

Network for Greening the Financial System

NGFS Report

Summary Note on the Improvement of Modelling Tools for Nature-related Financial Risk Scenarios

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Executive Summary

Accelerating nature degradation is creating economic and financial risks. The erosion of biodiversity and the degradation of ecosystems, such as through deforestation or water pollution, are becoming a global issue. Central banks and supervisory authorities increasingly recognize the risks that unhealthy ecosystems could pose to macro-financial stability, due to their strong close interactions with growth, inflation, creditworthiness, and asset valuations.

While scenarios are strategic planning tools that are crucial in considering the economic and financial implications of nature degradation, currently available modelling frameworks still struggle to capture the complex features of economy-finance-nature interactions. Nature-related risks, as highlighted by the NGFS in 2023, are more complex than climate-related ones, notably given the large number of different ecosystems that are subjected to degradation and their geographical specificities. This complexity means that existing nature-economy-finance models are not yet fully equipped to provide the comprehensive, forward-looking insights required for robust policy and investment decisions.

The strong interlinkages between climate and the broader dimensions of nature – the ‘climate-nature nexus’ – add a layer of interactions that ultimately requires joint assessment and solutions. Climate change and nature degradation are not separate challenges but are deeply intertwined, creating feedback loops that can amplify risks. For example, deforestation reduces Earth’s capacity to absorb carbon, thereby accelerating climate change. This, in turn, further degrades ecosystems through higher temperature and changing precipitations patterns. This complex interplay means that analyzing these risks in isolation can be misleading. A holistic approach would allow to better understand how climate and nature shocks interact and to design policies that address both crises simultaneously, thereby unlocking potential co-benefits and avoiding unintended consequences.

This note takes stock of the recent surge in practical tools designed to help supervisors, central banks and financial institutions assessing the economic and financial consequences of nature degradation. A variety of approaches are emerging, ranging from

databases such as ENCORE or multi-regional input-output tables like EXIOBASE and GLORIA that map sectoral direct and indirect dependencies and pressures on nature to more sophisticated analytical frameworks. Among these, the note highlights several pioneering methods developed by NGFS members that serve as critical entry points for understanding these risks. For instance, De Nederlandsche Bank’s Ecosystem Degradation Sensitivity Indicator (EDSI) links ecosystem shocks directly to bank capital adequacy. Similarly, the European Central Bank has used the Nature-related Value at Risk (NVaR) framework to quantify how disruptions like water scarcity can impact sectoral productivity, while a Banque de France analysis demonstrates how nature-related shocks can trigger material inflation. These pioneering tools also underscore the significant opportunities for further development.

Bridging the existing gaps requires a concerted, multi-disciplinary effort to further improve both data infrastructure and modelling frameworks. The inherently local nature of physical risks, such as water scarcity and soil degradation, makes granular, location-specific data a prerequisite for micro-financial risk assessment, which however is often missing. Furthermore, it is critical to strengthen the linkages between biophysical and economic models to better translate the degradation of a specific ecosystem service into a tangible economic impact, such as a change in GDP, employment, or inflation. Current macroeconomic models are often ill-suited for this task, as they struggle to capture the non-linear dynamics, irreversible “tipping points,” and complex feedback loops that characterize natural systems. The problem is compounded by the large number of different ecosystems that are subjected to degradation. To address this, this note advocates for an integrated and modular approach, where different types of models (e.g., biophysical, land-use, and macro-financial) are linked together to provide a more holistic and robust assessment of risk transmission channels.

This note also outlines core design considerations for future NGFS nature scenarios. Key decisions will involve balancing a scenario’s severity with its plausibility, choosing the right analytical perspective for the intended use (macro vs. micro), and managing the trade-off between local detail and global consistency. Other important

considerations include selecting appropriate time horizons and, crucially, balance trade-offs when pursuing fully integrated climate-nature scenarios to capture the critical interactions between these systemic risks.

The NGFS is committed to developing standardized, policy-relevant scenarios to guide the financial sector in managing these risks. This work focuses on fostering

a collaborative ecosystem that brings together experts from ecology to finance, aligning supervisory needs with the latest scientific research. By advancing a diverse set of robust and transparent methodologies and scenarios, the NGFS aims to help financial authorities and financial institutions integrate nature, jointly with climate, into their risk management frameworks.

1. Introduction

Accelerating nature degradation is creating economic and financial risks¹. The global erosion of biodiversity and the accelerating degradation of ecosystems are transforming the global risk landscape for economies and financial systems.² Central banks and supervisors increasingly recognize that unhealthy ecosystems are a potential risk to macro-financial stability, due to their strong close interactions with growth, inflation, creditworthiness, and asset valuations.^{3, 4}

The NGFS conceptual framework on nature-related financial risks⁵ outlines how nature degradation impacts economies and the financial system. Nature⁶ supplies ecosystem services – from timber production and fisheries to pollination, soil fertility, water provision and climate regulation – that are indispensable to production, consumption, and long-term economic development. The human-induced degradation of these services creates physical risks, like reduced output and asset devaluation. Although necessary to manage such risks, policies to address nature degradation, if insufficiently anticipated, can introduce transition risks by altering prices and revenues due to quick shift in the economy. Both physical

and transition risks can spread through supply chains and financial markets, posing systemic threats.

In this context, the NGFS is focused on developing scenarios to enable central banks and supervisors⁷ to evaluate the potential effects of nature degradation, and the corresponding policy responses, on economic performance and financial stability. This note aims to take stock of ongoing discussions and methodological approaches in the economic and financial modelling of nature-related risks, and puts forward recommendations for the way ahead. It highlights progress since the latest NGFS publication on the topic,⁸ especially in nature-related risk assessment by NGFS members and researchers, acknowledges remaining gaps and sets a forward agenda to embed nature-related risks into macro-financial analysis and prudential oversight. The insights informing this proposed agenda draw extensively on an NGFS workshop conducted in August 2025 on “Designing and modelling nature-related financial risks scenarios” hosted by Banque de France in Paris, which convened environmental economists, macroeconomic and biophysical modelers, and central bankers.

1 NGFS (2022), *Statement on Nature-related Financial Risks*.

2 In this note, biodiversity erosion and ecosystem degradation will be collectively referred as nature degradation.

3 FSB (2024). *Stocktake on Nature-related Risks Supervisory and regulatory approaches and perspectives on financial risk*. Financial Stability Board.

4 NGFS (2024). *Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors*.

5 NGFS (2024). *Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors*.

6 In this note, nature is defined as “the natural world with an emphasis on the diversity of living organisms and their interactions among themselves and with their environment” in line with the IPBES (2019), *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, definition and as applied in NGFS (2024), *ibid*.

7 Usable nature-related scenarios could help supervisors to nudge intermediaries to look for and mitigate these heterogeneous risks. Intermediaries are in a unique position to integrate them in their risk-appetite framework.

8 NGFS (2023). *Recommendations toward the development of scenarios for assessing nature-related economic and financial risks*.

2. The Climate-Nature Nexus

As climate change intensifies and nature continues to degrade, understanding the interdependence between climate and nature has become essential for designing effective policy and risk-management frameworks.^{9, 10}

A growing number of studies show that treating climate and nature jointly within scenarios can materially alter both the scale and the timing of risks, revealing vulnerabilities that remain hidden when these dimensions are considered in isolation.^{11, 12} For instance, as global temperatures rise, some species might go extinct while others are forced to migrate to cooler environments, which disrupts ecosystems. This loss of ecosystem integrity and functionality, in turn, weakens the ability of natural ecosystems to store carbon, thus accelerating climate change.¹³ Treating nature and climate jointly also allows to assess the trade-offs between climate mitigation and nature protection and the potential harm that climate mitigation policies can cause to nature, as can be the case when biodiversity and ecosystem functioning are harmed by poorly planned tree planting prioritizing fast-growing monocultures over native species, or with the extraction of critical minerals for renewable energies¹⁴. Integrating ecosystem-service degradation, climate hazards, and economic and financial exposures into a unified analytical framework therefore provides a more comprehensive representation of systemic economic and financial risk¹⁵).

Physical risks are amplified when climate hazards intersect with ecosystem service dependencies, thus creating compound shocks to the financial systems.

Using financial network analysis, a recent study combines firm-level exposure to hazards (e.g., droughts, floods) and reliance on ecosystem services (e.g., water supply,

vegetation-based flood protection) with bank lending data.¹⁶ Community detection reveals clusters where firms simultaneously face multiple climate-related hazards and ecosystem-service degradation – such as high drought exposure alongside heavy surface-water dependence, or flood risk coupled with loss of vegetative buffers. These clusters show how climate and nature shocks interact and could propagate through firms and reach the financial system.

At the same time, integrated climate and nature policies can lower economic and financial risks and provide a more comprehensive understanding of potential challenges.

A recent paper developed integrated climate–nature scenario narratives to align climate mitigation with nature restoration policies.¹⁷ Comparing integrated and siloed approaches shows materially different risk profiles: integrated scenarios provide a more comprehensive and granular view of biophysical and economic risks, with meaningful variation across policy pathways. Crucially, coordinated climate–nature action yields lower economic risk than separate, uncoordinated policies. These insights support embedding nature alongside climate in central bank and supervisory risk frameworks – consistent with NGFS guidance – and underscore the broader policy value of integrated approaches to managing the low-carbon and nature-positive transitions.

NGFS’ envisioned scenarios aim to capture nature-specific features, while maximizing consistency and complementarity with existing NGFS climate scenarios. Nature-specific features include for instance the multiple transmission channels between ecosystems and the economy, the lack of a single “CO₂-equivalent”

9 H.-O. Pörtner *et al.* Overcoming the coupled climate and biodiversity crises and their societal impacts. *Science* 380, 4881 (2023). DOI: [10.1126/science.aba4881](https://doi.org/10.1126/science.aba4881).

10 Pörtner, H. O., *et al.* (2021). IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. DOI: [10.5281/zenodo.4782538](https://doi.org/10.5281/zenodo.4782538).

11 Stevanović, M., Ceglar, A., von Jeetze, P. J., Costermani Visconti, A., Krisht, S., Johnson, J., Borrelli, P., Heemskerck, I., Popp, A., & Zadek, S. (2024). *Climate-nature scenario development for financial risk assessment*. Nature Finance.

12 Green Finance Institute (GFI) *et al.* (2024). Assessing the Materiality of Nature-Related Financial Risks for the UK.

13 Weiskopf, S. R., Isbell, F., Arce-Plata, M. I. *et al.* Biodiversity loss reduces global terrestrial carbon storage. *Nat Commun* 15, 4354 (2024). <https://doi.org/10.1038/s41467-024-47872-7>.

14 Pörtner, H. O., *et al.* (2021). IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. DOI: [10.5281/zenodo.4782538](https://doi.org/10.5281/zenodo.4782538).

15 See NGFS (2026), *Note on the Supervision of Nature-related risks* for details.

16 Ceglar, A., Marques, A., Boldrini, S. *et al.* European banks face significant vulnerability to ecosystem degradation and climate change. *Commun Earth Environ* 6, 750 (2025). <https://doi.org/10.1038/s43247-025-02543-3>.

17 Stevanović, M., Ceglar, A., von Jeetze, P. J., Costermani Visconti, A., Krisht, S., Johnson, J., Borrelli, P., Heemskerck, I., Popp, A., & Zadek, S. (2024). *Climate-nature scenario development for financial risk assessment*. Nature Finance.

metric, and the interplay between localized impacts and global systemic consequences.

Constructing these scenarios demands an integrated view of the economy-finance-nature nexus. As Figure 1 illustrates, four tightly interconnected dimensions must be captured:

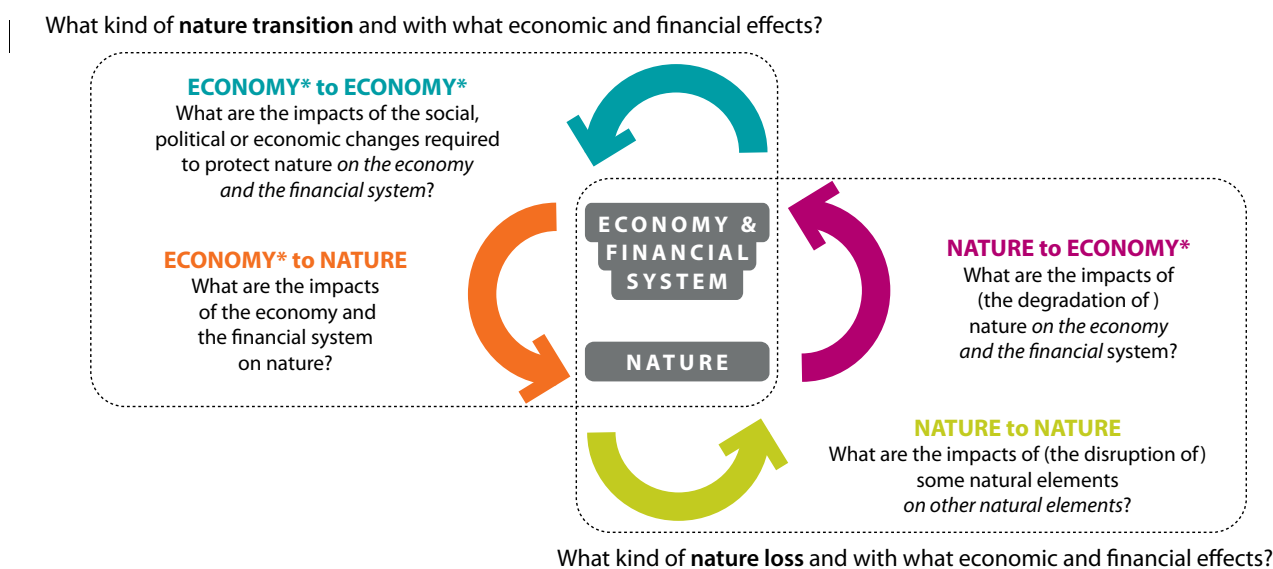
1. The complex dynamics of nature itself, including interconnections and feedback loops among biodiversity, land, water, and climate systems;
2. The economy’s and financial sector’s dependencies on ecosystem services, such as marine resources, timber production and other materials, pollination, soil fertility, water provision, climate regulation, and many other ecosystem services that are necessary to economic production;
3. The economy’s and financial sector’s impacts on nature through land-use change, pollution, resource

extraction, GHG emissions, and the introduction of invasive species; and

4. The impact of policy measures that can slow, halt, or reverse nature degradation, ranging from conservation targets to financial sector policies and fiscal incentives on the economy and the financial system.

Consequently, developing credible nature-related financial risk scenarios requires strong collaboration between earth scientists, ecologists, economists, data scientists, and financial risk experts. Building on existing work promoting climate-nature integrated assessment and following updates from scientific bodies such as the IPCC and IPBES would help better address trade-offs and identify synergies. This would ensure that scientific insights are translated into the “common language” of macro-financial analysis. Each of these dimensions involves distinct datasets, scientific disciplines, and modelling approaches.

Figure 1 **A framework for analyzing nature-economy-finance interactions**



*Here, “economy” refers to both the real economy and the financial system.
Source: Authors, based on [Salin et al. 2024](#).

Despite recent advances, modelling approaches for assessing the economy-finance-nature nexus still struggle to capture the nature-specific characteristics needed to assess economic and financial impacts more accurately. In 2023 the NGFS issued a technical document, “Recommendations Toward the Development of Scenarios for Assessing Nature-Related Economic and

Financial Risks.”¹⁸ This report highlighted that despite great progress in recent years, existing modelling approaches for assessing the economy-finance-nature nexus might still underestimate or misrepresent the economic and financial risks associated with nature degradation and the transformative changes needed to halt and reverse it.

18 NGFS (2023). Recommendations toward the development of scenarios for assessing nature-related economic and financial risks.

3. Noteworthy Advances Are Emerging

In the absence of fully-fledged nature-related financial risks scenarios, recent years have seen a surge of practical tools that help financial institutions and central banks and supervisors measure whether nature degradation could threaten financial portfolios.

Databases such as ENCORE¹⁹ or multi-regional input–output tables like EXIOBASE²⁰ and GLORIA²¹ and their environmental extensions, map how individual sectors depend and put pressure on specific ecosystems and ecosystem services, and trace how those sectors are linked through global supply chains²². Used together, they highlight “hot-spots”: regions or industries whose revenues stem from vulnerable natural assets, signaling where credit, market, or operational exposures may concentrate.²³ For instance, studies consistently find that water-related ecosystem services, like water supply and flood control, pose one of the most significant risk, as sectors heavily dependent on them – including agriculture, but also manufacturing and energy production – account for a large share of economic output and bank lending.

These approaches provide important and widely used entry points for understanding nature-economy linkages but also highlight opportunities for further development. ENCORE, for example, provides sectoral

scores based on global or country averages, which means it overlooks crucial area-specific contexts.²⁴ Likewise, traditional input–output models are essentially static and scale economic relationships linearly; they are unable to capture evolving ecosystem conditions, tipping points, macroeconomic feedback loops beyond sectoral multiplier effects, or the real-world difficulty of substituting scarce natural inputs.²⁵ This would generally lead to an underestimation of tail risks and can lead to either underestimating losses if substitution is assumed to be smooth or overestimating them if alternatives are ignored.

However, emerging methods are addressing some of these limitations by integrating global data with local context to provide a more refined analysis.^{26, 27}

These approaches set materiality thresholds and layer in additional geolocated biophysical data, such as water stress maps, ecosystem integrity scores (as in the DNB-EDSI²⁸ framework (see box 1)), or proximity to ecological tipping points (as in the ESGAP-SESI²⁹ framework) – to provide a more detailed picture of risk.

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

20 <https://www.exioibase.eu/>.

21 <https://ielab.info/accounts/login?PostAuthenticationURLParam=%2Fresources%2Fgloria>.

22 See NGFS (2026): *Navigating nature-related data: metrics, sources and uses for more details*.

23 See for instance DNB 2020, Svartzman *et al.* 2021, World Bank 2021, World Bank and Bank Negara Malaysia 2022, Martinez-Jaramillo *et al.* 2023, Boldrini *et al.* 2023, UNDP 2025, World Bank 2025b, Ceglar *et al.* 2025., Hadji-Lazaro *et al.*, 2024.

24 The ENCORE website recently was updated to include country dashboards for European Union countries to provide country-level dependencies and impacts by linking ENCORE materiality ratings to the EXIOBASE Input-Output data (<https://countries.encorenature.org/>).

25 Nevertheless, there are new dynamic input-out models which overcome some of the above-mentioned limitations.

26 Hadji-Lazaro, Paul, Julien Calas, Antoine Godin, Andrew Skowno, Pamela Sekese (2025). A framework to assess socioeconomic and spatialized nature-related risks: An application to South Africa. *Environmental and Sustainability Indicators*, Volume 26, <https://doi.org/10.1016/j.indic.2025.100605>.

27 See for instance Maurin *et al.* (2025). Assessing economic exposure to nature-related risks. AFD Research Papers.

28 Gallet, S., Hendricks, A., Prodani, J. (2024). The ecosystem service degradation sensitivity indicator (EDSI): A new framework for understanding the financial risk repercussions of nature degradation. DNB Working Paper.

29 Usubiaga-Liaño, A., & Ekins, P. (2021a) Monitoring the environmental sustainability of countries through the Strong Environmental Sustainability Index. *Ecological Indicators*, 132, 108281. <https://doi.org/10.1016/j.ecolind.2021.108281>.

Box 1

Quantifying Nature Degradation for Financial Stability: The Ecosystem Degradation Sensitivity Indicator (EDSI) Framework

The EDSI framework, developed in a recent De Nederlandsche Bank (DNB) working paper¹, offers a practical pathway for nature-risk assessment in the absence of “perfect, fit-for-purpose” methodologies.

The EDSI framework moves beyond static exposure mapping by translating shocks to ecosystem services into concrete impacts on a bank’s capital adequacy. It achieves this by modelling how nature degradation can trigger asset depreciation for firms, which in turn erodes a bank’s capital base. This transmission from nature to the financial system is quantified by analyzing three core components:

1. **Ecosystem Shock:** The severity of the disruption to a specific ecosystem service, such as water provision or pollination.
2. **Sectoral Dependence:** The degree to which an economic sector relies on that ecosystem service for its operations and profitability.
3. **Geographic Vulnerability:** The extent of nature degradation in the specific locations where a firm and its upstream suppliers operate, which can be traced using input-output methods.

The framework’s analytical strength comes from its foundation in the Merton (1974) model, a cornerstone of modern credit risk assessment. While the Merton model assesses default risk based on a firm’s asset value relative to its debt, the EDSI framework innovatively extends this logic by incorporating the degradation of nature as a driver of depreciation of firms’ assets.

By linking environmental stress to prudential metrics, the EDSI framework allows supervisors to identify and prioritize vulnerable financial institutions, fostering targeted dialogue on risk management and capital planning. Its flexible design allows authorities to conduct sensitivity analyses using a range of available proxy data.

Future development of the framework can extend its application beyond credit risk to assess market risks in bond and equity portfolios, evaluate impacts on insurers’ capital positions, and model more complex scenarios that integrate the interconnected shocks of nature degradation and climate change.

1 Gallet, S., Hendricks, A., Prodani, J. (2024). The ecosystem service degradation sensitivity indicator (EDSI): A new framework for understanding the financial risk repercussions of nature degradation. DNB Working Paper.

Other approaches focus on creating narratives for nature-related risks³⁰ or pioneering new approaches to model their economic and financial consequences.³¹

For example, a study by the Green Finance Institute et al., (2024) introduces several innovations, such as creating the first UK Nature-Related Risk Inventory, analyzing international supply chain dependencies, developing sector-specific nature risk scores (NVaR) that have since

also been applied to the Euro area portfolio (see box 2).³² The UK study also goes one step further by modelling the macroeconomic impacts of these risks and conducts for the first time a nature-related financial stress test on the UK’s seven largest banks. The analysis suggests that physical nature-related risks could lead to a 4-5% adjustment in the valuations of domestic lending over the next decade.

30 Ranger, N., Alvarez J., Freeman, A., Harwood, T., Obersteiner, M., Paulus, E. and Sabuco, J. (2023). The Green Scorpion: the Macro-Criticality of Nature for Finance – Foundations for scenario-based analysis of complex and cascading physical nature-related risks. Oxford: Environmental Change Institute, University of Oxford.

31 Green Finance Institute (GFI) et al. (2024). Assessing the Materiality of Nature-Related Financial Risks for the UK.

32 Ceglar, A., et al. (2025). Nature at risk: Implications for the euro area economy and financial stability. ECB Occasional Paper Series No. 380.

Box 2

Nature-related valuation and risk (NVaR): a bridge between nature and financial risk

The Nature-related Value at Risk (NVaR) framework translates the degradation of natural ecosystems – such as biodiversity loss or water scarcity – into quantifiable metrics for economic and financial decision-making. It provides a systematic way to measure how disruptions to critical ecosystem services, like water purification or flood protection, can impact sectoral productivity and propagate through the financial system (see figure 2).

In a recent European Central Bank (ECB) paper¹, the NVaR framework was applied to the euro area economy to assess risks stemming from the degradation of water-related ecosystem services. The analysis revealed that these risks are a material threat. Under a severe but plausible surface-water scarcity scenario, the study found that up to 24% of the euro area's economic output could be at risk. Furthermore, a complementary analysis identified a potential feedback loop where euro area firms and banks contribute to the degradation of the

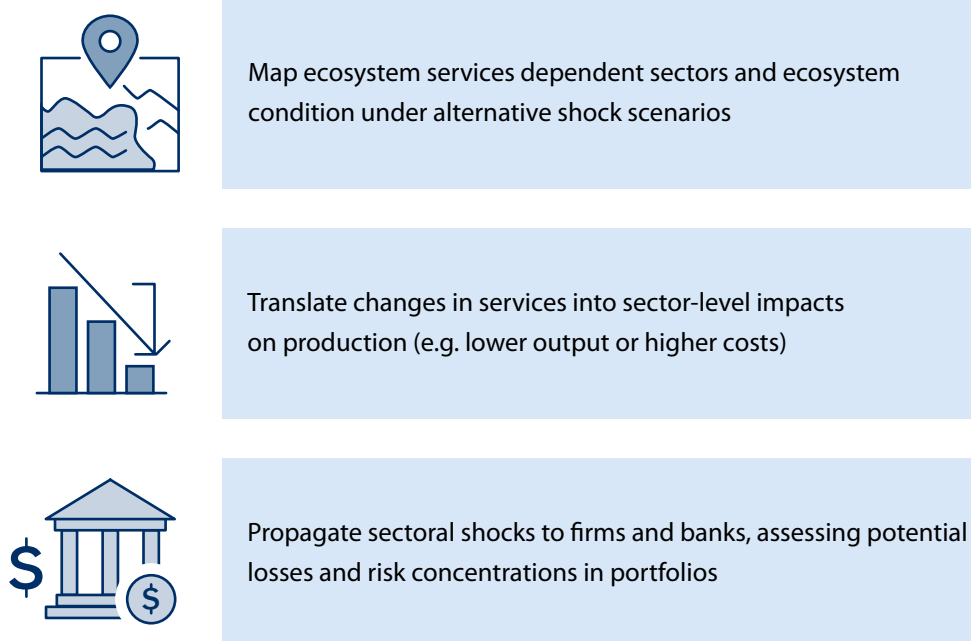
very water services they depend on, amplifying financial risks over time.

Although constrained by data limitations, the NVaR framework demonstrates how nature-related risks can be quantified in a manner relevant to central banks and supervisors. Key applications include:

- Identifying Risk Hotspots: Pinpointing the specific sectors, regions, and financial counterparties most exposed to ecosystem disruptions.
- Informing Stability Assessments: Translating ecosystem shocks into potential macro-financial impacts, enabling a more forward-looking approach to financial stability monitoring.

By providing a clear methodology to measure these emerging threats, the NVaR framework supports the integration of nature-related risks into supervisory oversight and policy development.

Figure 2 The three steps of the NVAR approach



Source: Ceglar et al. 2025.

1 Ceglar, A., et al. (2025). Nature at risk: Implications for the euro area economy and financial stability. ECB Occasional Paper Series No. 380.

There is also a growing body of biophysical models emerging that incorporate specific linkages between ecosystems and the economy.³³ Biophysical models examine issues such as the impact of pollination on crop yields, the role of nature degradation in water scarcity (e.g., through deforestation and wetland degradation), and the effects of land use on deforestation. For instance, the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP)³⁴ offers over 200 biophysical models in 10 biophysical sectors, such as fishing and water. This provides a consistent framework to compare model results across biophysical sectors and scales, assess interlinkages, and align with global climate scenarios.³⁵ Yet, ISIMIP models are currently not sufficiently linked to the economy, marking a key area for future development.³⁶

Furthermore, new approaches are being developed to assess the potential macroeconomic impacts of nature degradation and nature policies (see box 3 and 4).^{37,38} For instance, Johnson *et al.* (2023)³⁹, modeled how future GDP growth will result in the expansion of cropland, pastureland, and managed forests using the SEALS LUC model. Using the InVEST and DBEM models, they show how this future change in land use could affect six ecosystem services. Then, they connect these declining ecosystem services to the economy to analyze both how this could result in physical risks (by affecting GDP for example) and the economic policies that could mitigate those risks stemming from nature degradation.

Box 3

Assessing the Inflationary Impact of Nature Degradation in France

A 2025 Banque de France working paper¹ provides a model-based analysis of how nature degradation can create material macroeconomic risks, specifically by triggering inflationary episodes through the agricultural sector. The research uses a multi-model approach to quantify how nature-related shocks to agriculture can propagate through supply chains and affect consumer prices.

The authors employ two distinct but complementary methods to assess the impact on French inflation (see figure 3):

1. **Bottom-Up Approach:** This approach first identifies the exposure of key crops to four nature-related hazards:

water stress, pollination loss, invasive species, and pests. The resulting yield reductions are treated as a productivity shock. This shock is then fed into a global value chain model to simulate its impact on agricultural prices. Finally, these price increases are channeled into an inflation forecasting model.

- **Key Finding:** A simulated nature-related shock to agriculture could increase French agricultural prices by 13%, leading to a total impact of +0.54 percentage points on headline consumer price inflation (HICP) over a one- to two-year horizon.

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1 Wegner, O., *et al.* (2025), Seeds of Inflation: Macro Modelling of Nature-Related Risks through Agricultural Prices, Banque de France Working Paper No. 1006.

33 See for a review Johnson *et al.* (2025). Earth-Economy Modelling: Advances in Linking Economic and Ecosystem Models. Annual Review of Resource Economics. Vol. 17.

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

35 For a review of selected models in the ISIMIP suite, please be referred to NGFS (2023). Recommendations toward the development of scenarios for assessing nature-related economic and financial risks.

36 Ibid.

37 Johnson, Justin Andrew; Baldos, Uris; Cervigni, Raffaello; Chonabayashi, Shun; Corong, Erwin; Gavryliuk, Olga; Hertel, Thomas; Nootenboom, Christopher; Gerber, James; Ruta, Giovanni; Polasky, Stephen. (2021). The Economic Case for Nature: A Global Earth-Economy Model to Assess Development Policy Pathways. © World Bank.

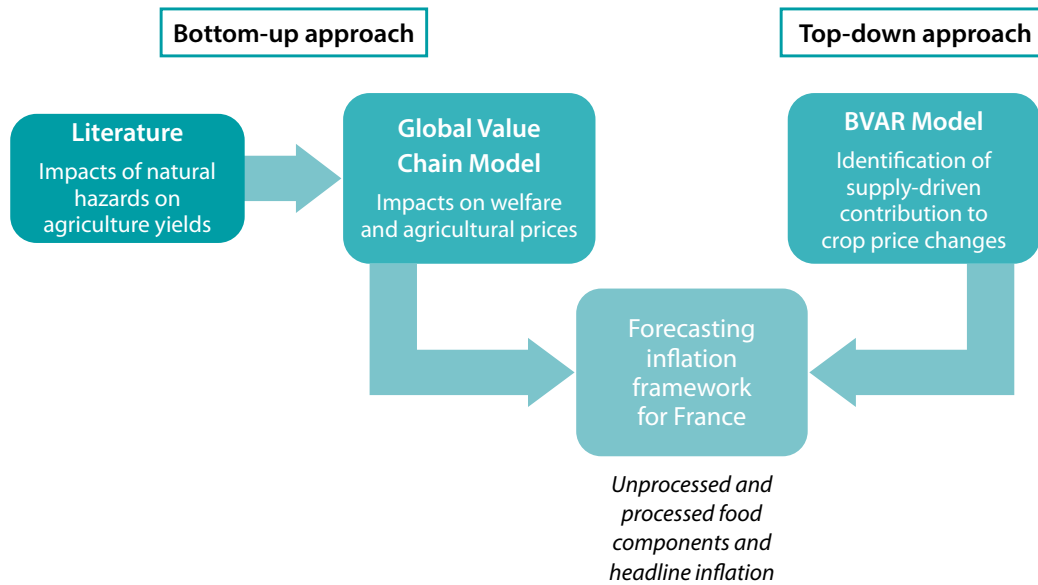
38 Wegner, O., *et al.* (2025). Seeds of Inflation: Macro Modelling of Nature-Related Risks through Agricultural Prices. Banque de France Working Paper.

39 Johnson J. A., Baldos U. L., Corong E., Hertel T., Polasky S., *et al.* (2023a). Investing in nature can improve equity and economic returns. *PNAS* 120: e2220401120.

2. **Top-Down Approach:** This approach starts with observed historical price movements of major agricultural commodities. Using a Bayesian VAR model, it disentangles the drivers of these price changes, isolating the portion attributable to idiosyncratic, nature-related production shocks. This historical shock data is then used to model the inflationary impact.

- **Key Finding:** This method estimates that a simultaneous materialization of nature-related shocks would increase headline HICP by approximately +0.41 percentage points, an order of magnitude consistent with the bottom-up results.

Figure 3 The multi-model framework underlying the Banque de France approach



Source: Wegner et al. 2025.

The study demonstrates that nature-related risks are a tangible threat to price stability. While the simulated shocks are modeled as one-off events with a short-term inflationary impact, the authors caution that an intensification or frequent recurrence of such events

could lead to more persistent inflationary pressures. Furthermore, reduced profitability in exposed sectors could create heightened financial tensions, posing a dual risk to both price and financial stability mandates.

Box 4

Modelling the Economic Co-Benefits of Nature-Based Climate Policy in Chile

To achieve its goal of carbon neutrality by 2050, Chile's climate strategy (Nationally Determined Contributions, or NDCs) relies heavily on its Forestry and Other Land Uses (FOLU) sector to act as a net carbon sink. A 2025 study by Banerjee *et al.*¹ analyzes the broader economic and environmental impacts of these FOLU strategies, demonstrating that climate action can generate significant co-benefits.

The analysis uses an Integrated Economic-Environmental Modelling (IEEM + ESM) platform, which links a dynamic economic model (CGE) with spatial land-use and ecosystem service models. This framework allows for a holistic assessment of policy scenarios – such as reducing wildfire-driven forest loss, afforestation, and restoration – by tracking their effects on the economy, land use, and the environment simultaneously.

A key feature of the framework is its ability to create feedback loops. For instance, improvements in ecosystem services like soil retention and crop pollination, which result from the FOLU policies, are translated into productivity gains for the agricultural sector. These gains are then fed back into the economic model to calculate the final macroeconomic impact.

Overall, the results suggest that policies that enhance nature can simultaneously improve ES and economic growth and employment. The analysis reveals that implementing Chile's FOLU strategies generates substantial positive outcomes beyond carbon reduction. Key findings include:

- **Economic Gains:** The policies would result in cumulative GDP gains of US\$16 billion by 2050, primarily driven by increased timber provision and enhanced ecosystem services that boost agricultural productivity.
- **Environmental Co-Benefits:** The strategies significantly improve water security, reduce soil erosion, and enhance crop pollination, contributing to a more resilient and sustainable agricultural sector.
- **Most Effective Policy:** Policies aimed at reducing forest loss from wildfires were found to be the most effective and expedient way to meet NDC targets while unlocking these benefits.

The IEEM + ESM framework provides a powerful example of how policymakers can quantitatively assess the transition pathways of their climate strategies. The Chilean case demonstrates that well-designed, nature-based climate policies are not a cost but an investment, capable of delivering mutually reinforcing economic, social, and environmental returns.

1 Onil Banerjee *et al.* (2025) *Environ. Res.: Ecology* 4 035002.

4. Bridging the Gaps in Data and Modelling for Nature-Related Risk Assessment

To fully assess nature-related financial risks, there is a need to further improve analytical tools and data infrastructure through an integrated and modular approach. Despite notable progress, critical gaps in data and modelling still hinder the ability of central banks and supervisors to fully assess nature-related financial risks. Overcoming these challenges requires a concerted effort to further improve data infrastructure and analytical tools. A modular approach that integrates biophysical, sectoral, and macro-financial models is key to developing credible, policy-relevant scenarios.

Key priorities for action include short-term achievable improvements, particularly related to data availability, transparency and consistency, and long-term structural developments, aimed at advancing modelling frameworks:

- **Enhancing geospatial data granularity:** The inability to conduct more precise microfinancial risk assessments stems from a significant informational deficiency: the lack of granular data mapping the geographic location of corporate assets and their associated supply chains. Such data is a prerequisite for evaluating exposure to physical nature risks, as these hazards are inherently location-specific and their impacts are not uniform across a given economic sector. Likewise, firm- and household-level microdata such as sales, employment, or income would enable a more granular mapping and assessment of transmission channels.
- **Enhancing nature-related data quality and consistency:** Quality, coverage, and consistency of nature-related data – data about the current state of ecosystems as well as the ecosystem services they generate – vary significantly, often due to a lack of sustained funding for data collection. To address this, efforts must prioritize improving data quality and consistency through robust verification methods, such as geospatial analysis, and by establishing well-funded, continuous data production flows similar to those used by financial data providers.
- **Enhancing sectoral, spatial and technological granularity in modelling frameworks:** The structure of standard macroeconomic models often fails to capture the localized (e.g., water-scarce vs. water-abundant regions within a country) and process-specific (e.g., substitution possibilities for pollination) nature of ecological impacts. Models and datasets also need to be enhanced to incorporate greater sectoral and spatial detail. For example, datasets like ENCORE or input–output tables, which can be a basis to models, classify economic activities using standard sector typologies (such as NACE or ISIC). However, the level of sectoral aggregation of these datasets – and models that rely on them – does not allow for sufficient differentiation between specific practices within a sector (e.g. intensive vs. organic agricultural practices, or different manufacturing processes), even though such practices can vary significantly in their impact on nature and their dependence on ecosystem services.
- **Embracing a multi-disciplinary approach:** Because single-model approaches may struggle to capture all dimensions of nature-related risks, an approach bringing in expertise from multiple disciplines and linking different models seems necessary. One solution could be to couple macro-financial models with sector-specific models that can better represent detailed changes in production practices⁴⁰ – for example, partial-equilibrium land-use models. This integrated and modular approach allows for a more comprehensive assessment by combining the strengths of different models. However, model coupling can also raise methodological challenges, among which the difficulties to represent feedback loops between macro-financial and sectoral modelling, and the potential lack of common variables, different spatial coverage and time periodicity between the different models.
- **Strengthening biophysical-economic linkages in modelling frameworks:** Current nature-economy models provide incomplete coverage of ecosystem services (e.g., overlooking soil formation or coastal protection) and do not fully represent the interconnection of ecosystem services, despite notable progress over the last years. Furthermore, translating ecosystem service degradation into changes in GDP, employment or inflation requires modelling the

40 See for instance the NGFS short-term climate scenarios as an example of soft-linking multiple modelling frameworks (NGFS 2025, Mandel *et al.* 2025).

various “transmission channels”⁴¹ through which ecosystem service losses affect the economy (see box 5). These channels can include, for example, ecosystem service losses translating into higher food prices causing consumers to adjust their consumption basket, producers having to substitute inputs, and impacts on workers’ health that affect labor productivity. Many of these transmission channels are currently not sufficiently specified in most nature-economy models. Another important approach is the explicit representation of ecosystem services as an input into sectoral production functions of nature-economy models, allowing declines in ecosystem conditions to directly affect economic output and productivity. More interdisciplinary collaboration between biophysical and economic modelers could help closing this gap.

- **Improve model dynamics:** Most standard macroeconomic models rely on assumptions of exogenous growth (e.g. labor productivity), smooth adjustment of (relative) prices, rational expectations of homogenous agents, a stable equilibrium, and lack endogenous financial sector amplification. These features constrain their ability to represent tipping points and non-linearities that are central to nature-related risks, as the abundance and stability of ecosystem services can no longer be taken for granted. Models often fail to represent the risks of breaching irreversible thresholds after which

ecosystems cannot be restored, therefore threatening the economic activities that directly or indirectly depend on the services these ecosystems provide. Moving beyond these assumptions to better reflect the materiality of nature-related risks is particularly important if scenarios are to be used in stress-testing exercises, which aim to test the resilience of the financial system to severe but plausible shocks.

- **Standardizing uncertainty and sensitivity analysis:** To ensure the credibility of these complex models, a transparent framework for managing uncertainty, particularly relevant in the context of nature-economy interactions, is essential. This involves running diverse complementary models in parallel to compare results, conducting sensitivity analyses and robustness checks.⁴² Likewise, maintaining open-source code and documentation ensures transparency and helps demystifying “black-box” perceptions of model results.

An important next step will be to turn these key priorities into concrete technical pathways, such as the explicit incorporation of ecosystem services into production functions, the formalization of the link between asset value impairment and credit risk, or the development of modular interfaces between biophysical and macro-financial models.

41 See the transmission channel figure in the NGFS conceptual framework document (NGFS, 2024).

42 One way could be by creating ‘envelopes’ of scenarios. This involves testing various combinations of external factors and internal parameters to see a wider range of potential outcomes.

5. Towards Nature-related Financial Risk Scenarios

When designing NGFS nature risk scenarios, relevant for the financial sector, several core considerations beyond modelling and data are crucial.

First, a decision in scenario design is balancing severity with plausibility. This balance informs the choice between two main approaches: an “ecosystem-centered” view, which enhances plausibility by starting with already threatened ecosystems and mapping their economic effects (e.g. scenarios based on water-related risks and their spillovers), and an “economy-centered” view, which prioritizes severity by focusing on scenarios with the greatest potential economic impact (e.g. a scenario of a global agriculture crisis due to the deterioration of several ecosystem services at once with consequences on food and manufactured production).

Second, the analytical perspective chosen will influence the final use of the resulting scenarios.

A macroeconomic perspective is more suitable to assess systemic effects on indicators like GDP, inflation and systemic financial risk. In contrast, a microeconomic perspective provides the granular, sector- and location-specific detail required by financial institutions to assess localized impacts. Conversely, the minimum analytical outputs of nature scenarios (deliver macroeconomic loss paths, sectoral vulnerability metrics, capital shortfall estimates, tail-risk indicators...) might vary depending on a potentially desirable final use.

Third, there is a “local-global trade-off” in the modelling framework.

Global scenarios offer a systemic view for a coherent narrative reflecting trade interconnectedness, cross-country comparison and identifying transboundary risks. Such scenarios could include major, high-impact, tipping points events with global consequences. Examples include the collapse of the Atlantic Meridional Overturning Circulation (AMOC)⁴³ or the dieback of the Amazon rainforest⁴⁴, both of which could drastically alter global precipitation and temperature patterns. Individual country scenarios offer more spatial explicitness. This allows to

model more specifically the consequences of ecosystem service degradation on economic activities as well as more detailed policies or even policy mixes. Such insights can be useful for more granular risk management or to design more tailored policy tools. An incremental approach, for instance starting with smaller-scale scenarios targeted on regionally relevant narratives and gradually adding complexity and interconnection with global narratives, can offer both depth and coherence. Yet, it is more resource- and time-intensive.

Fourth, another critical decision is the choice of the time horizon.

Shorter-term scenarios (3-5 years) are more tangible and align with traditional stress-testing frameworks used by central banks and supervisors and financial institutions. A longer horizon (20+ years) may reflect more adequately the materiality of the economic and financial risks as well as the benefits of nature policies, as many more severe nature-related impacts and restorative benefits only materialize over decades.

Fifth, there is a trade-off between simplified and more in-depth assessments of selected ecosystem service failures and aiming for comprehensive coverage.

Focusing on a few key ecosystem services, like water or biomass, is more efficient, improves communication, and allows for more precise economic modelling where data is strong. However, focusing narrowly only on one ecosystem service at the expense of others risks underestimating nature-related systemic risks, which often stem from the interaction between multiple services. A broader approach, while more complex, provides a more holistic risk assessment and is becoming more feasible as modelling capabilities advance.

Finally, there is a trade-off between developing stand-alone nature risk scenarios versus those integrated with climate change.

The ultimate objective for the NGFS is to design scenarios integrating nature and climate, as these two sources of physical risk would be cumulative or even amplifying, while nature-related policies could offer

43 Sybren Drijfhout et al. (2025) *Environ. Res. Lett.* **20** 094062.

44 Flores, B. M., Montoya, E., Sakschewski, B. et al. Critical transitions in the Amazon forest system. *Nature* **626**, 555–564 (2024). <https://doi.org/10.1038/s41586-023-06970-0>.

climate-related co-benefits. However, the integration of nature-related risks into climate scenarios presents some methodological challenges: unlike climate change, which has a clear metric (CO₂ equivalent reduction), nature lacks a single, condensed measure and is multidimensional. Furthermore, many ecosystem services, such as the

regulation of local climate and air quality, are difficult to quantify and value. These factors make modelling nature's economic impact more complex than climate's, requiring more sophisticated endogenous interactions than are currently available in most climate-economy models.

6. Recommendations for the Development of Nature-related Financial Risk Scenarios

Based on the progress and insights gathered, several high-level recommendations can guide the next steps in advancing the development of nature-related financial risk scenarios and the assessment of nature-related physical and transition risks.

- 1. Even if nature is multi-dimensional and context-specific, a unified set of global nature-related financial risk scenarios could be very beneficial for the policy and business community.** Drawing inspiration from the standardized frameworks used for climate analysis, creating central bank-endorsed scenarios could provide a consistent foundation for financial institutions to assess their exposures and will allow for global comparability. It may be valuable to pursue the development of both global and local narratives in parallel – for instance, using global-scale narratives informed with location-specific characteristics to downscale impacts locally- as this dual approach can capture systemic, cross-border risks as well as the specific ecological and economic conditions of a particular jurisdiction. Engaging with scientific bodies like the IPBES scenario and models task force could further strengthen the scientific grounding of these scenarios and facilitate their eventual integration with existing climate frameworks.
- 2. Fostering the co-development of analytical capabilities, both within central banks and supervisors and in the broader research community, is essential.** This involves fostering a multidisciplinary approach and providing stable, long-term support to external research teams to advance modelling frontiers, while simultaneously investing in continuous training to build internal expertise. A key focus should be on improving the quality, consistency, and granularity of the underlying data. Establishing well-funded, continuous data production flows, similar to those for traditional financial data, and using robust verification methods like geospatial analysis could significantly enhance the reliability of risk assessments.
- 3. It is important to build upon the promising methodologies that have already been developed and applied, while complementing those with new approaches.** Valuable insights for both methodological advancement and practical risk management can be gained by further refining and applying the approaches

currently utilized by a growing number of NGFS members. Encouraging the continued use, enhancement and interconnection of these tools will accelerate learning and help identify best practices across the financial sector. Nevertheless, new, complementary approaches would help overcome limitations of existing models (see Section 4). A diverse modelling approach would also allow to better address the inherent uncertainties in nature-economy interactions (see also next point).

- 4. A core principle guiding all efforts must be commitment to robust validation.** It is important to rigorously test model outputs against observed, real-world data. Since future nature-related impacts may not mirror the past, it is also crucial to develop transparent frameworks for managing uncertainty. This includes running diverse models in parallel to compare results, conducting sensitivity analyses, and maintaining open-source code and documentation. Maintaining these standards is paramount for preserving the credibility of central banks and supervisors and ensuring that the management of nature-related risks is based on robust and reliable scientific evidence.
- 5. NGFS' envisioned scenarios aim to capture nature-specific features, while maximizing consistency and complementarity with existing NGFS climate scenarios.** The integration of climate- and nature-related financial risk scenarios is important, as it will allow for the assessment of cumulative and amplifying risks, as well as the co-benefits of nature-positive policies (see section 2 and 5). To achieve this, a dual approach is envisioned: developing standalone nature scenarios in the short term to accelerate progress, while simultaneously working towards fully integrated climate-nature scenarios as the ultimate objective.

The NGFS is working to create standardized scenarios to help central banks, supervisors and financial institutions understand and assess nature-related economic and financial risks. This involves fostering collaboration between experts from various fields and aligning supervisory needs with the latest academic research. The NGFS aims to accelerate the development of robust methodologies and ultimately integrate nature-related dimensions into its climate scenario work.

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