement of nature risks will likely lead to these risks being further priced into financial markets.

The materialisation of acute and chronic physical risks may also lead to incremental policies and regulations from governments to try and mitigate nature degradation. These regulatory actions might lead to stranded assets in relation to issues such as deforestation and water stress as well as changes in income derived from activities exploiting these resources. Downward market valuations may therefore stem from higher operational costs due to increased capital expenditure and increased reputational risks from the impact on nature, leading to reduced revenues. For example, agricultural companies relaying on land-use change for their revenues as well as mining companies with intense water usage may have to write down a number of assets from their balance sheets in response to increased regulation, which may ultimately affect their valuations. Similarities can be identified with climate change, whereby changes in operational costs or reputational risks may impact the valuation of non-financial corporates (OECD, 2021[63]).

Due to the emerging nature of practices for reducing nature impacts, particularly through the notion of ‘nature positive’, at this time market participants might not be able to efficiently price companies’ strategies to reduce their nature footprint in the longer term. Hence, in the short-term, companies with ambitious nature goals may be subject to lower market valuations due to higher capital expenditures. Over time, increased awareness of nature risk and transition drivers may inversely lead to increased market valuations thanks to improved resilience of supply chains and operations with regards to nature as well as lower exposure to regulatory changes.

Initial indication of increased transition risks can be seen with the adoption of the Global Biodiversity Framework at COP15, which includes biodiversity targets to be achieved by 2030 (CBD, 2022[4]). Furthermore, the adoption of European Sustainability Reporting Standards (ESRS) E4 reporting standards in the European Union will greatly increase the availability of corporate data on biodiversity and ecosystems, which will enable investors to better understand and inevitability price biodiversity risks into market valuations (EFRAG, 2022[64]).

At a micro-financial level, financial institutions can be affected by changes in market valuations due to volatility or repricing of financial assets, including commodities, equity prices and derivative instruments. At a macro-financial level, sudden repricing of sectoral valuations in response to acute nature-related events may lead to more systemic market risks for financial institutions. Additionally, due to the broad dependency of the economy on nature and the opaqueness of indirect dependencies through value chains, there may be limited opportunities for financial institutions to effectively hedge against the materialisation of nature risks.

The ECB’s recent climate stress test highlighted how the combined credit and market risk losses under short term physical and transition risk scenarios for 41 banks would amount to around EUR 70 billion, with the estimate significantly understating the actual risk (ECB, 2022[65]). Market risks stemming from the transition to a ‘nature positive’ economy may not necessarily affect the same sectors and corporates which are subject to market risks from the climate transition, however where overlap exists compounding market risks can be expected.

5.3. Liquidity risk

Liquidity risk can materialise if financial institutions are unable to meet cash and collateral obligations without incurring major losses due to nature events. Both physical and transition risks might negatively affect financial institutions' liquidity to a varying degree.

Acute physical risk events may deteriorate the liquidity position of banks whose balance sheets are exposed to nature risk. For example, looking at deforestation, if a number of financial institutions were to divest or limit the funding provided to companies sourcing commodities grown on previously forested land due to the increasing risk, pressure could grow on local banks with already opened credit lines. In that case, credit and market risks might lead to liquidity issues which could be further compounded by a decrease in market participants' confidence in the bank's ability to remain solvent. Additional liquidity risks might come from financial institutions' use of derivatives for trading or hedging purposes in two ways. The first could be due to market volatility following a physical event, which might leave a counterparty unable to meet its funding requirements and could significantly damage a banks' liquidity position. The second could arise because of stricter margin requirements as a result of nature risks, leading to increased demand for collateral by counterparties, which could then have effects on the liquidity position of the bank.

While additional work is needed to understand the full extent of physical and transition risks' effects on financial institutions' liquidity stemming from nature risk, there is indirect evidence through the impact of climate change on liquidity risks. Previous research establishes a link between banking liquidity and climate risk in emerging markets. Evidence from twenty emerging markets show a negative relationship banking spreads and lending to high emitters, with banking spreads improving if the lending portfolio has lower exposure to emitting firms (Su et al., 2022[66]). Furthermore, physical climate events may impact banks' liquidity through deposit outflow due to unprecedented withdrawals, as well as unfunded exposures (for example guarantees) (Brei, Mohan and Strobl, 2019[67]; Lang et al., 2023[68]). Other research shows the negative impacts on banks' liquidity in the aftermath of the 2013 Elbe River flood from lending to flood-affected counterparties, with the effects persisting for two years following the flood (Koetter, Noth and Rehbein, 2020[69]).

Additionally, due to the interlinkages between climate and nature, nature may act as an amplifier or mitigator to the materialisation of climate-related financial risks. For example, the restoration of nature can improve flood risk management through increased water retention, bank erosion control and flood conveyance solutions (ADB, 2022[70]). These measures can mitigate the economic risks from flooding and may subsequently reduce the impact on banks' liquidity for banks' lending to flood-affected counterparties.

5.4. Other financial risk channels and systemic tail risks

Other financial risk channels may be relevant for wider nature, however, evidence to substantiate the breath and magnitude of these risks is yet to be researched. For example, insurers may experience nature-related financial risks through their investments and liabilities related to transition and physical risks (EIOPA, 2023[71]) as well as the possibility of inaccurate assessment of nature risks. Other risk channels which may be relevant include interest rate risk, currency risk and operational risks. Additionally, tail risks following unexpected events such as an abrupt physical event related to nature might lead to a number of simultaneous financial risks, including consequences for price stability.

5.5. Financial system interaction

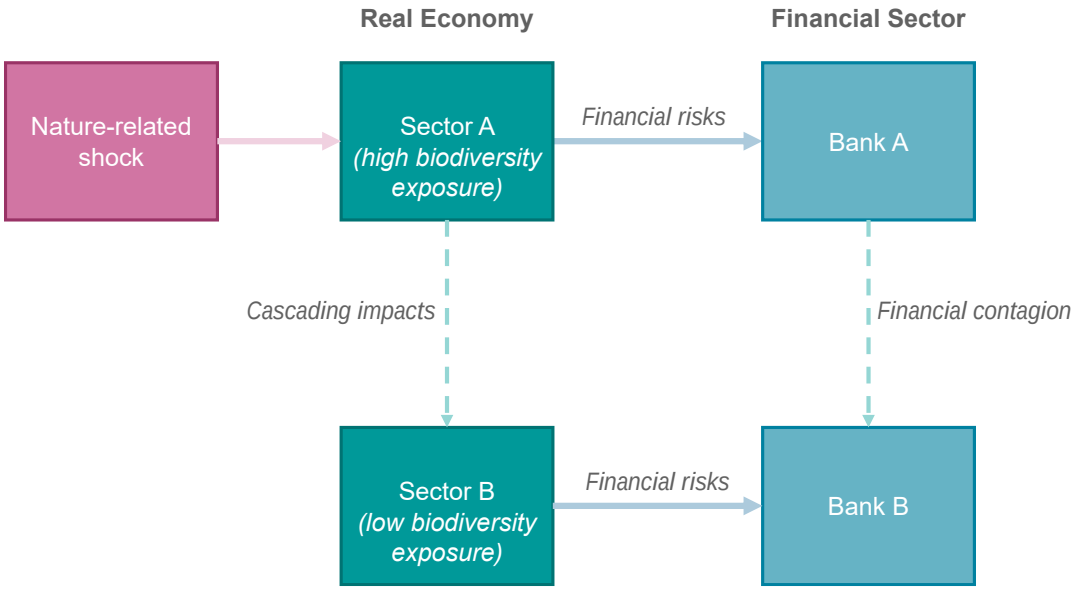
Beyond the financial risk channels, by which nature-related financial risks may enter financial markets, financial market interactions may amplify and propagate these risks. The spread of financial risk through

markets by result from; (i) interconnectedness of financial institutions through financial linkages or correlations across market prices, and (ii) contagion from cross-market linkages after a shock to one or more financial institutions (Bricco and Xu, 2019[72]). These can arise from both direct (such as interbank lending) and indirect exposures (exposure to common assets) (Ibid). Both the connectivity and concentration of key players greatly determines the propagation mechanisms of risk in the financial system (Gai, Haldane and Kapadia, 2011[73]). The European Central Bank (ECB) previously identifies two key channels by which contagion may emerge in the financial system: (i) physical exposures; and (ii) asymmetrical information (ECB, 2005[74]).

The size and impact of these risks within financial markets will be partially determined by the structure and interconnectedness of the financial system, as well as the exposure to sectors with a high impact and/or dependency on ecosystem services. Direct economic risks stemming from nature loss are likely to be primarily concentrated in a select number of sectors – including those identified as the primary drivers of nature loss (fisheries; agriculture; forestry; harvesting; mining; infrastructure; tourism; and transportation) (IPBES, 2019[1]).Financial institutions most exposed to these highly exposed sectors more likely to experience substantial risks in the event of nature-related financial risk materialisation.

Financial institutions with low or no exposures to these high-risk sectors may still face financial risks through two channels. First, from the indirect, cascading impacts through value chains which may affect corporates with little direct exposure to nature-related risks, which may lead to subsequent financial risks materialising from the corporates. Second, from the interconnectedness of the financial system and through financial contagion from highly exposed financial institutions. Figure 5.2 below offers a simplified illustration of these two risk channels and their impact financial institutions with low exposure to high-risk sectors. In the illustration Bank A has a high exposure to Sector A (a high-risk sector), and Bank B has a high exposure to Sector B (lower-risk sector), but Bank A and B are connected through interbank exposures.

Figure 5.2. Stylised overview of transmission of nature-related risks through the financial system



Source: OECD authors' illustration.

There are several factors which may determine the strength and prevalence of these transmission channels through the real economy and financial system (see Box 5.1 for guiding questions on financial system interaction):

- **The market concentration of nonfinancial corporates within high-risk sectors.** If these sectors are highly concentrated by a few large players, there will be more limited opportunities for regional and technological substitution for their downstream value chains. Consequently, the impacts from nature-related risks (such as increases in commodity prices) are more likely to cascade down value chains and create more prolific indirect risks. These economic risks may subsequently lead to financial risks for financial institutions exposed to these indirect sectors. For example, the agricultural sector has seen dominant trends of decreasing number of holdings, with an enlargement of holdings, and a specialisation and intensification of production (Ripoll-Bosh and Schoenmaker, 2021[75]). Moreover, if a sector is dominated by a few nonfinancial corporates, then there is greater probability of multiple financial institutions being exposed to a single counterparty, which exacerbates the risks within the financial system.
- **The concentration of exposures to high-risk sectors within the financial system.** If exposures to high-risk sectors are concentrated in a few financial institutions, this may amplify the risks through the financial system. If a few financial institutions experience a severe stress from concentrated exposure to high-risk sectors, this may amplify the channels by which the risks may spread to other institutions (e.g., the fire sale of assets to raise liquidity). Conversely, if the exposure to high-risk sectors is broadly spread throughout the financial system, this reduces the concentration within any single financial institutions and may reduce the extent to which risks are propagated through the system. Exposures to some high-risk sectors for nature-related financial risks are typically concentrated within a limited number of financial institutions, which may amplify these risks in the financial sector. For example, agricultural-related exposures may be concentrated within the financial system in financial institutions such as agricultural or community banks (FDIC, 2021[76]). As nature-related financial risks are yet to be reflected in the regulatory framework, the full extent of these risks is unlikely to be captured.
- **The interconnectedness of highly exposed financial institutions.** The interconnectedness of financial institutions is a key determinant of risk propagation within the financial system. If the financial institutions most exposed to nature-related financial risks are deeply connected to the rest of the financial system, then the propagation channels for financial risks are likely to be greater. The reactionary response of these financial institutions in the event of a stress will subsequently amplify the propagation risks through the interconnectedness channel of the financial system. For nature-related financial risks, economies that are highly dependent on the primary sectors of the economy, there may be a higher probability that the financial institutions with the greatest exposure to high-risk sectors are also large and deeply connected institutions within the financial system.
- **The potential for information asymmetries within the real economy and financial system.** Asymmetries in information notably between different financial institutions, and between financial institutions and corporates may give rise further risk of contagion within the financial system. The direct impacts of nature-related financial risks are highly regional and geographically specific. However, the indirect impacts are likely to be cross-border and their effects felt more globally. In relation to information asymmetries, there are three sources by which this may arise. First, the cross-border asymmetries in information about specific nature-related events. Institutions are less likely to have detailed knowledge and understanding of the nature-related financial risks in foreign jurisdictions, including their probability and magnitude of impact. Second, there is significant complexity in global value chains and therefore financial institutions are unlikely to have a thorough oversight of the potential indirect impacts within their portfolio stemming from a nature-related event. Finally, financial institutions are likely to have asymmetric information about the relative exposure to nature-related financial risks of other institutions, particularly those located in foreign jurisdictions. All these components of asymmetric information are likely to amplify the potential for contagion within the financial system.

Box 5.1. Guiding questions on financial system interaction

1. What is the market concentration of nonfinancial corporates within identified high-risk sectors? Additionally, are multiple financial institutions exposed to a few dominant nonfinancial corporates in these sectors?
2. What is the concentration of financial institutions' exposures to high-risk sectors within the financial system?
3. What is the size and interconnectedness of financial institutions with the greatest aggregate exposure to high-risk sectors?
4. Can clear information asymmetries be identified either within the real economy or the financial sector, which may amplify the financial risks stemming from nature-loss? For example, what is the concentration of cross-border exposures and dependencies within the financial system?
5. Is there significant overlap between the high-risk sectors identified for nature-related financial risks and those identified for climate-related risks? Is there possible amplification of financial risks from the interaction of climate change and nature loss?

5.6. Feedback between the financial system and the real economy

Finally, two relevant feedbacks between the financial system and the real economy exist regarding nature loss. First, financed activities can exacerbate the degradation of nature through the financing of economic activities which cause significant harm, which may increase the likelihood of physical risks in the future. Second, there are potential changes in financial activities in response to the materialisation of nature-related financial risks. This may occur through multiple channels, including bank lending and financial institutions' investment in high-risk sectors.

While additional research is needed to understand the effects of a nature event in terms of feedback loops between the financial system and the real economy, evidence from climate change and natural disasters can provide a starting point in understanding potential feedback. Banks adapt pre-emptively to exacerbated climate risk in areas which frequently experience abnormally high temperatures in a country, through changes in the lending practices (Islam and Singh, 2023[77]). Additionally, the study indicates that large banks reduce lending to small farms by 2-3 percent more, relative to their counterparts, following periods of increased abnormal temperatures in a country (Ibid). Another study reveals increases in loan spreads following natural disasters, not only for the affected area, but for at-risk areas not directly affected by the natural disaster (Correa et al., 2022[78]). Moreover, the impact on loan spreads is accentuated when attention to climate change is high (Ibid). Similar feedback loops in banks' behaviour can be envisaged for nature-related events. These studies indicate two possible feedback channels, the first, in pre-emptive measures taken by banks when perceived risks are high, and second, in response to the materialisation of a nature-related event. Additionally, a deterioration in macro-financial conditions may more broadly impact on the economic conditions of an economy and induce further economic risks (NGFS - INSPIRE, 2022[3]).

6 Considerations for supervisors

To aid financial authorities in monitoring the risks previously highlighted for the financial system, this chapter provides high-level considerations regarding possible steps towards their integration into financial risk identification and assessment. The purpose is to develop a common foundation for understanding the relevance of nature-related financial risks for the activities of financial supervisors.

In this context, existing frameworks providing recommendations and good practices for approaches on climate-related risks can be useful to understand the relevance of nature related risks for financial supervisors and regulators, noting that there may be limitations to the degree to which tools and analysis for climate-related risk can be applied to nature risks. Examples include the Financial Stability Board's recommendations on supervisory and regulatory approaches on climate-related risks (FSB, 2022[79]), the Basel Committee on Banking Supervision (BCBS) Principles for the effective management and supervision of climate-related financial risks (BCBS, 2022[80]), the NGFS Guide for Supervisors on integrating climate-related and environmental risks into prudential supervision (NGFS, 2020[14]).

The following sections should be viewed as considerations for the management of nature-related financial risk and not recommendations. In this regard, these suggestions outline possible avenues for financial authorities to consider these risks in their operations but are not recommending any single approach to be undertaken by financial regulators and supervisors. This reflects the emerging context in understanding of nature-related financial risks, and the considerations outlined offer flexibility to regulatory authorities to pursue alternative interpretations and avenues to incorporate these risks into supervisory practices.

These considerations could be useful to accelerate efforts in identifying the key nature-related risks which financial systems are exposed to and the relevant key metrics. This can be achieved through international coordination and cooperation using international bodies' global platforms to establish common definitions and explore widespread risks across financial systems. Afterwards, authorities may start to develop supervisory expectations on financial institutions governance, processes, and controls on relevant data, requiring qualitative information and the use of estimates to supplement current gaps. This would also allow for the expansion of scenario analysis and stress testing to account for nature-related risk, tailoring scenarios to the domestic context to account for risk specificities.

The considerations also highlight the current ability of authorities to implement them. The sections correspond to the current ease of implementation of these considerations and if further development or prerequisites are necessary. The first section refers to considerations which can start to be implemented immediately, the second refers to considerations which can be implemented in the short-to-medium term, and the last refers to considerations which may be implemented in the medium-to-long term.

6.1. Applicability of climate-related financial risks to nature-related financial risks

Existing climate-related risks considerations, noting possible limitations to the degree to which tools and analysis for climate-related risk can be applied to nature risks, can be useful to understand what could be needed from the perspective of nature-related financial risks in terms of national supervision and international cooperation, data, and methodologies.

When looking at national supervision and international cooperation, several climate-related risks considerations can be relevant for nature-related risks. Nationally, oversight on financial institutions'

governance, processes, and controls on reported nature-related data is also important. In this regard, supervisory expectations may serve as an effective mechanism for nature-related risks.

Internationally, the potential cross-border risks and inter-dependencies as well as the emerging nature of nature-related risks means expertise is limited and quickly evolving. Hence, global coordination and cooperation will be important to better understand these risks and help develop approaches to measure, assess, and monitor these risks. International bodies may take a leading role to facilitate exchanges in knowledge and develop a globalized understanding of these risks. The use of mutually understood definitions for nature-related risks would promote further consistency across jurisdictions and system-wide scenario analysis could offer important insights in the global financial risks stemming from specific regional areas of high nature importance.

With regards to data and methodologies, the need for more defined and granular data on nature-related risks, impacts and dependencies could help with the ongoing assessments of vulnerabilities. Similar to climate change, forward-looking scenario analysis will likely be a key tool to inform macroprudential assessments on nature-related risks. However, increased complexity and need for granular information regarding nature-related risks may lend itself more towards bottom-up or hybrid approaches (such as sectoral approaches) which may better capture intra-sectoral risk differentials, indirect exposures, and cross-border impacts. Nonetheless, the capacity and ability of financial institutions to participate in these exercises needs to be considered. Hence, a range of approaches may be most appropriate, depending on the domestic context of the financial system.

6.2. Short-term considerations

In the short term, financial authorities can usefully identify the key nature-related risks which their financial system is exposed to, and the relevant key metrics. Additional resources, such as those provided by TNFD may accelerate authorities' ability to identify relevant data and metrics. Financial authorities may accelerate these efforts to identify the relevant information and define the key metrics. The collection of some nature-related data may require corporate disclosure, but data on the current state of ecosystems may be publicly available for authorities.

Financial authorities can already start to establish common definitions related to nature-related risks, both in their home jurisdictions and cross jurisdictions. As mentioned in the Introduction, the NGFS has published a conceptual framework to establish common definitions around these risks (NGFS, 2023[11]). Financial authorities may further develop these common definitions with respect to their domestic contexts.

Global coordination and cooperation towards regulatory reporting frameworks could accelerate the mitigation of nature-related risks. However, financial authorities may additionally need to understand, assess, and monitor priorities and risks at the domestic level, depending on the identified material issues, especially given the localised nature of biodiversity and broader nature-related risks.

Financial authorities may already use prudential approaches to assess the widespread risks across the financial system and assess tools and/or monitoring measures that might be relevant in this context. Financial authorities may consider the concentration of exposure to these risks within the financial system, and the channels by which they may spread across the financial system – namely (i) interconnectedness, (ii) financial contagion, (iii) concentration and (iv) complexity.

Financial authorities can engage and coordinate across jurisdictions through active dialogue and to share best practices given the global nature of nature-related risks. Standard-setting and international bodies can provide a global platform for facilitating cooperation and coordination and develop a common understanding of these risks and how to approach them.

6.3. Medium term considerations

In the medium term, financial authorities may start to develop supervisory expectations on financial institutions' governance, processes, and controls on relevant data. However, due to the emerging nature of these risks, further developments in understanding and identification of key metrics may be necessary. In the initial phase, flexibility in the metrics used by financial institutions may have benefits in improving institutions' understanding of these risks within their own portfolio and authorities to understand the most relevant metrics to be reported. Therefore, over time and where appropriate within jurisdictions legal and regulatory frameworks, supervisory and regulatory authorities could consider the need for third-party verification to strengthen the reliability of nature-related data.

The current limited scope of corporate reporting and gaps in data which is 'fit-for-purpose' places limitations on the current use of quantitative assessments. Currently, initiatives on reporting frameworks, such as TNFD and the Corporate Sustainability Reporting Directive (CSRD), are attempting to help respond to this challenge. However, in the short-term, financial authorities may require qualitative information and the use of estimates to supplement current gaps. Due to the emerging nature of these risks, in the short term, flexibility in reporting of these risks may be beneficial. Over time, as methods to capture these risks and understanding improves, authorities may want to move towards more quantitative methods and greater standardisation in the reporting requirements for financial institutions.

The ability for financial authorities to expand scenario analysis and stress testing to account for nature-related risks in the short term may be hampered with the lack of global reference scenarios. However, the locality and sectoral differences in exposure to the risks may require greater tailoring of scenarios to the domestic context to account for the risks. In anticipation of the development of global nature scenarios, such as those being developed by the NGFS, authorities may start to examine the aspects listed to refine the key considerations for future use of scenario analysis and stress tests. Additionally, financial authorities may take lessons learnt from climate scenario analysis to inform their approach and move towards an integrated assessment of climate- and nature-related risks.

Financial authorities may consider credit and market risk channels to understand how these risks may impact the financial system. However, equal consideration can be given to financial risks beyond credit and market risk, to the extent they pose material risks as identified depending on the specific risk and business model of national financial institutions.

6.4. Long term considerations

In the mid- to longer term, the design of nature scenario analysis and stress tests may need to be informed by global reference scenarios. Hence, authorities may be restricted in their ability to conduct such exercises in the short-and medium-term. However, financial authorities may consider their domestic contexts in tailoring scenarios, in anticipation of future global scenario development.

Domestic risks stemming from nature loss may be a priority for financial authorities to understand the risks to the financial sector, although this is dependent on the specific country-context. Cross-border risks are an important aspect which may not be ignored by authorities. However, the possibility of joint scenario exercises will require most authorities to first understand the risks in the domestic jurisdictions.

The NGFS Nature Taskforce is currently developing work to integrate nature-related risks into the NGFS workstreams. This may include the development of global nature scenarios to complement the climate scenarios. Hence, financial authorities may make use of these scenarios in future analysis once they have been developed.

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