Nature's Nudge:

The role of collateral frameworks in the transition towards a sustainable economy

Maud Abdelli, Uuriintuya Batsaikhan, Carolin Carella

positivemoney

WWF

Published October 2024

About Positive Money Europe

Positive Money is an international research and campaign organisation working to redesign our economic system for social justice and a liveable planet. Set up in the aftermath of the financial crisis, Positive Money is a not-for-profit company funded by charitable trusts and foundations, as well as small donations from its network of supporters. Positive Money Europe has an office in Brussels and is a registered interest group in the EU's lobbying transparency register (entry number 224435319949-22). www.positivemoney.eu

About WWF

WWF is one of the world's most respected and experienced conservation organizations, with over five million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which people live in harmony with nature. WWF has worked with the finance sector for more than a decade via innovative collaborations that seek to integrate ESG risks and opportunities into mainstream finance, to redirect financial flows in support of the global sustainable development agenda. Through its Greening Financial Regulation Initiative (GFRI), WWF engages specifically with central banks and financial regulators and supervisors on the need to fully integrate climate and environmental risks into mandates and operations. For more information, visit panda.org/gfr or contact us at gfr@wwf.ch.

About the authors

Maud Abdelli is Head of WWF Greening Financial Regulation Initiative, maud.abdelli@wwf.ch
Carolin Carella is Research Lead at the WWF Greening Financial Regulation Initiative, carolin.carella@wwf.ch
Uuriintuya Batsaikhan is Head of Research at Positive Money Europe, uuree.batsaikhan@positivemoney.eu

Acknowledgements

We thank Pierre Monnin, Jochen Krimphoff, Yannis Dafermos, Clarisse Murphy, Chiara Pass, Antoine Pugliese, Vicky Van Eyck, the team at Carbon4 Finance Virginie Wauquiez, Nolwen Kazoum, Melissa Perez, Gilles De Dorlodot, Souheila Mgaieth, and the team at the ECB's Climate Change Center, the team of Banque de France and other anonymous central bankers for their time and comments on our study. For excellent research and project support we would like to thank Iris Hysko and Jordi Schröder Bosch.

This research project has been supported by the European Climate Foundation, Laudes Foundation and the Sunrise Project. The responsibility for the information and the views expressed in this paper are solely those of the authors and reflect the views or policies of Positive Money Europe and WWF.

Cover photo © Johan Hammar.

Download: This document is available to download as a free PDF at: positivemoney.eu or at panda.org/gfr

Contents

List of Abbreviations

BIA	Biodiversity Impact Analytics
CIA	Carbon Impact Analytics
CRA	Credit Rating Agency
CRIS	Climate Risk Impact Screening
CSRD	Corporate Sustainability Reporting Directive
C4F	Carbon4 Finance
C&E	Climate and Environmental
DNSH	Do No Significant Harm
ECAI	External Credit Assessment Institutions
ECB	European Central Bank
ETP	Energy Technology Perspectives
EVIC	Enterprise Value Including Cash
ECMS	Eurosystem Collateral Management System
EUDR	European Union Deforestation Directive
ESRS	European Sustainability Reporting Standards
FAO	Food and Agricultural Organization
GBS	Global Biodiversity Score
GHG	Greenhouse Gas
GICS	Global Industry Classification Standard
ICAS	Internal Credit Assessment System
IEA	International Energy Agency
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LOLR	Lender of Last Resort
MSA	Mean Species Abundance
NACE	Nomenclature of Economic Activities
NCB	National Central Bank
NGFS	Network for Greening the Financial System
NRFR	Nature-Related Financial Risk
PFAS	Per- and polyfluoroalkyl substances
RCP	Representative Concentration Pathway
SRES	Special Report Emissions Scenarios
TCFD	Task Force on Climate-Related Financial Disclosures
TSC	Technical Screening Criteria

List of tables and figures

Executive Summary

- **Collateral frameworks play a crucial role in central banking operations, helping to maintain the stability of the financial system.** The European Central Bank (ECB) uses collateral to secure loans and manage associated risks, protecting itself against the default of its counterparties. In doing so, the ECB is meeting its primary mandate of price stability and financial stability, but also promoting the general economic policies of the European Union as part of its secondary mandate, including sustainable development, high quality protection of the environment and the transition to a low-carbon economy.
- **Despite plans by the ECB to integrate climate change considerations into its collateral framework, the current scope is narrowly focused on climate-related risks only.** This neglects broader environmental implications, such as nature degradation and biodiversity loss. But, as climate change and nature loss are reinforcing each other, the integration of both climate and environmental (C&E) aspects into ECB's collateral framework is vital to address all economic vulnerabilities and to signal financial market participants accordingly. Properly adjusted collateral mechanisms (e.g. eligibility criteria, concentration limits and haircuts) can help the ECB meet its two key objectives: *risk management*, by preventing the accumulation of systemic risks tied to unsustainable assets; and *market signalling* that encourages the transition away from carbon-intensive and environmentally harmful activities towards those that drive a net zero, nature positive economy.
- **To that end, this paper proposes an initial exploratory methodology to integrate C&E risk and impacts into the collateral framework.** This study leverages publicly available ECB collateral data, focusing on French marketable securities issuers and four Carbon4 Finance (C4F) climate and biodiversity databases, providing issuer-level exposures to physical risks and C&E impacts. The latter is used as a proxy for transition risks.
- **The results highlight the interdependencies between C&E risks and impacts and showcase that an integrated analysis of both climate and broader environmental aspects is crucial.** The Eurosystem collateral framework should therefore be recalibrated to fully integrate C&E risks and impacts, and account for interconnected risks (e.g. companies dependent on vulnerable ecosystem services at-risk-of collapse due to increasing acute and chronic climate change hazards). This paper demonstrates that the ECB already has data and tools to adopt precautionary measures in its collateral framework, to start addressing interconnected C&E risks and impacts.
- **This report provides a set of recommendations to be implemented in the short and medium term.** The ECB should pre-emptively act now on *exclusion, haircuts, and concentration limits*: by excluding assets from unsustainable companies not on a transition path (e.g., companies linked to deforestation, fossil fuel extraction and exploration); by progressively integrating EU Taxonomy for eligibility considerations; by applying concentration limits to reduce dependency on high-emission and environmentally harmful assets in collateral pools; by applying higher haircuts to assets with high climate-related and environmental risks where science-based and transparent transition plans are lacking.

Introduction

The European Central Bank (ECB)'s primary mandate is to maintain price stability. The secondary mandate, without prejudice to the primary mandate, is to support the general economic policies of the European Union (EU), including sustainable development and high quality protection of the environment.[1] To maintain price stability and promote financial stability, the ECB uses monetary policy operations to influence market participant behaviour. The ECB influences market participant behaviour, among other mechanisms, via its lending to commercial banks. For that the ECB's collateral framework plays a principal role.

For banks to borrow from the ECB, they have to pledge an asset (collateral) as a security in case they default on their loan. The collateral framework governs *which* assets commercial banks can pledge in order to borrow from the ECB, and *how* these assets (collateral) should be valued. The collateral framework provides important functions for the ECB (lender) and the banks (borrowers). Firstly, the quality of collateral accepted supports a robust liquidity management in the Eurosystem and provides a reliable financial guarantee should commercial banks default on their loan with the central bank. Secondly, the collateral framework incentivises banks to maintain a portfolio of high quality and secure assets so that they can readily borrow from the ECB, which in turn should encourage banks to provide loans, buy bonds or other types of securities of high credit and liquidity quality. In defining its collateral acceptance conditions, a central bank can therefore help manage systemic risks by reducing the liquidity shortage and stranded assets risks for the whole financial system.

Central banks have recognised that climate change and nature loss represent material financial risks to our economies and the financial system (NGFS, 2022; Ceglar et al, 2024). There is also a recognition that these risks are endogenous, insofar as today's financial capital allocation locks in economic activities that are fuelling climate change and biodiversity loss. This, in turn, leads to the accumulation of transition risks and future physical risks.

As such, proper integration of climate and environmental (C&E)[2] risks and impacts considerations into the collateral framework of central banks is crucial to ensure that the collateral provided continues to be safe enough for central bank operations and that the right signals and incentives are sent to banks, reducing the risk of moral hazard.[3] The existence of moral hazard is not easy to prove, but in essence the underlying assumption contained in the *lender of last resort (LOLR)* function of central banks can have adverse effects if banks continue to provide credit and invest in carbon intensive, environmentally harmful activities, assuming that their stranded assets[4] will always be accepted as collateral.

The ECB collateral framework in its current format has been criticised for its potential to undermine the transition to a sustainable economy, even while markets seem to start pricing transition risks in corporate bond markets and valuing corporates efforts to mitigate climate change (Boermans et al, 2024). By accepting assets with minimal considerations given to their C&E risks and impacts, the ECB is indirectly providing cheaper financing conditions

1. Treaty on the Functioning of the European Union, Article 127 (1), see https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A12016E127.
2. By climate and environmental (C&E) risks we mean risks arising from climate change, environmental degradation, and nature and biodiversity-related loss, as defined by the Network for Greening the Financial System (NGFS), https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_for_supervisors.pdf.
3. Moral hazard refers to a situation where a financial institution engages in riskier behaviour because it expects that any potential losses will be absorbed by external parties, such as the government or taxpayers, rather than by the bank itself. This reduces the incentive for prudent decision-making, as the institution is shielded from the full consequences of its actions.
4. Stranded assets are assets which experience unanticipated devaluation leading to wealth loss. It could lead to losses in bank portfolios from borrowers defaulting on their loans.

to carbon-intensive and environmentally harmful activities, making it harder for greener and environmentally friendly entities to compete and access financing (Dafermos et al, 2021).

The ECB should, therefore, ensure that assets accepted as collateral are not only financially sound, but also aligned with the EU's long-term climate and nature goals. The Eurosystem itself recognises that nature-related risks have major implications for both its primary and secondary mandate (Ceglar et al, 2024). Only a holistic approach that takes into account C&E risks and impacts will enable the ECB to meet both of its mandates.

In its 2024-2025 climate action roadmap, the ECB announced the possibility to apply "climate change collateral pool concentration limits", but in July 2024 the ECB communicated that due to lacking technical preconditions this will be no longer be pursued.[5] Instead, alternative options are now being considered for integrating climate-related aspects into the collateral framework, but the ECB made no specifications as to what these alternative measures may be. The measures are only limited to climate-related risks without explicitly considering climate-related impact and broader environmental aspects.[6] Furthermore, the ECB is set to review its climate action roadmap in 2025.

In light of ECB's upcoming review, this paper explores *why* the greening of the collateral framework should consider broader environmental aspects in conjunction with climate-related risks and impacts and *how* these can be integrated into the ECB collateral framework. In 2022 we provided a framework for assessing C&E risks and impacts into the Eurosystem Internal Credit Assessment Systems (ICASs) focusing on non-marketable assets, i.e. credit claims (Abdelli and Batsaikhan, 2022). Instead, in this paper the objective is to show how the ECB and National Central Banks (NCBs), with available data and methods, can already start incorporating C&E risks and impacts into their assessment of marketable assets. We aim to provide initial methodological building blocks to assess private sector marketable securities issued by non-financial and financial corporates, using the example of Banque de France's collateral pool. With our methodology that can be applied to all other NCBs, the ECB would have the tools and data available to start aligning its collateral framework with its sustainability goals. This paper uses Carbon4 Finance (C4F) company-level data on impact and risk-related indicators to approximate potential C&E risk exposures, as well as the impact that companies have on nature and climate. Our analysis contributes to the discourse on green collateral frameworks with relevance for the following areas:

Table 1. Scope and relevance of the study

Analysis of the Study	Relevance for ECB	Relevant Carbon4 Data
Exposure to physical C&E risks	Physical Risk Assessment (Risk management)	Climate Risk Impact Screening (CRIS), Biodiversity Impact Analytics - Dependency (BIA - Dependency)
	Signalling which assets are considered high quality liquid assets	
C&E impact	Proxy for Transition Risk (Risk management)	Climate Impact Assessment (CIA), Biodiversity Impact Analytics - Impact (BIA-Impact)
	Macroprudential Risk Perspective - today's impacts are tomorrow's physical risks	
	Secondary mandate	
	Signalling which economic activities are (in) compatible with EU's economy	

5. See decision by the ECB Governing Council taken in July 2024: https://www.ecb.europa.eu/press/govcdec/otherdec/2024/html/ecb.gc240719~dde12c2121.en.html
6. In 2022, the Eurosystem has agreed on a framework for climate risk in internal credit assessment systems (ICASs) to be implemented by the end-2024 together with national credit registries, however, again, it is limited to climate risks only, see https://www.ecb.europa.eu/press/economic-bulletin/focus/2022/html/ecb.ebbox202206_06~d7f88f706f.en.html.

Using four databases provided by C4F, we aim to provide a holistic approach that shows the interconnectedness of companies' exposure to climate physical risks and their dependency on ecosystem services, as well as the interplay between companies' impact on climate and biodiversity (proxy for transition risks). We aim to provide a double materiality approach in recognition that transition risks and (future) physical risks associated with climate change and nature loss are amplified by (today's) financial flows, i.e. impact. Similar to Ceglar et al (2024), our study not only considers C&E risks and impacts individually, but also considers them in an integrated way.

Besides ECB's planned review of the climate action roadmap in 2025, the ECB is set to establish a unified system to manage the collateral accepted at the level of the Eurosystem, the Eurosystem Collateral Management System (ECMS). The ECMS is planned to be operational in the first half of 2025.[7] The ECMS provides another chance to effectively streamline C&E considerations into collateral management.

Given these policy opportunities, this study provides insights and recommendations for the ECB to already:

a. apply a holistic approach broadening its plans to include broader environmental considerations alongside climate change;

b. use its risk management function and methods to ensure that its collateral adequately reflects the risks and impacts posed by climate change and nature degradation;

c. send a strong and clear signal to financial markets about the importance of mitigating C&E risks and impacts and the need to support the transition to a greener economy, by reviewing the eligibility criteria of assets as collateral; and

d. adapt its roadmap and collaborate with banks to ensure a smooth transition to a new, sustainable collateral framework.

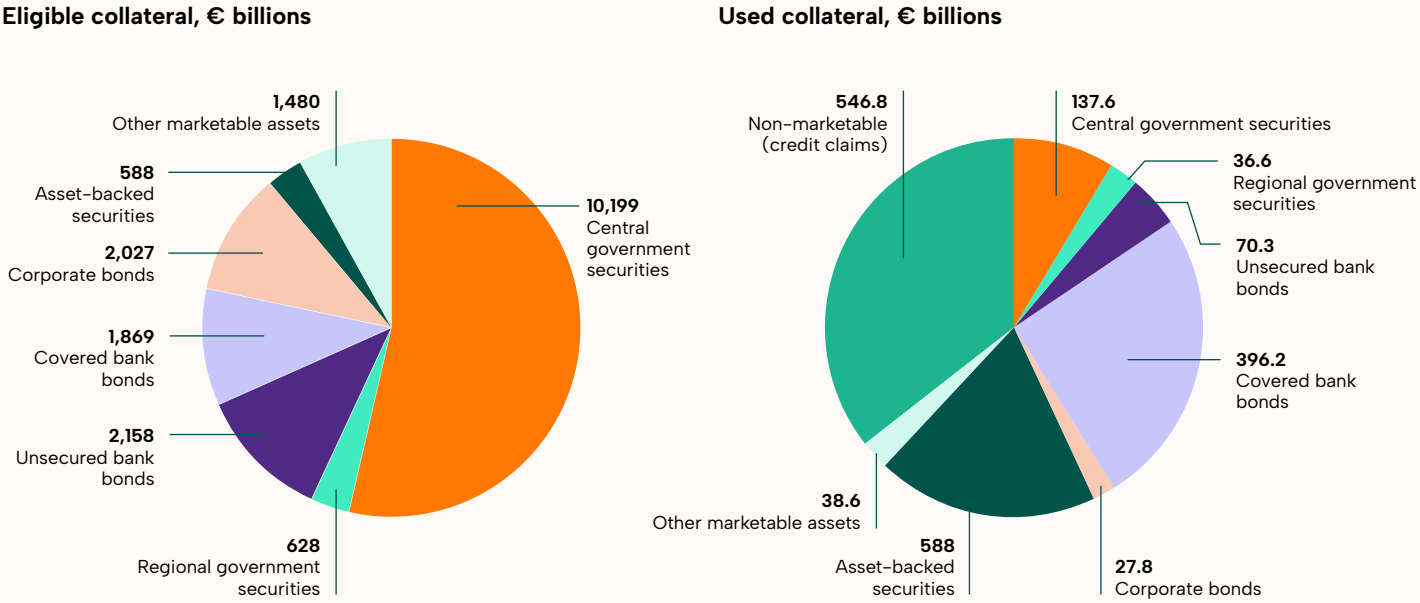
The rest of the paper is organised as follows: we provide explanations of how the collateral framework works (section 1), why it is important to take into account both climate and nature (section 2), state of the art in the research on greening the collateral framework (section 3), aims and objectives of the paper (section 4), methodology and data we use (section 5), the results of the analysis (section 6) and the discussion (section 7), we provide policy recommendations that could be implemented now and over the medium-term (section 8) and conclude with limitations of this research (section 9) and areas of further research (section 10).

7. See ECB press release from the 25th of September 2024, https://www.ecb.europa.eu/press/intro/news/html/ecb.mipnews240925.en.html#:~:text=The%20ECMS%20is%20a%20unified,collateral%20for%20Eurosystem%20credit%20operations.

1. How does the Eurosystem collateral framework work?

The Eurosystem collateral framework is essential for the implementation of monetary policy operations. As of 2024 Q2, the universe of eligible assets in the collateral basket of the ECB stood at more than €18 trillion, more than half of which are government bonds (€10 trillion) and the rest are corporate bonds (€2 trillion), bank bonds (€3 trillion) and other marketable assets (asset-backed securities, regional government bonds and others) (Figure 1, left-hand side). As for used collateral, it stood at around €1.5 trillion, composed of marketable assets (around €1 trillion) and non-marketable assets, i.e. credit claims (€547 billion) (Figure 1, right-hand side).[8]

Figure 1. Eligible and used collateral data.



While the purpose of the collateral framework is to protect the Eurosystem from losses in its credit operations, in practice, assets that are eligible and have lower haircuts benefit from higher demand, boosting their price and reducing their risk. This makes it easier for the issuers of these assets to get access to cheaper finance and have a more favourable debt structure (Pelizzon et al, 2024).

To ensure that liquidity-providing operations are based on and secured by high quality collateral, the framework includes a broad range of asset classes (marketable and non-marketable assets) and relies on robust risk management procedures. To maintain the robustness of its collateral basket, diverse risk management measures are applied on the assets, that include:

- **Asset selection:** Eligible assets are selected based on their high credit quality and their value is checked on a daily basis to the adequate coverage of credit risk.

8. As of 2024 Q2, see Eurosystem collateral data, https://www.ecb.europa.eu/mopo/coll/charts/html/index.en.html.

- **Exclusion:** Exclusion of certain assets deemed too risky, illiquid or incompatible with other eligibility criteria.

- **Valuation haircuts:** Valuation haircuts are also used to lower the market value of an asset according to the risks it contains.

- **Additional margins:** Initial and/or variation margins are used in repurchasing agreements (repo) transactions to prevent or compensate for the loss of value of an asset, asking the bank to supply additional assets or cash.

- **Concentration limits:** Limits of exposure to a certain issuer can be applied to certain counterparties, if for example there is a correlation between the credit quality of the counterparty and the credit quality of the collateral provided.

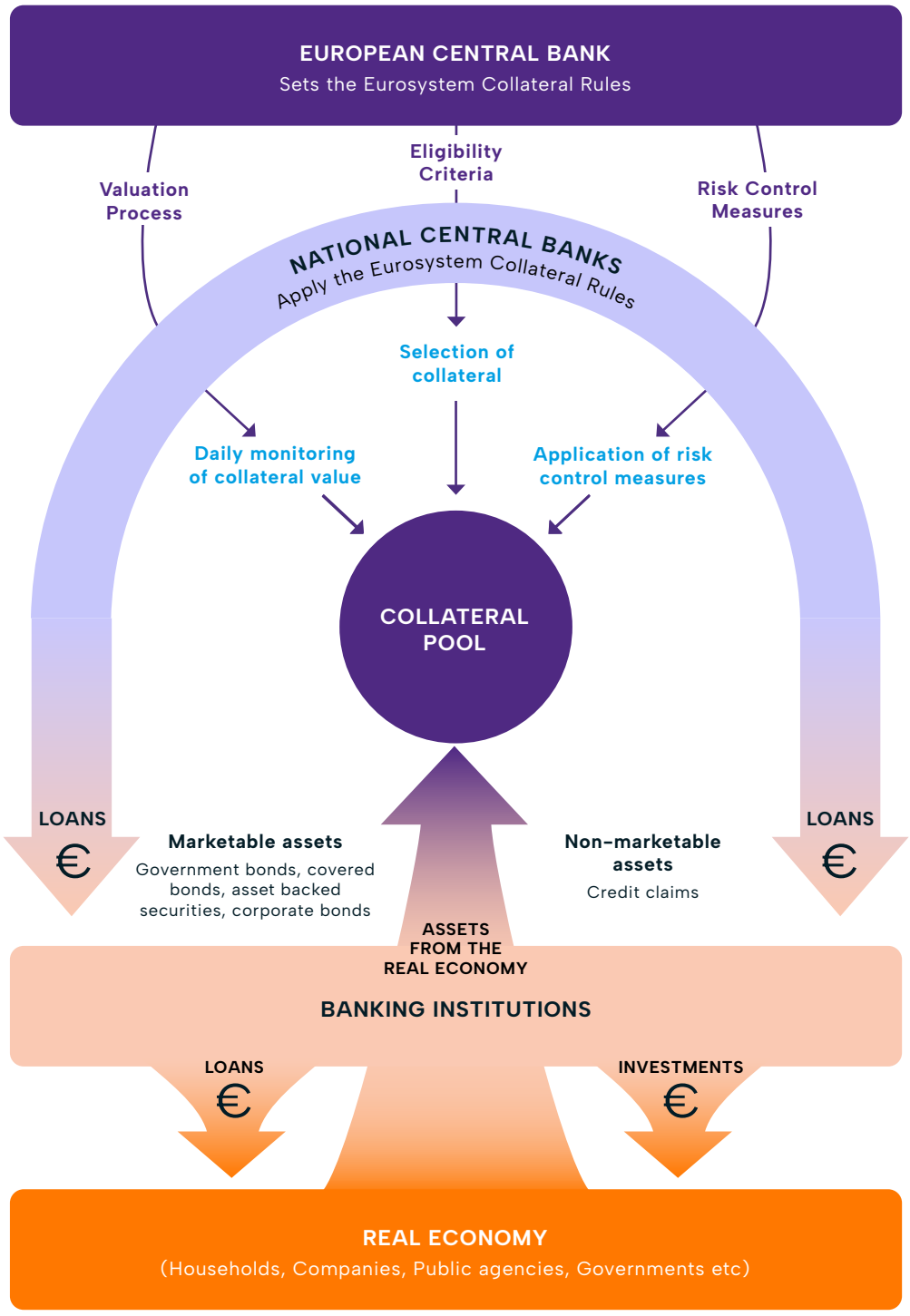
- **Additional guarantees:** Additional guarantees in order to accept certain assets, giving enough flexibility to the ECB to adapt its risk control measures.

So far, the ECB determines the general condition for collateral eligibility and risk controls for the whole Eurosystem, but each NCB is in charge of implementing the monetary policy operations under its jurisdiction (see Figure 2).

A unified system to manage the collateral accepted at the level of the Eurosystem should soon be launched. The Eurosystem Collateral Management System (ECMS) will be a unified system for managing all assets used as collateral in the Eurosystem credit operations. It will replace the national collateral management systems of NCBs and is expected to start operations on the 18th November 2024.[9] The ECMS could facilitate the integration of C&E aspects into collateral management. Indeed, in using different data sources such as the ECB climate risk indicators[10] and other data sources on the exposure of corporates and financial institutions to C&E risks and their impacts, the ECMS will increase the efficiency of the monitoring of collateral quality and improve the collateral management.

9. ECB on ECMS, 2024, https://www.ecb.europa.eu/press/pr/date/2024/html/ecb.pr240814~05f90141a2.en.html#:~:text=The%20Eurosystem's%20harmonised%20rules%20and,planned%20for%2018%20November%202024.
10. See https://www.ecb.europa.eu/stats/all-key-statistics/horizontal-indicators/sustainability-indicators/html/index.en.html.
ECB Physical risk indicators assess the impact of climate change natural hazards on the corporates' ability to pay back the loan and the performance of its equity. ECB carbon emissions indicators provide information on the carbon intensity of securities and loan portfolios of financial institutions.

Figure 2. Simplified diagram on the functioning of the Eurosystem Collateral Framework



Source: Authors.

2. Climate and nature nexus

While the ECB's planned inclusion of climate aspects in its collateral framework is commendable, overlooking broader environmental-related risks and impacts results in an incomplete risk management approach and misguided market signalling. Nature and biodiversity, and its benefit to people and the economy, are inextricably connected with climate change (Pörtner et al, 2021). These interdependencies are marked by positive and negative feedback loops that can materialise into (systemic) risks or opportunities (see Figure 3).

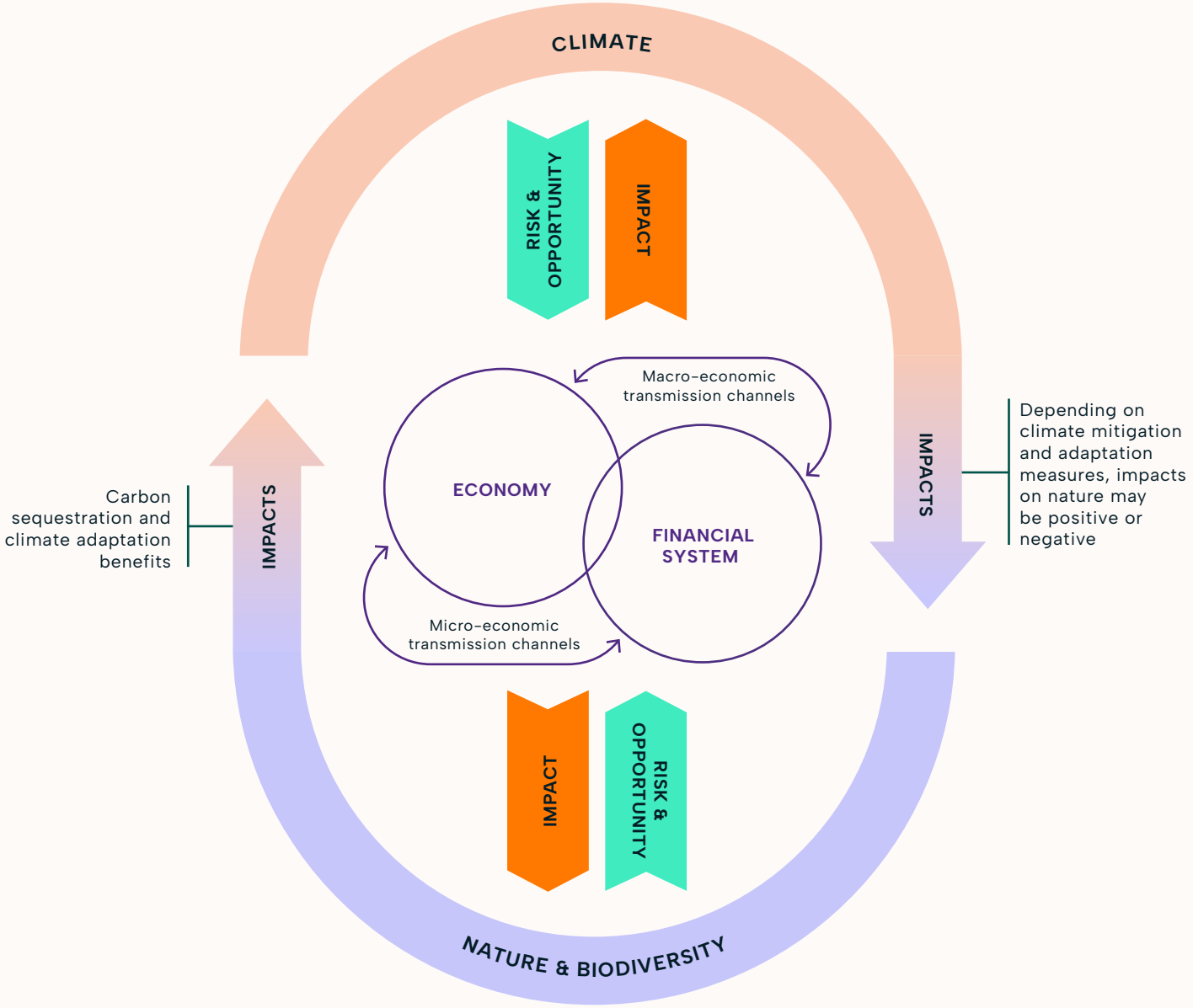
Biodiversity loss and nature degradation accelerate climate change. Over the past decade natural ecosystems have absorbed 54% of anthropogenic driven carbon dioxide (CO_2) emissions (WWF, 2022a). Over the past 20 years, tree loss from activities like logging and wildfires has resulted in an average of 8.1 billion tonnes of CO2 emissions annually, about half of the CO2 that forests have removed from the atmosphere (Benschop, 2023). Furthermore, biodiversity loss reduces the productivity of ecosystems, diminishing their capacity to withstand climate change effects and also reduces their carbon storage capacity (Weiskopf et al, 2024). On the flip side, nature conservation and restoration can support climate change mitigation via increased absorption (e.g. through seagrass meadows restoration) (WWF, 2022a).

Biodiversity loss inhibits adaptation capacities against climate change. Healthy ecosystems provide natural insurance against climate change effects, such as wetlands attenuating storm surges and vegetation mitigating elevated temperatures (WWF, 2022a). Conversely, unhealthy and degraded ecosystems lose their effectiveness in supporting climate change adaptation, such as non-free flowing rivers heightening flood risk (Adkins, 2024).

Climate change is one of the main drivers of biodiversity loss and nature degradation. While some species adapt (e.g. via geographical dispersion) others cannot do so fast enough. These shifts have knock-on effects on overall ecosystem health and functioning (e.g. climate change accelerates proliferation of invasive species (Pörtner et al, 2021)). In parallel, climate change-induced chronic changes and extreme weather events are straining ecosystem resilience (Flores et al, 2024).

Climate-centred mitigation and adaptation solutions may harm nature and biodiversity. In the context of the net-zero transition, solutions are on the rise to reduce greenhouse gas (GHG) emissions and adapt to climate change. However, by pursuing a narrow solutions framework, without considering adverse consequences on nature and people, climate mitigation and adaptation measures may have adverse damaging effects on nature (e.g. monoculture or non-native tree plantation for carbon sequestration or seawalls for flood prevention) (Pörtner et al, 2021; WWF, 2022a).

Figure 3. Interactions between biodiversity loss, nature degradation, climate change and the economy



Source: Authors' own depiction adapted from Pörtner et al, 2021 and NGFS, 2024

Financial supervisors and central banks have become increasingly aware of the biophysical relationships between climate and nature as a source of economic and financial risks. From that stems the need to pursue a holistic and integrated approach in tackling climate change and nature loss and their associated idiosyncratic and systemic risks. The Network for Greening the Financial System (NGFS) has made the first step in this direction via its new framework that proposes the umbrella term of nature-related financial risks (NRFR), that is defined as follows:

> (...) the risks of negative effects on economies, individual financial institutions and financial systems that result from:
>
> i. the degradation of nature, including its biodiversity, and the loss of ecosystem services that flow from it (i.e. physical risks); or
>
> ii. the misalignment of economic actors with actions aimed at protecting, restoring, and/or reducing negative impacts on nature (i.e. transition risks)

The NGFS highlights that, due to the inextricable interconnection, climate change is within the scope of NRFR (NGFS, 2024). This paper encompasses NRFR by the interchangeable term C&E risks. Although C&E risks originate from specific locations, they may materialise well-beyond their geographical area affecting various actors (companies, households, financial actors, governments etc.), due to feedback loops and second order effects. This is why the NGFS stresses the systemic dimension of nature-related financial risks in its framework. Other studies and reports, in this context, speak explicitly of nature-related systemic risks (Almeida et al, 2022).

It is also important to note that the framework thematises the endogeneity of the financial system, meaning that future risks associated with climate change and nature loss are also amplified by today's financial decisions, and therefore, today's financial flows (impact) require attention from the perspective of future (macroprudential) physical risks, but also as a proxy measurement of present-time exposures to transition risks.

How can nature-related risks transmit into conventional financial risk categories?	
Credit Risk	For companies heavily dependent on natural ecosystems, such as agriculture, forestry, and tourism that are highly sensitive to environmental changes. If these sectors experience disruptions (e.g., reduced crop yields due to ecosystem collapse, lack of snow in alpine regions), of which the losses are not sufficiently insured, companies may experience revenue shocks increasing a likelihood of default on loans, increasing credit risk for banks and lenders.
Liquidity Risk	Severe weather events, such as floods or droughts, can damage infrastructure, interrupt supply chains, or force companies to halt production. These disruptions can increase the costs for businesses, leading to operational and liquidity challenges that banks and financial institutions may be exposed to.
Operational Risk	Supply chain interruptions caused by extreme weather or loss of biodiversity can affect production processes, leading to increased operational costs or reduced revenues. Organisations may also struggle with compliance issues as regulations surrounding environmental practices become stricter, requiring a shift and re-design of production processes and supply chains.
Market Risk	The decline in natural ecosystems could alter commodity prices, influencing markets that depend on these resources. Investors may also shift their preferences, which could affect the valuations of firms that are not adapting to these trends.

Sources: Boldrini et al, 2023; Ceglar et al, 2024.

While nature-related risks transmit to conventional financial risk categories, such as the above, it cannot be assumed that conventional risk identification and management processes would accurately depict (or price-in) C&E risks sufficiently (Eren et al, 2022).[11] There are different reasons as to why C&E risks may be underpriced. C&E risks are characterised by radical uncertainty, differentiated time-horizons, non-linearity and tipping points dynamics,[12] factors often not integrated in conventional valuation and risk management processes. Even

11. See also ECB/ESRB 2024: https://www.ecb.europa.eu/press/pr/date/2023/html/ecb.pr231218_1~6b3bea9532.en.html.
12. The Stockholm Resilience Centre has identified, in its latest assessment, that 6 out of 9 ecological boundaries have been breached that means we are beyond a safe operating space for ca. 2/3 of the processes that underpin the "stability and resilience of the Earth System" (Stockholm Resilience Centre, 2023).

risk assessments that at least explicitly account for climate-related risks, fall short to capture their full extent. A study found that because of neglecting critical risk interdependencies, such as feedback effects between climate change and ecosystem services and associated tipping points, physical climate-related risks could be underestimated by a factor of 2-3 (Thomä, 2024). It is exactly for this reason that a precautionary approach[13] by market participants, including central banks, is paramount to maintain price and financial stability while providing enabling conditions for governments, economies and societies to transition towards a resilient, sustainable and inclusive economy.[14] In this respect, it is the central banks' role to lead by example and to signal the market accordingly.

Nature and climate change non-linear interactions risk breaching tipping points with irreversible catastrophic and systemic consequences for humans and our economies.

Nature loss and climate change are reinforcing one another. This spiralling trend could push (eco)systems beyond their safe operating space into a new irreversible state, with further knock-on effects on climate change, other ecosystems, wildlife as well as the human world (health, well-being and economies). For example, the Amazon rainforest is a key regulator of regional and global hydrological cycles besides its many other benefits. Climate change is causing prolonged phases of droughts and elevated temperatures. In the meantime human activities driving deforestation, forest fragmentation and conversion in the Amazon are reducing the native forest stock, therefore, reducing evapotranspiration, further altering rainfall patterns. Together with prolonged droughts, this increases the risk of wildfires, which further reduces forest stock and increases emissions (Marsden et al, 2024). These droughts also directly impact the potential of hydropower generation in the Amazon river basin (Almeida et al, 2021). This has supply-side pressures on electricity and food, which present an inflationary upward pressure as has been experienced in Brazil (Caswell, 2022). These effects ultimately could lead to the Amazon reaching a threshold where it could turn into a dry savannah. This would have major disruption effects on the regional and global hydrological cycle and make the Amazon change from being a major carbon sink to a source of GHG emissions.

Collateral frameworks that rely on "conventional" practices for the definition of eligibility criteria and haircut systems, or exclusively focus on a specific subset (i.e. climate-related risk) in isolation, are likely falling short of capturing C&E risks and impact holistically. Additionally, markets are being misguided by being made to operate as though securities stemming from carbon-intensive and nature-damaging companies are valuable and safe, and eligible to be used to access liquidity. This signalling is promoting the status quo that has both a GHG and nature-damaging bias. Only through a climate-nature integrated approach can the full scale of NRFR (or C&E risks) and impacts be approximated and tackled.

13. Precautionary approach allows for action before the full materialisation of a particular risk, based on the acknowledgement that climate change and biodiversity loss would lead to catastrophic and irreversible damages (WWF, 2022b).
14. In that, the costs of inaction are far greater than the transition costs (Dreyer, 2024; Ethz, 2024).

3. Greening the collateral framework – state of the art

The existing research concerning the integration of C&E risk into the collateral frameworks reveals that they remain inadequate in accounting for these types of risks. One of the reasons, according to Monnin (2018), is that central banks like the ECB and the Bank of England continue to depend on credit rating agencies, whose activities and operations remain opaque and non-standardised.[15] The ECB's own assessment found that there are large differences in methodologies and practices in the way different rating agencies measure and integrate climate risk (Breitenstein et al, 2022).

As a result, fossil fuel and other heavy carbon-biased assets continue to be part of the collateral framework. This effectively results in an implicit financial advantage for carbon-intensive enterprises, allowing them to secure loans at reduced rates due to the low haircuts tied to their collateralised assets (Dafermos et al, 2021). A recent study finds that there are around €250 billion worth of high carbon assets in the ECB collateral framework, these assets continue to be pledged as collateral and have haircuts as low as 1% (EIU, 2024; Murphy, 2024). This fact conflicts with the objectives of the Paris Agreement, of which EU institutions, including the ECB, are a party[16] and exacerbates a vicious loop of cheap finance and fossil fuel dependency (Dafermos et al, 2020).

There are different methodologies in the literature on integrating C&E risks into the collateral frameworks. The debate on whether to assess greenness at the asset or entity level is significant. Vestergaard (2022) advocates for asset-level assessments, highlighting the limitations of the counterparty-level approach, which may preferentially treat entities with mixed asset portfolios. The author proposes using the EU Taxonomy to categorise assets into green, grey, or brown based on their compliance with Technical Screening Criteria (TSC) and Do No Significant Harm Criteria (DNSH). On the other hand, Dafermos et al (2021) emphasise the importance of issuer-level assessments to prevent greenwashing, but also acknowledge the benefits of combining this with asset-level criteria to account for company-specific environmental efforts.[17] In this respect, the "always environmentally harmful list" from a WWF report, can support issuer-level assessment to identify companies' economic activities that have the potential to be retrofitted to align with a 1.5°C pathway and the global biodiversity framework, and those whose business model is inconsistent with such a transition (WWF, 2022b).

As for eligibility, some focus on positive screening, avoiding negative screening due to the limited availability of green assets (Vestergaard, 2022). Others advocate for negative screening for fossil-intensive assets as a priority step (Murphy, 2024) and both positive and negative screening, due to the risk of stranded assets without sufficient adaptation finance, especially for entities with high physical risk exposure (Dafermos, 2024).

For the haircuts, different methodologies were proposed, including the multiplier approach, where assets in the low-carbon category would get no extra haircut, and haircuts of medium- and high-carbon assets would be

15. There have been significant steps made to regulate the ESG rating agencies in Europe. On 24 April 2024, the Parliament adopted in plenary the final text of the regulation, see: https://www.europarl.europa.eu/legislative-train/theme-an-economy-that-works-for-people/file-esg-rating.
16. See Monetary Dialogues with President Mario Draghi, 28 February, 2018, https://www.youtube.com/watch?v=Z9yzqUDl2DA, and ECB annual report 2017 Article 25, https://www.europarl.europa.eu/doceo/document/A-8-2018-0424_EN.html.
17. Under Art. 8 of the EU taxonomy regulation (2020/852) more and better data will become available for the share of both EU taxonomy eligible activities and alignment (in terms of revenue, CapEx and OpEx), which will give the ECB the opportunity to use the data to fine-tune the collateral assesments, see https://eur-lex.europa.eu/eli/reg/2020/852/oj.

multiplied by 0.1 and 0.2, respectively (Schoenmaker, 2021). Vestergaard (2022) proposes a system where green assets receive a 50% reduction in haircuts, while brown assets face a 50% increase. This approach is echoed by Dafermos et al (2021), who suggest adjusting haircuts based on the overall environmental performance of companies. NGFS (2021) introduces a sliding scale approach, adjusting haircuts based on the carbon intensity of both sectors and issuers, allowing for differentiation based on environmental impact.

In this paper we strongly urge a double-materiality approach, accounting for not only the risks but also the impacts that the rules of the collateral framework have on the environment. We are aiming to provide an analysis that moves beyond climate risk and impact solely, to include broader nature (incl. biodiversity) impact, recognizing the inseparable link between climate and nature (see previous section). Not taking into account both C&E risks and impact dimensions in the collateral framework exacerbates the existing market failures. As such, assets of the entities whose core activities are simply not future-fit and pose significant risks for the natural environment should not be pledged as collateral, sending misleading signals regarding their risk profile.

At the same time, we recognise the overwhelming need to transition our economies from fossil dependency and the need for transition finance. We propose to treat the collateral framework as a continuum and employ a granular and comprehensive approach in treating corporate and bank securities. We view that given the sample size of around 100 of the largest corporates and banks in France included in our analysis for which climate and biodiversity data is available, such an exercise is entirely possible. These entities represent a significant share of the (global) economy, it follows that such granular and detailed attention should be desired.

4. Aims and objectives

Since the ECB has not (yet) disclosed the specifics of how it will exactly implement climate-related aspects into its collateral framework. This paper seizes the opportunity to provide an explorative quantitative and qualitative assessment of how the ECB and NCBs could integrate C&E aspects into the collateral framework for marketable securities issued by non-financial and financial corporates.

The aim of this paper is to primarily challenge the status quo and the way that the current collateral framework is (mis)signalling to the market (the riskiness and value of certain assets) and therefore is (in)compatible with its primary and secondary mandate (to enable transition to a just and sustainable economy). The primary framing of this paper considers the signalling power of the collateral framework more than the risk management perspective (i.e. the risks that the pledged collateral poses to the ECB monetary policy functioning and robustness). The latter would be a more complex endeavour that would require both entity-level and asset-level analysis (Dafermos et al, 2022). Nonetheless, this paper uses C4F impact and risk-related indicators to approximate potential C&E risk exposures and impacts of entities represented in the collateral basket of the ECB.

To uncover the ECB collateral framework embedded C&E risks and impacts as well as the associated signalling effects it has on the market (impact) this study provides an in-depth analysis of the collateral pool that is assessed by the Banque de France. Despite considering the French collateral only, the aim is to develop insights that will help ensure that the ECB in its final framework and upcoming unified system (ECMS) does not miss key C&E aspects in order to 'walk the talk' in greening monetary policy. Additionally as this paper is the first, to the authors' knowledge, that explores the integrated consideration of C&E risks and impacts in the collateral framework, it can serve as a starting point for concrete operational implementation by the ECB and other NCBs.

5. Methodology

This analysis uses collateral data made publicly available by the ECB, and company-level data from C4F[18] on climate and biodiversity risk and impact scores. For the Banque de France collateral case study analysis, we cleaned and sampled the ECB collateral data and carried out manual, more in-depth analysis using C4F intermediate results and indicators. To measure C&E risks and impacts we used proxies made available by C4F databases: Climate Impact Analytics (CIA), Climate Risk Impact Screening (CRIS), Biodiversity Impact Analytics powered by the Global Biodiversity Score (GBS) for Dependency (BIA-GBS Dependency) and Impact (BIA-GBS Impact) (see Figure 4).

The analysis was carried out at individual company level, i.e. each company (security issuer) received their individual C&E risk and impact scores. Depending on the company and according to C4F coverage, the analysis was carried out directly on the issuer or on the parent company. This analysis disregarded the collateral value of the issuers in the collateral pool (as this information is not accessible) and the number of securities issued per issuer present in the collateral. This means that each issuer has equal weighting in the sample. It is important to note that although the assessment was carried out at individual company level, these were aggregated again at sector level for the purpose of publishing the results. This means that the results do not indicate information about sectoral exposure to C&E risks and impact but rather about the average of the entities in the sample that are assigned to that sector.

Data collection & preparation

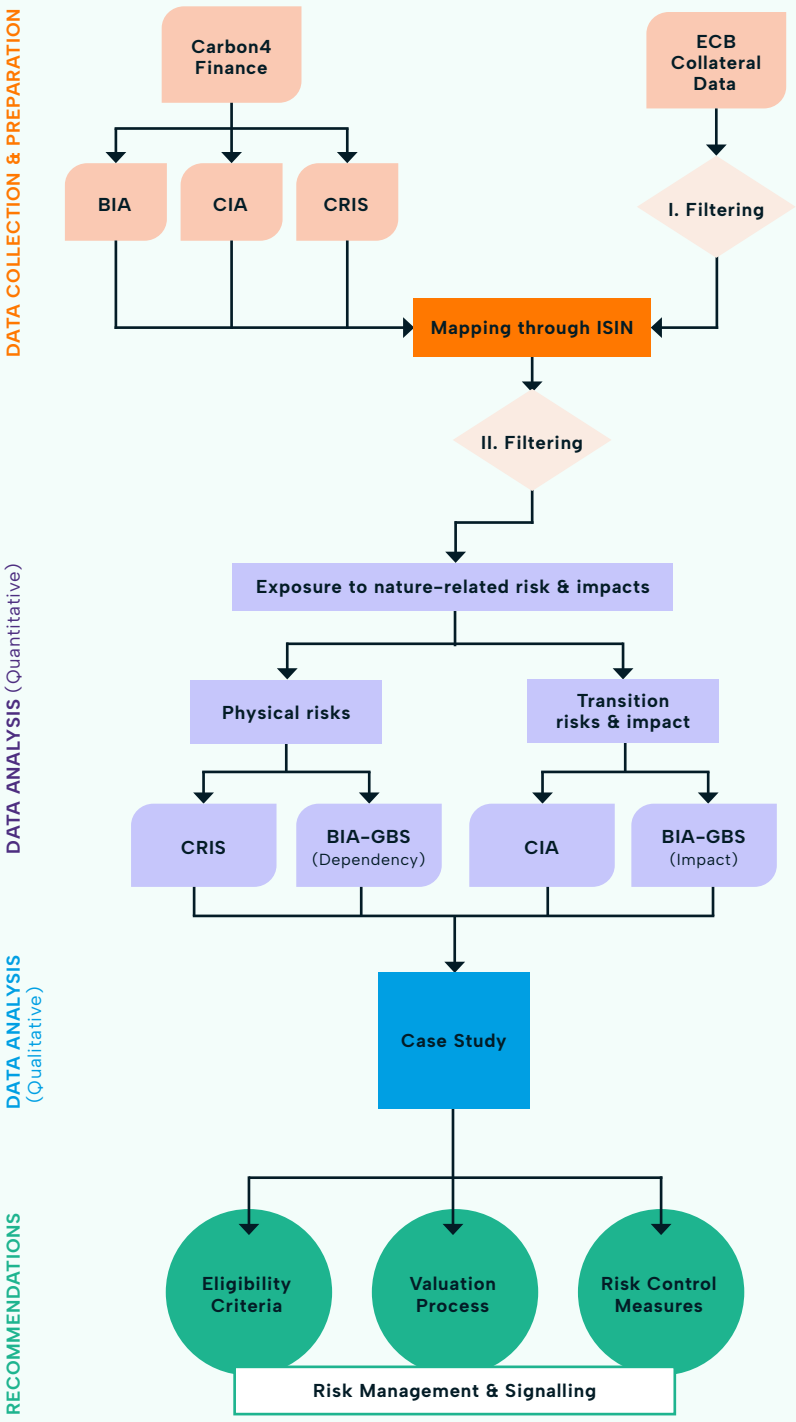
The collateral data was retrieved from the ECB website that publishes the list of eligible marketable collateral on a daily basis.[19] We downloaded the list of eligible marketable collateral for January 1-31, 2024 period, filtered for securities whose issuer's residence is France and deleted duplicates. Further steps involved dropping the type of securities that are out of scope, including asset-backed securities, covered bonds and public sector bonds.[20]

Due to C4F's different methodologies in assessing entities, bottom-up versus top-down, straightforward NACE or GICS classification of sectors was not possible. This paper takes on the C4F suggested sectoral classification, based on their grouping of companies. This classification also determines the parameters and methodology of analysis, such as the cap and floor for climate-related analyses to make the scoring and analysis comparable across different sectors.

Each C4F database is explained below in brief but further details can be retrieved from their methodological guides available on C4F website and platform.

18. ECB has access to Carbon4 Finance and Institutional Shareholder Services (ISS) for climate and biodiversity data, see https://www.ecb.europa.eu/ecb/climate/climate-related-financial-disclosures/shared/pdf/ecb.crfd2024_NMPPs.en.pdf.
19. See https://www.ecb.europa.eu/mopo/coll/assets/html/index.en.html.
20. Detailed filtering process is enclosed in the Annex.

Figure 4. Methodology overview



5.1 Climate-related risks and impacts

C4F's Climate Risk Impact Screening (CRIS) is used to assess a company's exposure to climate-related physical risks. Whereas, Carbon Impact Analytics (CIA) is used as a measure to assess the climate-related impact of an entity, and can also be used as a proxy for climate-related transition risk.

Climate Risk Impact Screening (CRIS)

CRIS methodology evaluates climate-related physical risk based on IPCC projections across two time horizons: mid-century (2050) and end-century (2100). It considers three climate scenarios: low-emission scenario: temperatures remain below 3°C by 2100 (RCP 4.5, SRES B1) with steady increases until 2060; medium-emission scenario: predicts temperatures above 3°C (RCP 6.0, SRES A1B) with significant rises throughout the century; high-emission scenario: projects temperatures exceeding 4°C (RCP 8.5, SRES A2) with drastic increases until 2100.

Seven climate hazards are assessed according to two types of hazards: acute (heatwave, drought, rain intensity and storm) and chronic (increased average temperature, altered rainfall patterns and sea level rise). There are aggravating factors that worsen the effects of climate hazards, these include biodiversity migration and loss that exacerbate average temperature increase, water scarcity that aggravates floods, coastal erosion that aggravates rise in sea levels, flood, river and groundwater movements that aggravate the intensity and frequency of rainfall extremes, showing once again the complex and intrinsic connection between climate and nature risks.

Risk is assessed based on both exposure and vulnerability, without considering adaptation strategies. Exposure depends on the geographical location of the asset, including its global supply chain operations. Vulnerability depends on the asset and its sectoral activities.

The overall risk score is determined by aggregating seven individual hazard scores, with higher weights assigned to acute hazards. Final scores are reported on a scale of 1 to 99, reflecting the assessed risk across all scenarios and time horizons, enabling better understanding and management of climate-related physical risks.

Carbon Impact Analytics (CIA)

CIA methodology evaluates companies' activities based on a combination of quantitative and qualitative analysis. The most important quantitative metrics include GHG emissions for Scope 1, 2 and 3 for:

- GHG emissions induced by the entity both downstream and upstream;
- GHG emissions reduced by the entity (difference between the company's current emission intensities and the same metric 5 years prior);
- GHG emissions avoided by the entity (difference between the company's emissions and a reference situation – either a scenario (e.g., IEA's 2DS scenario) or a reference product mix (e.g., electric vehicles compared to combustion vehicles);
- GHG emissions saved by the entity (as a sum of avoided and reduced emissions).

Induced and saved emissions intensities for three scopes are calculated according to activity approach and value approach with different denominators (Table 2). The activity approach allows for comparison between entities within the same sector and same maturity. It represents the induced emissions from the entity's activities to generate one unit of economic output. Whereas the value approach allows for the comparison of entities across different sectors and represents the induced emissions from the entity's activities corresponding to one unit of the entity's value.

Table 2. Activity and Value Approaches used by C4F

	Asset Value (Value Approach)	Economic Activity (Activity Approach)
Corporate (excl. financials)	Enterprise Value Including Cash (EVIC)	Turnover of the issuer
Financial institutions	Total Financing	Net banking income

CIA overall score is calculated based on the combination of qualitative and quantitative metrics and as well as past, present and future performance of the entity. Past performance is the assessment of a company's emissions reduction over the past five years, calculating an induced emissions reduction rate across significant scopes and benchmarking against IEA Energy Technology Perspectives (ETP) scenarios.[21] The current performance of each activity is analysed relative to peers within the same sector. For future assessments, a forward-looking analysis is presented, focusing principally on the primary activity of the company by its revenue share, while also considering its second most significant activity. Forward-looking assessments include 5 qualitative metrics to gauge the company's strategic approach to climate risk, including governance, transparency, commitment to transition, management incentives, etc. While not included in the CIA overall rating, another important metric estimated by C4F is the eligible green share of turnover that is derived from the entities' activities eligible for EU Taxonomy based on the entity's turnover distribution.

To ensure comparability between different sectors, C4F provides sector-specific ratings that are capped or floored based on the climate impact of the activities, ensuring they reflect the appropriate GHG emissions stakes. For instance, from the score of 1 (best) to 15 (worst) oil & gas companies would be between 8 (cap) and 15 (floor) and ICT companies would be between 5 (cap) and 13 (floor).

21. Mostly, but not exclusively, FAO's Alternative pathways to 2050 is also used.

5.2 Environmental risks and impacts

Environmental risks and impacts in this study are measured using C4F's Biodiversity Impact Analytics (BIA) proxies for biodiversity-related risks. The C4F BIA is built upon the Global Biodiversity Score (GBS) that was created by CDC Biodiversité. Together, they co-developed the BIA-GBS database (short: BIA) to assess absolute biodiversity impact, impact attribution and intensities as well as biodiversity dependency of entities to provide actionable information to financial actors. C4F separates BIA-Dependency and BIA-Impact. The former is used as a proxy to assess exposure to biodiversity-related physical risk, and the latter is a measure for the impact on biodiversity by individual companies, which can also be used as proxy to biodiversity-related transition risk.

BIA-Dependency

BIA assesses companies' dependencies on nature (particularly ecosystem services) via an associated dependency score (in %) for scope 1 (direct operations) and scope 3 (upstream activities) of a company. An ecosystem service is defined as the benefits that people and organisations derive from nature either directly or indirectly. BIA bases itself on 21 ecosystem services that are classified across three types: provisioning services (e.g. surface and groundwater supply), regulation and maintenance services (e.g. climate regulation) and cultural services (e.g. recreation in nature). The BIA builds on the ENCORE Methodology and therefore measures dependency of an entity on the basis of its economic activities and the region in the world where it operates. BIA offers two key metrics to interpret the dependency of an entity on all and individual ecosystem services:

- **Average Dependency Score:** is a value between 0% (no known dependency) and 100% (very high dependency) for scope 1 and scope 3 upstream. This value illustrates the average dependency of an entity on ecosystem services given its economic activities weighted by their revenue share. This metric can be limited because of the various averaging steps that may mask critical dependencies (score >80%) of certain economic activities on one or few ecosystem services. This missing view is complemented by the Critical Dependency Score.

- **Critical Dependency Score:** represents the share of an entity's activities (scope 1 and scope 3 upstream) that critically[22] depend on at least one ecosystem service.

BIA-Impact

The BIA measures the impact of an entity on biodiversity by considering the Mean Species Abundance (MSA) that is expressed as a percentage, indicating the integrity of an ecosystem via a comparison to its pristine state (e.g. 0% fully artificialised ecosystem and 100% its pristine state). To quantify the absolute impact MSA.km^2 is used. 1 MSA.km^2 , defined as the impact integrated on a surface, means a full artificialization of 1km^2 of pristine nature (see Annex for further details). To connect a company's economic activities to the impact on biodiversity, BIA builds on 5 main pressures identified by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to be driving biodiversity loss and nature degradation: land/sea-use change, direct exploitation, climate change, pollution and invasive alien species BIA covers 4 out of 5 pressures (converted into 11 GBS pressures) across 2 out of 3 nature realms[23] (terrestrial and freshwater) (see Annex for further details).

22. Critical dependency is defined by the ENCORE methodology as "high" or "very high dependency" that matches dependency scores of 80-100%.
23. Marine ecosystems are not considered.

Ultimately an entities' biodiversity footprint (MSA.km^2) is calculated through various steps. First, by using the CRIS database that maps entities' revenues by sectoral activity and geography (primarily country level). Secondly, this information is plugged into EXIOBASE an Environmentally Extended, Multi-Regional Input-Output Model, that translates the economic sectors and geographical locations into inventories of needed physical materials and flows to perform the given entity's economic activity, considering its direct operations and upstream value chains. It is important to note that the companies' individual GHG emissions (across the whole value chain) are obtained from the CIA database as opposed to using industry/economic activity average using EXIOBASE, unlike for the other drivers. Therefore, a company's CIA results, in terms of the induced GHG, are reflected in the company's biodiversity impact in the climate change pressure for terrestrial and freshwater ecosystems. The extent to which physical material and flows contribute to the 11 GBS pressures is estimated by internal tools by CDC Biodiversité. Finally, BIA-GBS uses the GLOBIO model to translate pressures into impact on ecosystem integrity measured in MSA.km^2. BIA-GBS consider static as well as dynamic impacts, accounting for accumulated negative impacts as well as yearly marginal impacts. The tool allows for the disaggregation of dynamic and static impacts as well as providing normalised, aggregated scores. The tool also provides normalised scores that account for both terrestrial and freshwater impacts in aggregation (measured in MSA parts per billion time integrated - MSAppb*).

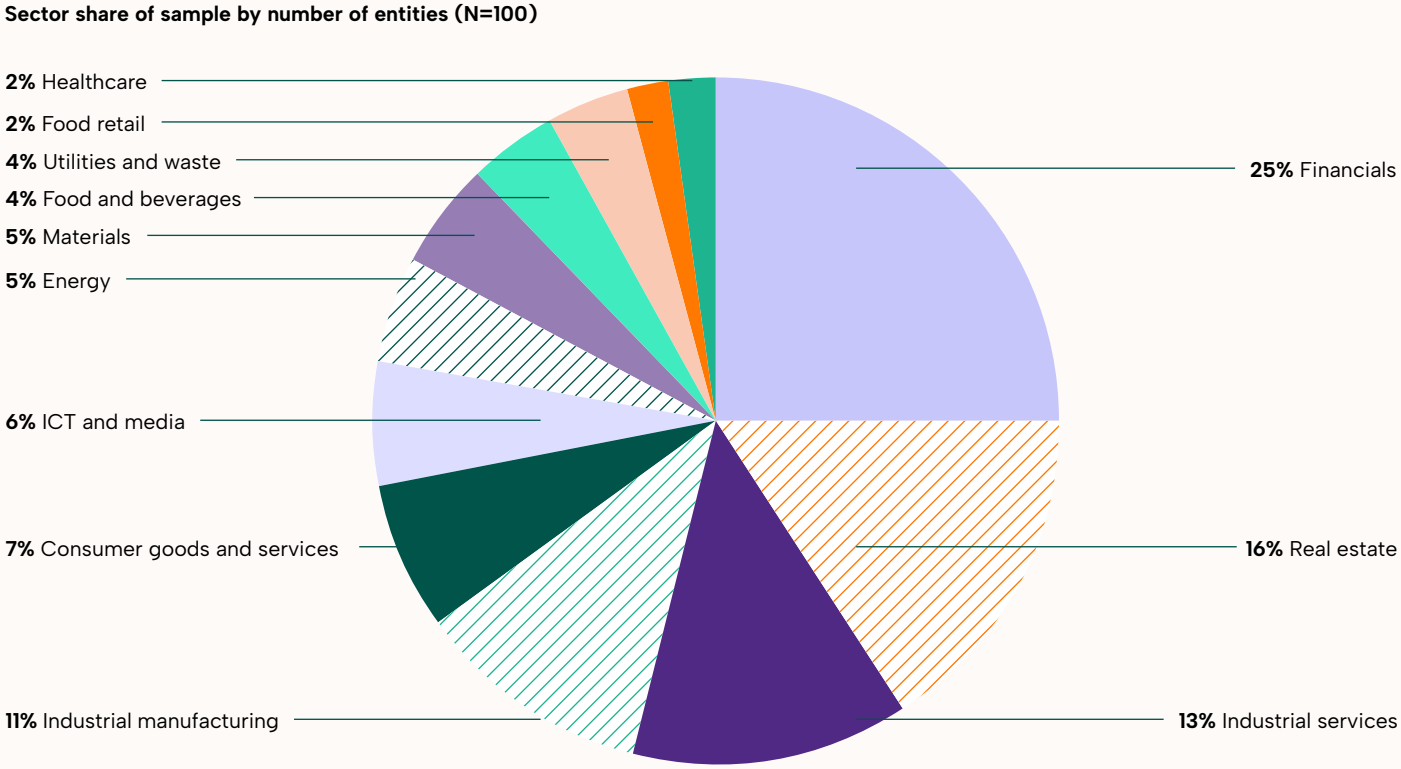
Furthermore, BIA also provides intensities of entities' impact via their so-called economic activity or value approach (this is analogous to CIA). In essence absolute metrics are divided by a measure of economic activity or company valuation (see Table 2). The former is particularly suited to make comparisons within sectors and the latter to consider the financial value of an entity and its impact in a broader portfolio.

6. Results

By matching the C4F entity universe with that of the downloaded, and filtered collateral data we have an analysable sample of 100 entities combined for CRIS, CIA and BIA (see Annex for full list of entities). Each database (CRIS, CIA, BIA) retains their individual sample size (e.g. BIA-Impact 79 entities), as some entities covered in one package (e.g. CRIS) may not be identically covered in another one (e.g. BIA).

For the overall combined sample, financial entities make up the biggest share of this sample, with 25, followed by real estate with 16 and industrial services with 13. The remaining entities, just less than half of the sample size, are primarily from industrial manufacturing, consumer goods & services and ICT media. The sectors with the lowest number of entities are food retail and healthcare, each with 2 entities.

Figure 5. Sample information combined for CIA, CRIS, BIA

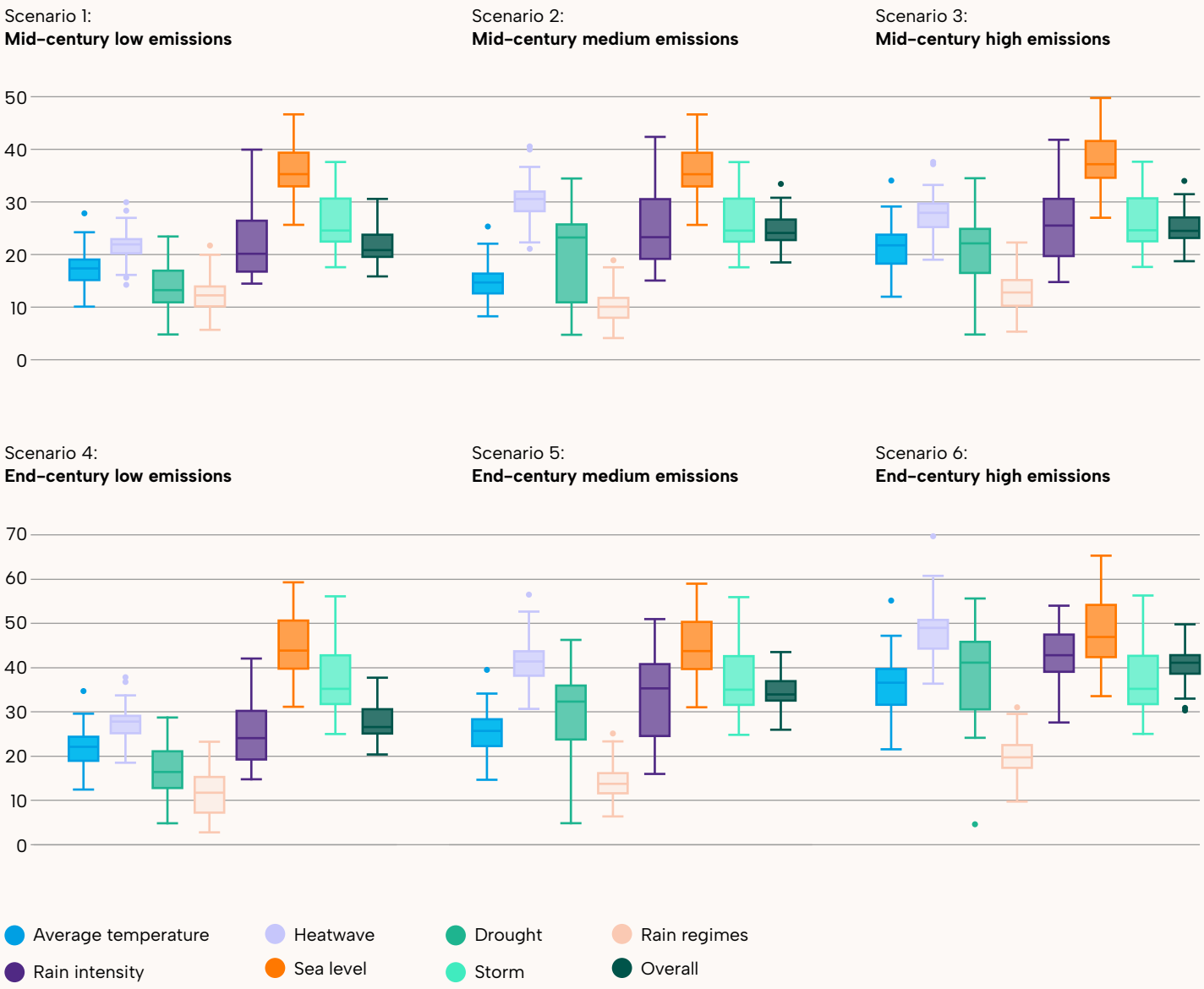


6.1 Exposure to climate-related and environmental physical risks

Climate-related physical risks

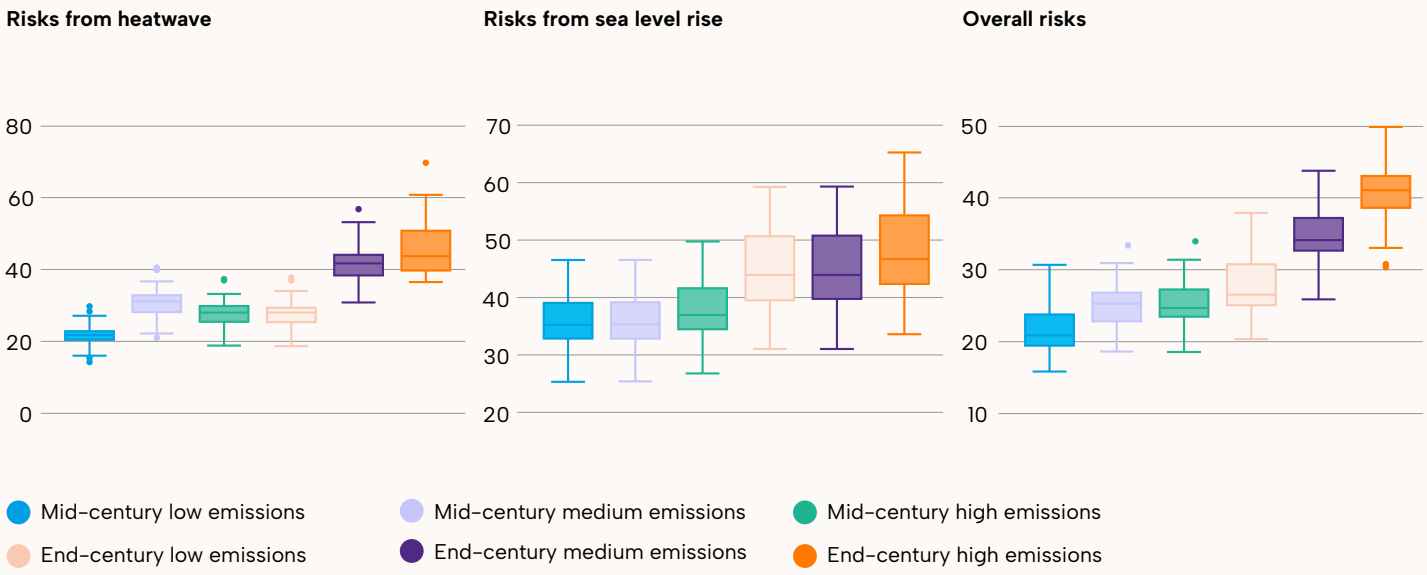
Climate-related physical risks substantially increase for the entities in the sample when moving to the end of century projections and with increasing emissions scenarios (Figure 6). In shorter-term mid-century projections the current portfolio is particularly prone to the risk of sea level rise, heatwaves and storms. For longer-term projections all risk categories substantially increase across the board culminating in elevated levels of drought and rain intensity. In the worst scenario, climate hazards will exacerbate each other even faster and stronger creating a vicious cycle of protracted physical shocks.

Figure 6. Climate physical risk scores for entities in the sample by different scenarios.



Out of different physical risks, the entities in the sample are most prone to risks from heatwaves and rising sea levels, while the overall risks rise with worsening scenarios (Figure 7). Due to the fact that the entities have global operations and depend on global supply chains, if, for instance, an activity in the food sector is heavily reliant on operations in coastal zones and islands prone to sea level rise, this will be reflected strongly in the entity's physical risk portfolio. In the last panel, the overall risks deteriorate quite substantially for end of century projections in medium and high emissions scenarios.

Figure 7. Climate physical risk scores by most prevalent hazards



Sectoral distribution of risks in Figure 8 shows that entities in energy (n=3), healthcare (n=2), food and beverages (n=3), utilities and waste (n=3), consumer goods and services (n=6) sectors are prone to sea level rise. It means that entities in these sectors in the sample are particularly prone to the risks of sea level rise and heatwave compared to entities within the same sector. Furthermore, entities in the food retail (n=2) sector are more prone to heatwaves, entities in the utilities and waste sector are particularly exposed and vulnerable to drought risks.

Figure 8. Climate physical risk scores by hazards and sectors (average of H2 and H4 medium emissions scenarios)

	Sea level rise	Heatwave	Storm	Rain intensity	Drought	Average temperature	Rain regimes
Energy							
Healthcare							
Food & Beverages							
Utilities & Waste							
Consumer Goods & Services							
Materials							
Industrial Manufacturing							
Industrial Services							
Financials							
ICT & Media							
Food Retail							
Real Estate							

CRIS score average	49	45	38	37	32	24	15

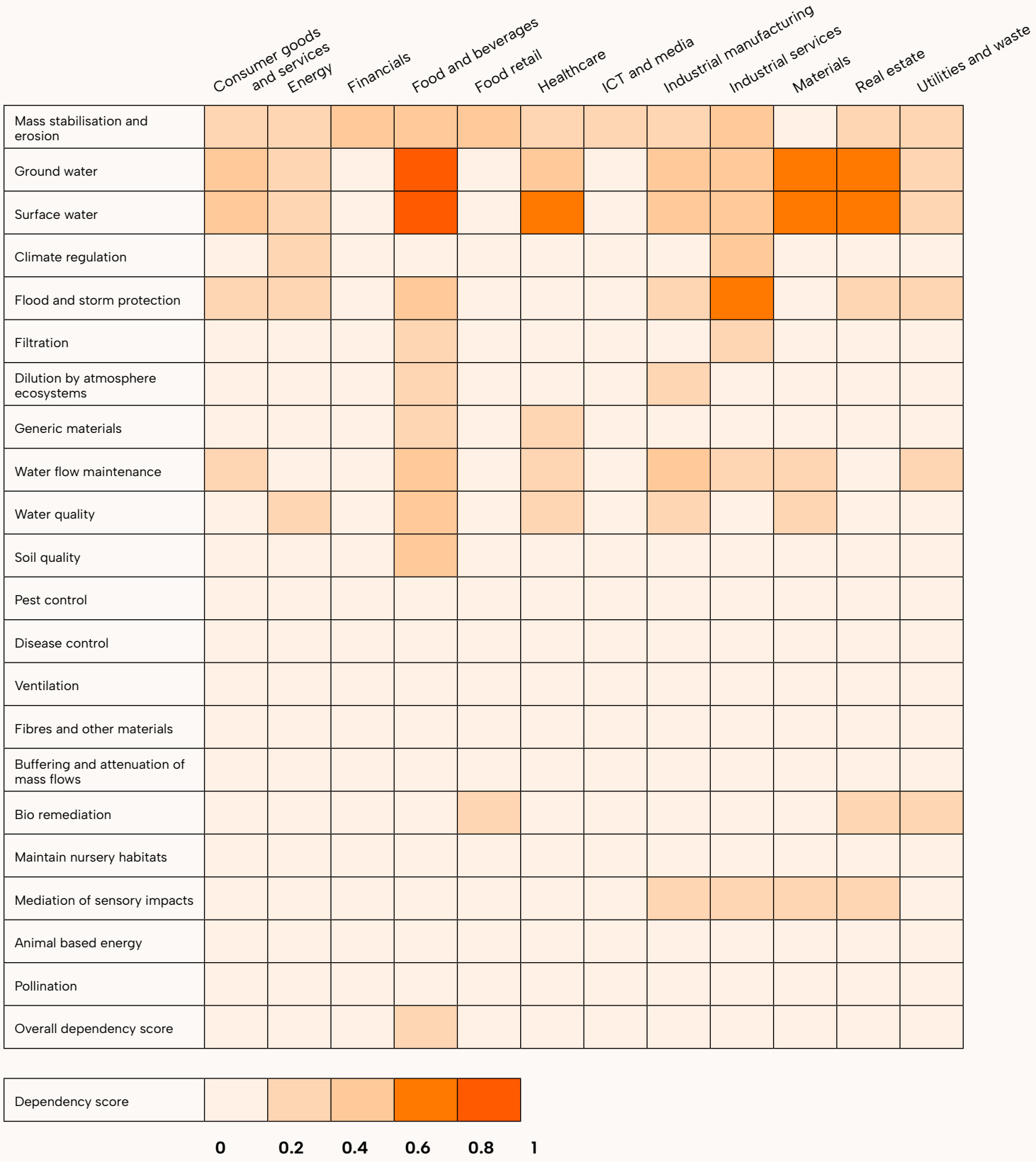
Biodiversity-related physical risks

The exposure to (environmental or) biodiversity-related physical risks can be proxied by the dependencies of the issuer's economic activities on ecosystem services. Figure 9 illustrates the scope 1 (direct operations) average dependency of companies (aggregated at sector level) (n=75) for the listed ecosystem services. Overall dependency score for each sector, except food & beverages, is in the lowest dependency category. Given that entities are rarely highly dependent on all ecosystem services, the overall dependency score may not adequately indicate specific potential sources of biodiversity-related physical risks. Therefore, it is also important to consider average dependencies on individual ecosystem services. For example, the three entities represented in the food & beverage sector (n=3), on average have at least middle dependency on a third of the analysed ecosystem services, with critical dependency (dependency score >80%) on groundwater and surface water. Figure 9 also shows that dependencies on soil and water quality, as well as hazard protection, for entities in the food & beverage sector, are not negligible. It is important to note that the entities linked to this sector are primarily active in a subset of this industry, namely alcohol and dairy production.

The entities in the materials (n=4) and real estate sector (n=13) have high dependency on groundwater and surface water. Real estate activities depend on water supply services provided by ecosystems to ensure sufficient quantity and quality of water for building operations such as sanitation, cleaning, and maintenance. Figure 9 also shows that real estate entities on average depend on hazard protection, to protect the building and infrastructure from the impacts of flood and storm (but also wind, sand and other storms). Real estate entities also rely on soil and sediment retention to provide a stable substrate, erosion control, and landslide mitigation for infrastructure.

Similarly, entities in the industrial services sector (n=10) on average are highly dependent on flood and storm protection. Companies in the industrial sector are also dependent on water processes, primarily for cooling and maintenance purposes of buildings and infrastructure. Noteworthy are also entities in the healthcare sector, which show to be highly dependent on surface water availability and to a lesser degree also quality, as these are fundamental services for manufacturing of medications. Mass stabilisation and erosion is also a key ecosystem service to ensure the stability and safety of healthcare infrastructures for care. Entities that are part of the consumer goods & services sector (n=6) on average depend primarily on water services. Two out of six entities are apparel companies whereby textiles, furs and leather items depend on water intensive production processes. From this sector, one company also produces perfume products that rely on water as a key input.

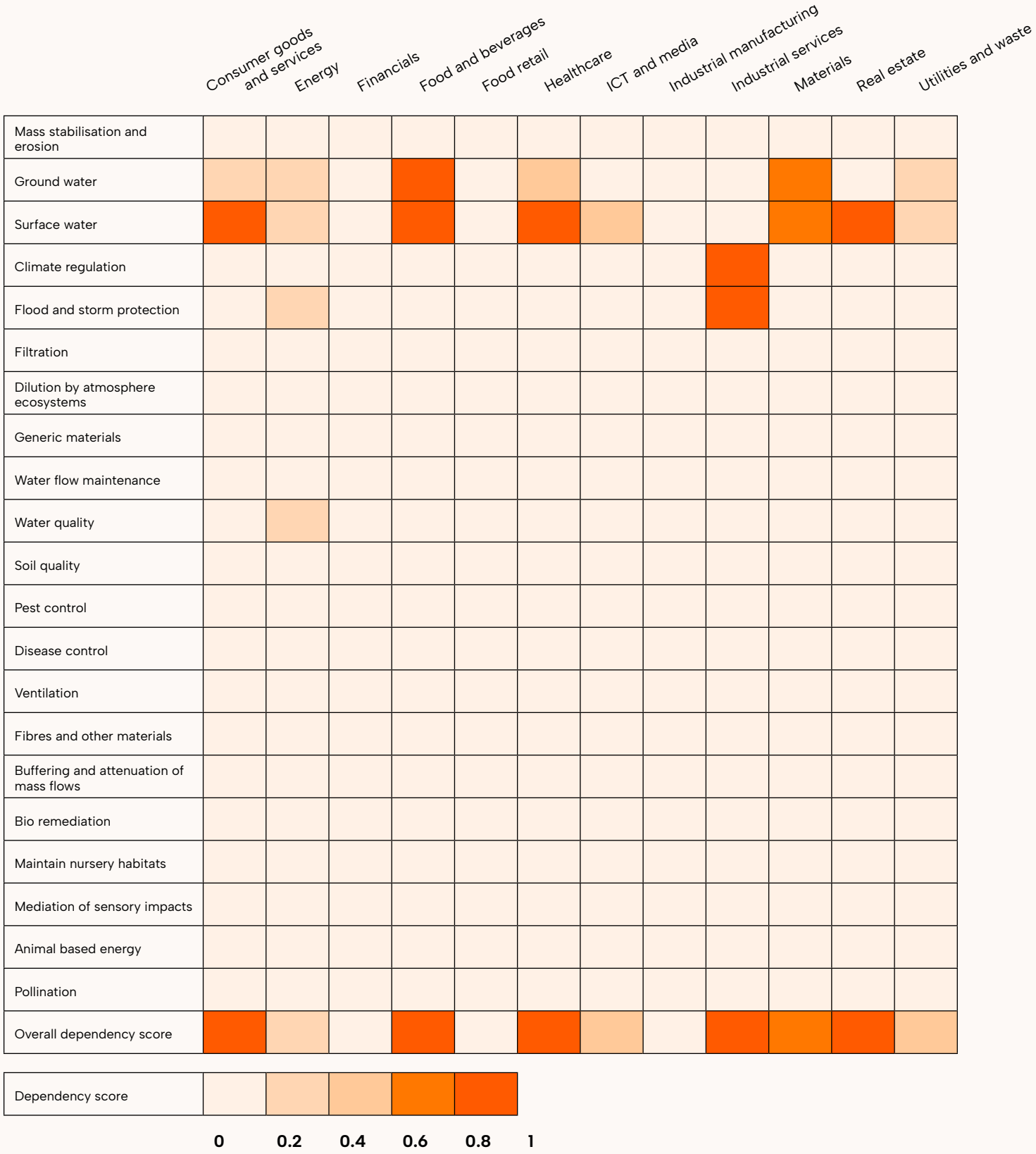
Figure 9. Average scope 1 dependency by sector & ecosystem service



BIA also illustrates the critical dependency score per entity which represents the share of the entities' economic activities that critically depend on at least one ecosystem service. Across the entire collateral pool, 60% of entities[24] critically depend on at least one ecosystem service. For scope 1 (direct operations) Figure 10 shows that entities part of the consumer goods & services, food & beverages, healthcare, industrial services and real estate (n= 31), on average, have at least 80% of their scope 1 activities critically dependent on at least one ecosystem service. For the three entities analysed, from the food & beverage sector, on average 99% of their activities are critically dependent on at least one ecosystem service. Only entities represented in the financials, food retail and industrial manufacturing have below 20% of their direct operations activities critically depend on at least one ecosystem service. By individual ecosystem services, the ones that on average experience the highest share of scope 1 economic activities depending on them are groundwater, surface water, climate regulation, and flood and storm protection. This suggests that should these ecosystem services severely degrade or cease to function it would have widespread repercussions. Recalling that climate-related physical risks will increase in the coming years (see CRIS results above), dwindling freshwater services and adequate flood and storm protection could become detrimental for many companies across different sectors.

24. Defined by more than 50% of their direct operations activities being critically dependent (>80%) on at least one ecosystem service.

Figure 10. Critical scope 1 dependency by sector & ecosystem service

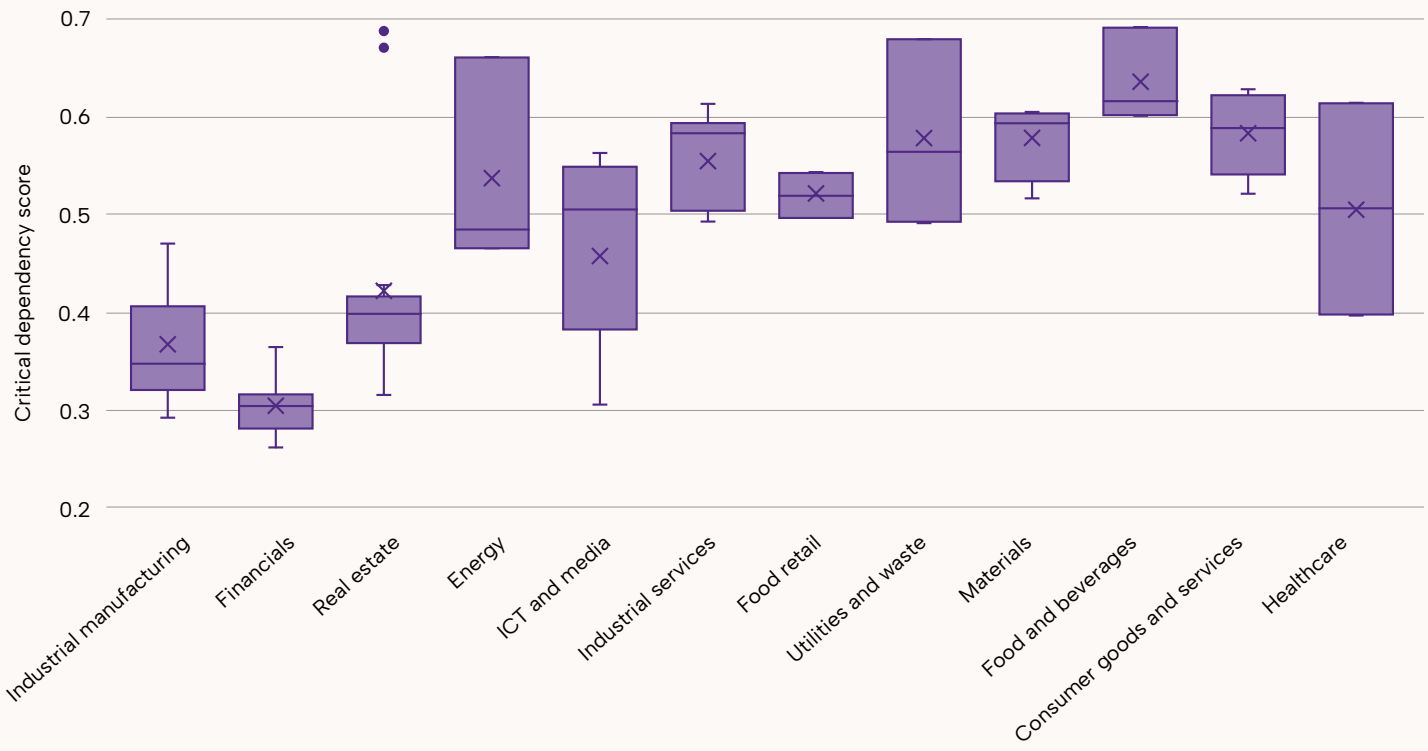


Looking at upstream average dependencies of entities shows a more homogenous picture as is illustrated in Figure 11. All sectors on average have at least a slight dependence on all ecosystem services. The entities that on average are showcasing slightly more elevated upstream dependency are in the food & beverage sector, particularly on mass stabilisation and erosion, ground and surface water, and flood and storm protection. Entities in industrial services on average depend at least 40% on mass stabilisation and erosion, climate regulation and flood and storm protection.

Figure 11. Average upstream dependency by sector & ecosystem service

Regarding upstream critical dependency, the distribution in Figure 12 shows that a majority of the sectors contain entities that, on average, have more than half of their upstream activities critically dependent on at least one ecosystem service. For utilities & waste, and food & beverage the average share of economic activities critically dependent on at least one ecosystem service lies at almost 70%. While on average entities in the real estate sector have 30% of their upstream activities critically dependent on at least one ecosystem service, there are two entities that see nearly 70% of their upstream activities critically dependent on at least one ecosystem service. This highlights the importance of assessing ecosystem services' dependencies at company level rather than sectoral averages, as there may be high variation within sectors.

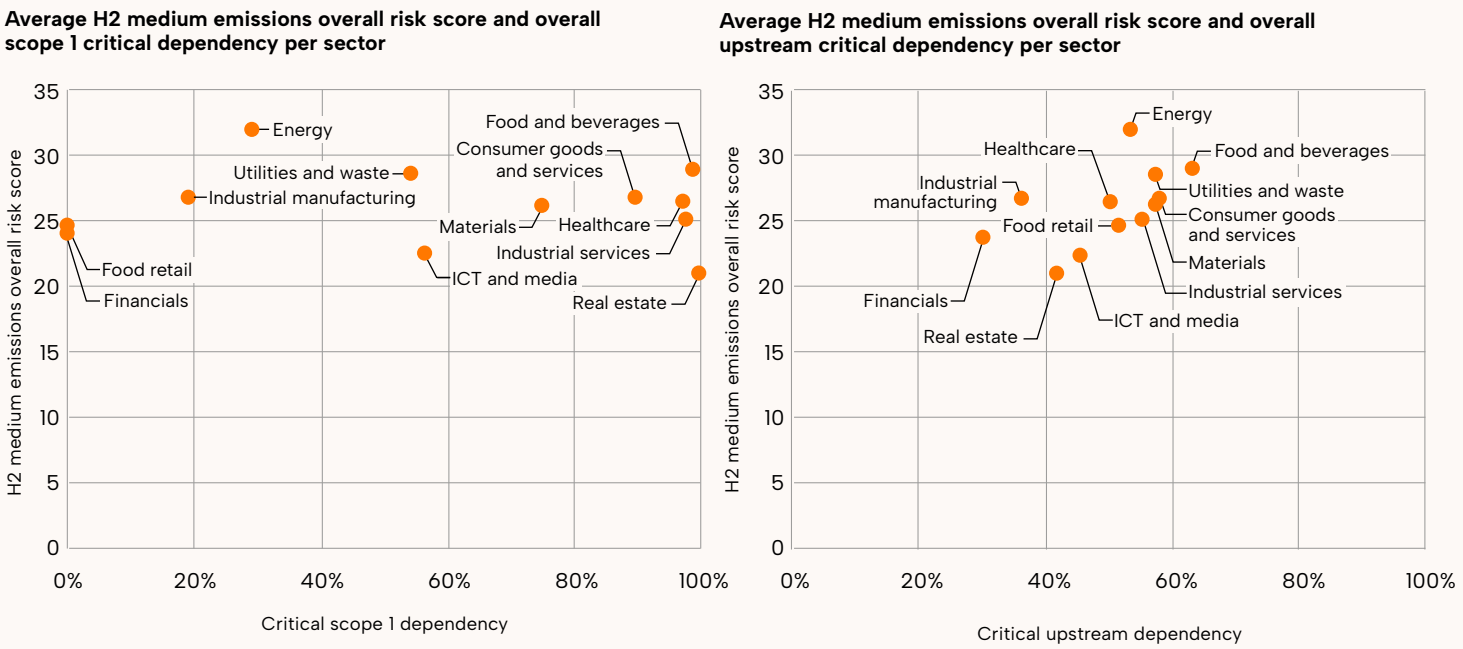
Figure 12. Critical upstream dependency by entity by sector distribution



Integrated view of exposure to C&E physical risks

The results above indicate that considering exposure to C&E physical risks in an integrated way is critical to get a more nuanced understanding for the purpose of collateral risk management. Figure 13 below maps average sector H2 medium overall risk score from CRIS and the overall critical dependency score for scope 1 and upstream (n=73). Mapping this data point from CRIS to scope 1 overall dependency score shows a quite diverse range along overall ecosystem service dependency. On the other hand, the spread is lower for upstream critical dependency, since entities within the different sectors, extent-wise, are similarly critically dependent on at least one ecosystem service via their upstream supply chain.

Figure 13. Scatter plot CRIS' H2 medium emissions overall risk score and BIA-Dependency overall critical and average dependency

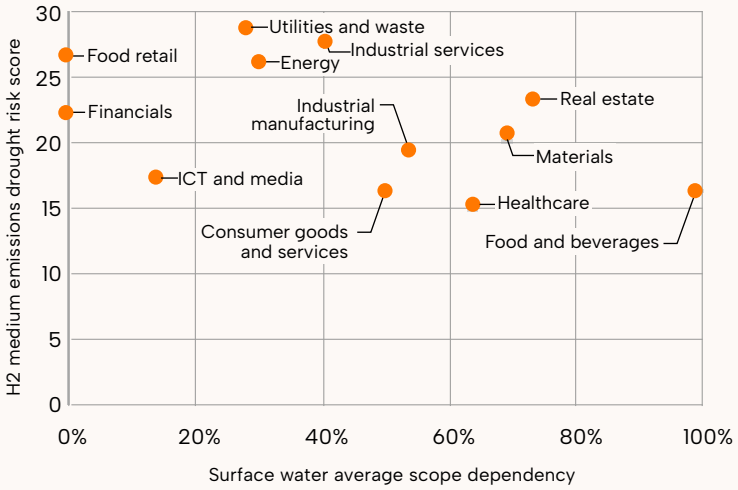


However, this mapping needs to be interpreted with caution since both CRIS and BIA-Dependency indicators consider the average across a myriad of hazards and ecosystem services, respectively. Therefore, deep-diving into interconnected hazards and ecosystem services may allow for more targeted findings. For example, in the BIA-Dependency analysis, surface and groundwater were shown to be among the most important ecosystem services in terms of average and critical dependency both for scope 1 and upstream. This information can be mapped with drought hazard across Horizon2 (H2, projections for 2100) medium emissions scenario (see Figure 14).

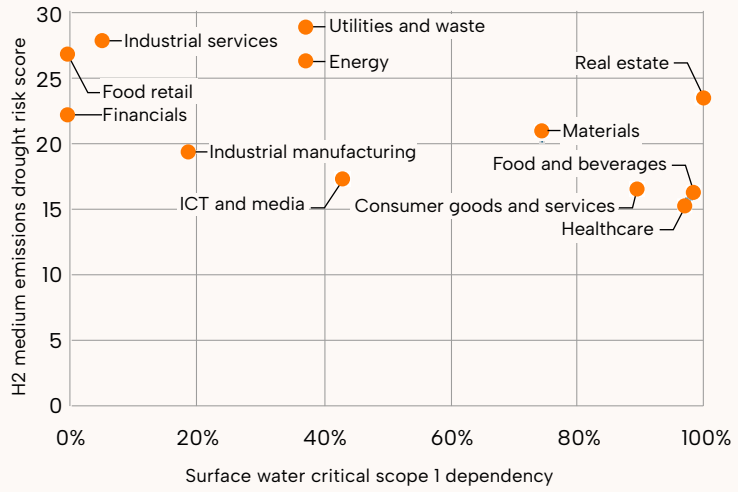
The results show that certain sectors, by their underlying entities' geographic location and economic activity composition, may have a relatively higher exposure and are more vulnerable to droughts and flooding, while also having a very high dependency on surface water. For instance, companies in the real estate sector, on average, see 100% of their scope 1 activities be critically dependent on surface water, while also experiencing a relatively high drought risk score. In general, entities on the top right quadrant (in this figure aggregated by sectoral average) can be deemed to be most exposed to the twin crises of climate change and nature loss. For upstream average dependency the picture is relatively more homogeneous, driven by a smaller range (15-51%). This dynamic is analogous to that found above in the overall dependency and overall H2 Medium emissions risk scores.

Figure 14. Scatter plot CRIS' H2 medium emissions drought risk score and BIA-Dependency critical and average surface water dependency

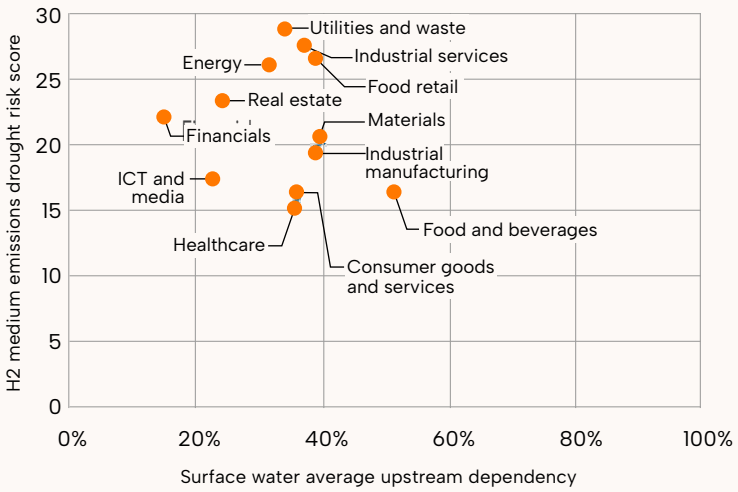
a) Average H2 Medium Emissions Drought Risk Score and Surface Water Average Scope 1 Dependency per Sector



b) Average H2 Medium Emissions Drought Risk Score and Surface Water Critical Scope 1 Critical Dependency per Sector



c) Average H2 Medium Emissions Drought Risk Score and Surface Water Average Upstream Dependency per Sector

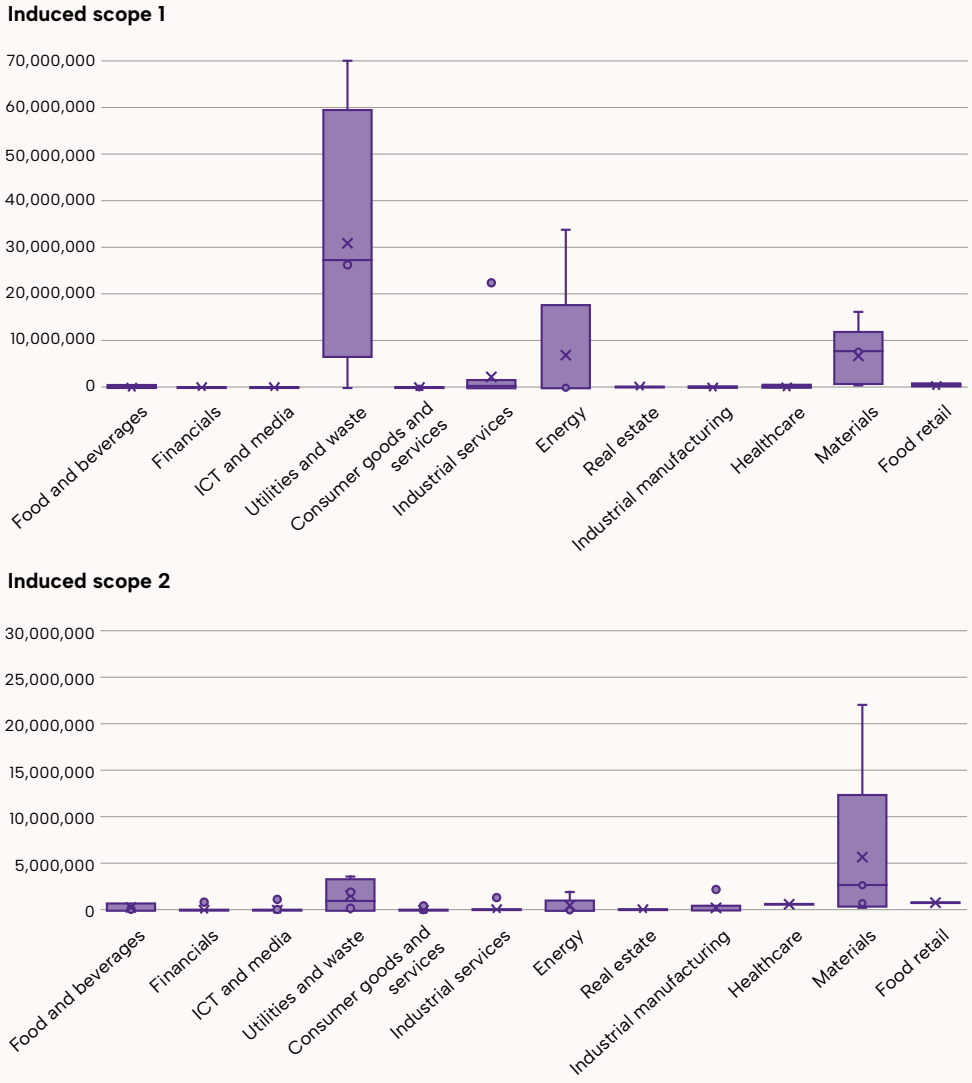


6.2 Climate-related and environmental impact and exposure to transition risks

Climate-related impact and transition risk

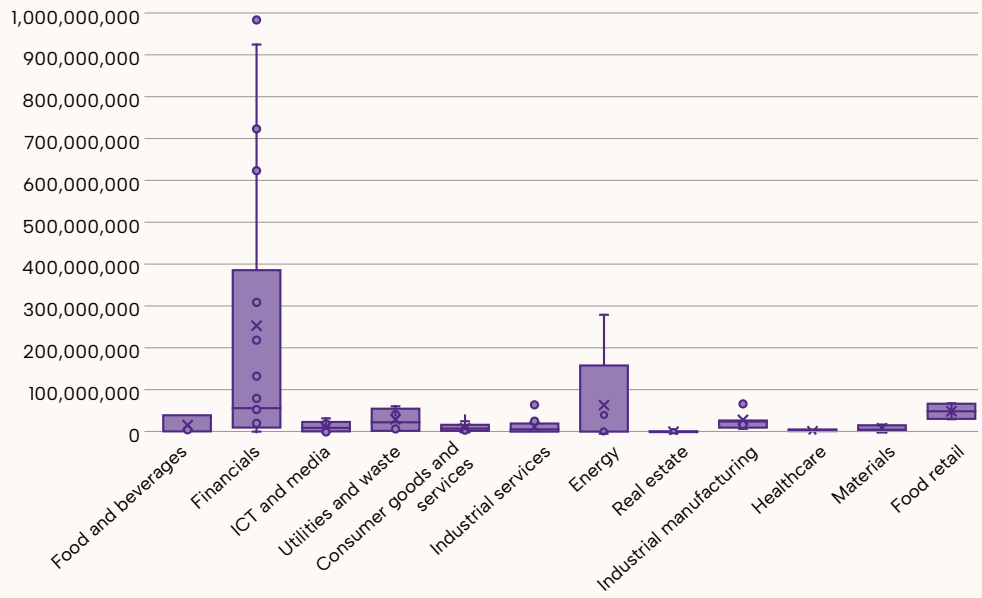
Induced GHG emissions are calculated both upstream and downstream for Scope 1, 2 and 3. Figure 15 below shows that only counting for Scope 1 and 2 means that a large universe of emissions would be unaccounted for. For scope 1 emissions, utilities & waste (n=4), energy (n=5) and materials (n=5) sectors have the highest emissions given heavy dependence on fossil fuels, energy-intensive processes, and the scale at which these industries operate. For scope 2, materials and, to a lesser extent, utilities and waste sectors have the highest scope 2 emissions due to its substantial reliance on purchased electricity and other forms of external energy to power energy-intensive processes to run continuous, large-scale operations. Industries in regions with carbon-intensive grids will have higher Scope 2 emissions. French financial entities in this sample have the highest scope 3 emissions, besides the energy sector itself.[25] Financials (n=22), particularly in this collateral portfolio, have large exposure to multiple industries and operate globally, with a high share of activities linked to scope 3 emissions. There are also a few outliers as shown in Figure 15 that merit further attention.

Figure 15. Induced emissions across Scope 1, 2 and 3, tCO_2e/EURm



25. Across Scope 1, 2 and 3 emissions in this sample, the energy sector emitted 360 million tCO2e in 2021.

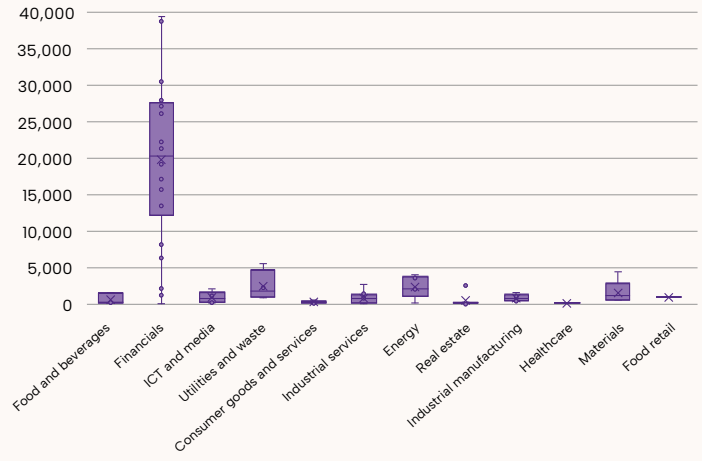
Induced scope 3



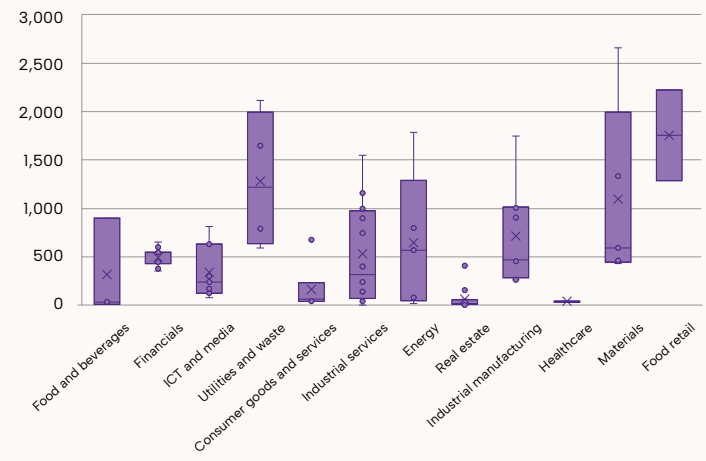
Induced emissions are calculated using the activity and value approach (Figure 16). The activity approach allows for a comparison between entities within the same sector and takes revenues for corporates and net banking income for financial institutions as denominators. With this approach, the figure below shows that the activities of French banks in the sample that we analyse are substantially more GHG intensive, with notable outliers, compared to other banks in the C4F database of financial sector entities. The value approach, on the other hand, supports analysis of entities across different sectors. In this portfolio, materials, utilities & waste, and energy sectors are substantially carbon intensive. When analysing the entire portfolio, therefore, the value approach allows for looking at the portfolio level to determine pockets of climate-related impact (proxying transition risk), while with the activity approach it is possible to zoom in further to focus on specific entities that represent elevated impact, and therefore, exposure to transition risk.

Figure 16. Induced emissions, activity and value approaches, tCO_2e/EURm

Induced scope 1, 2, 3 activity approach

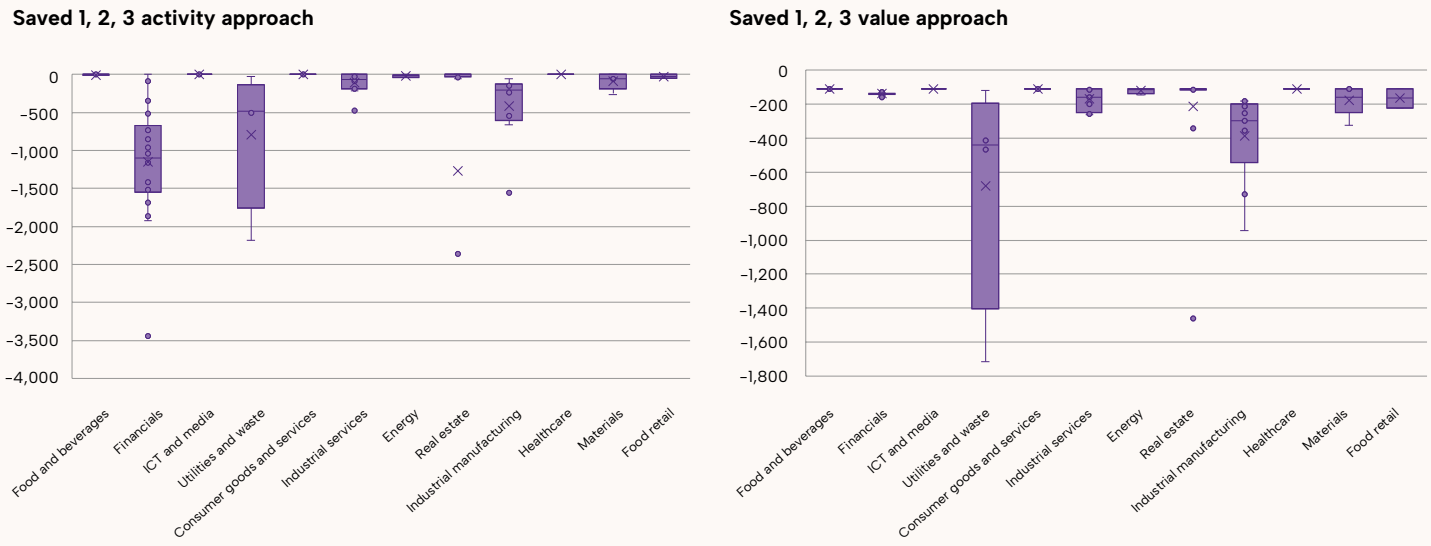


Induced scope 1, 2, 3 value approach



Saved emissions are a sum of avoided and reduced emissions. When looking at the portfolio, it can act as a proxy for transition commitment, transition readiness and potential impact. Saved emissions from the activity approach show that there are entities in the utilities & waste, financials, and industrial manufacturing (n=9) sectors that have more saved emissions compared to entities of the same sector. Emission savings through a value approach shows that large savings are possible in the utilities and waste sector as well as industrial manufacturing, industrial services (n=12), materials and food retail sectors (Figure 17). However, given that they are also emission-intensive sectors, it is important to have a granular look at the entities in these sectors to determine which ones are performing well or lagging behind.

Figure 17. Saved emissions, activity and value approaches, tCO_2e/EURm



Eligible green share shows the share of entities' activities eligible to the EU Taxonomy, based on the company's turnover distribution (Figure 18, left-hand side). This metric is calculated only for non-financial corporates and, due to data gaps, only a limited number of entities (39 out of 93) across 7 sectors are available for analysis. Real estate (n=16), industrial services, utilities & waste, and materials sectors contain entities which, for the most part, are broadly aligned with the EU taxonomy. These entities, down the line, as proposed by van Tilburg and van 't Klooster (2021) could be eligible for the lower, green interest rate by the ECB to accelerate transition. Entities could be analysed considering backward-and forward-looking indicators. For the forward-looking indicators it is important to consider both qualitative and quantitative metrics. The former could include the eligible green share and the latter could encompass the entity's strategy, targets, investments and governance that are aligned with TCFD recommendations (Figure 18, right-hand side).

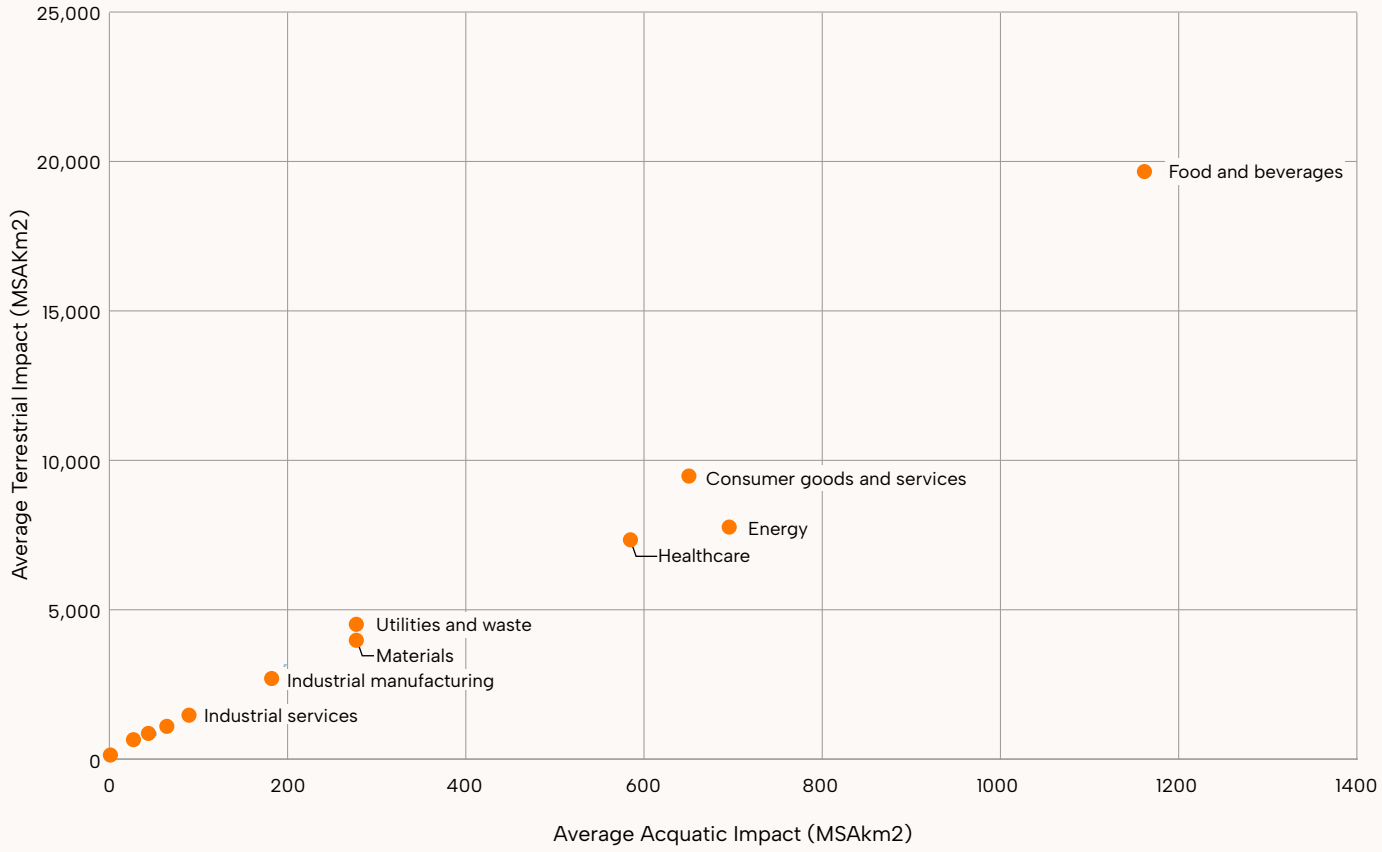
Figure 18. Eligible green share and qualitative forward-looking rating

Biodiversity-related impact and transition risk

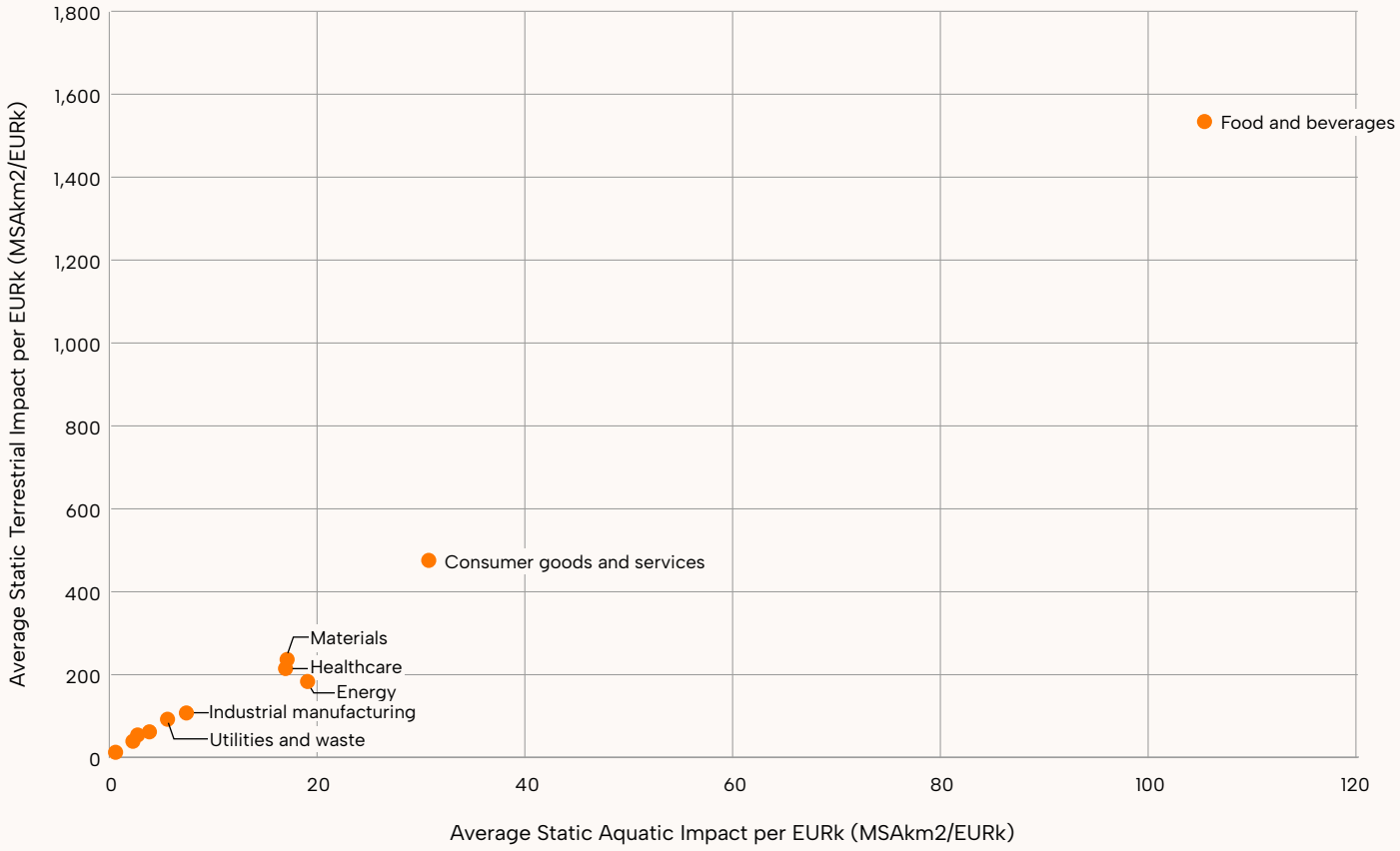
The impact on biodiversity is measured by MSA.km² at entity level (n=79). For example, as Figure 19a shows, the entities in the food & beverages (n=3) sector, on average, have each impacted freshwater and terrestrial biodiversity the equivalent of having fully artificialised 1165 km² and 19576 km², respectively. The biodiversity impact of the three food & beverage entities added together is the equivalent of having fully artificialised what used to be pristine nature the size of 3494 km² (freshwater impact) and 58735 km² (terrestrial impact). Regardless of whether the activity approach is used (dividing the impact by issuer's turnover) or the value approach (dividing the impact by EVIC for non-financial corporates and total financing for financial institutions), the food & beverages sector stands out as having on average a high static impact on both terrestrial and aquatic ecosystems compared to the other sectors. This indicates the entities from the analysed sample in the food & beverage sector, on average, are very nature intensive. In absolute terms, entities in the consumer goods & services (n= 6), energy (n=3) and healthcare (n=2) sectors, on average, have higher static terrestrial and aquatic impacts compared to the other sectors, but still comparatively significantly less than the food & beverages sector. Once economic activity (EURk) is accounted for (see Figure 19b), the energy and healthcare sector are no longer considerably higher than the rest of the sectors.

Figure 19. Static Average Terrestrial and Aquatic Impact. a) absolute b) by activity

a) Average Static Terrestrial and Aquatic Impact by Sector



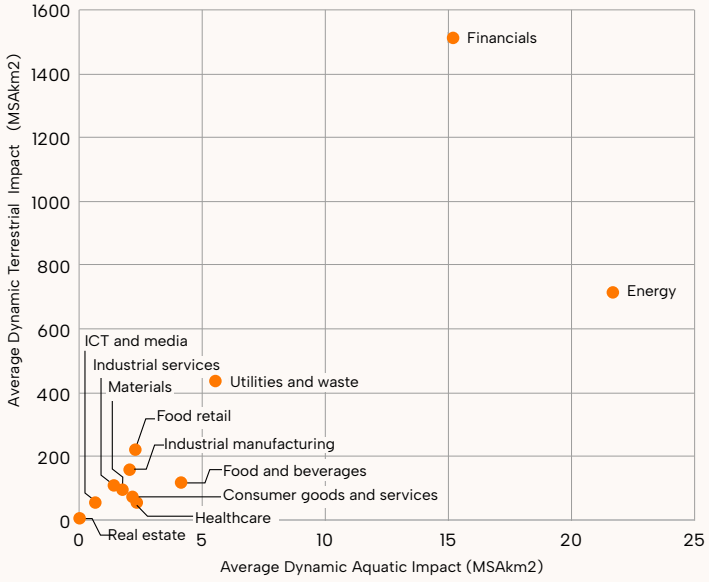
b) Average Static Terrestrial and Aquatic Impact by Sector (Activity Approach)



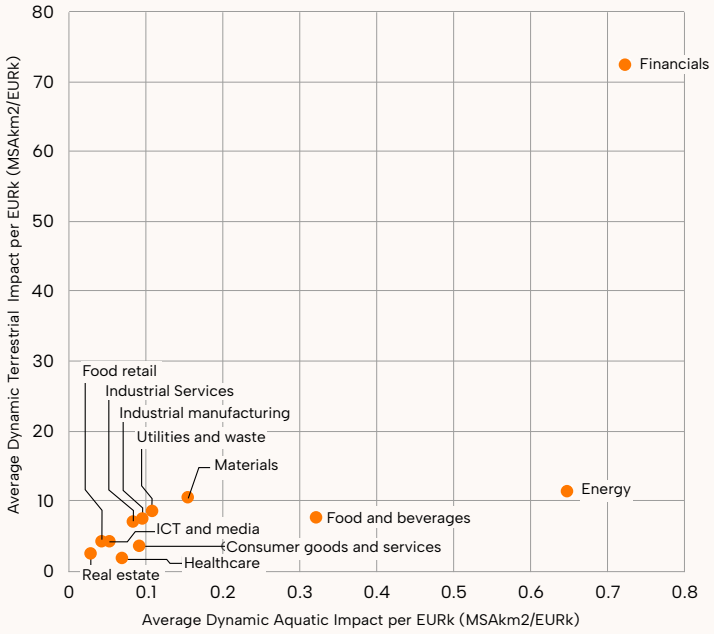
When looking at dynamic impacts, the impacts accumulated in a single year, divided by economic activity (i.e. the activity approach), there is a different constellation altogether. This indicates that for certain entities the dynamic impacts of the last year are not representative of the accumulated impact over previous years (see Figure 20). In fact, in absolute terms and measured by economic activity, the financial sector (n=13) on average is linked to higher average dynamic aquatic and terrestrial impact compared to the other sectors. This is mainly driven by C4F's methodology, wherebythe CIA database provides GHG emissions information for determining climate change-driven BIA impact. A financial institutions' scope 3 emissions are equivalent to the combined Scope 1, 2, and 3 emissions of the companies it finances. Since financial institutions finance the real economy, they are accountable for a significant portion of emissions. Consequently, these high GHG emissions have a substantial impact on biodiversity due to climate change pressures, affecting both terrestrial and aquatic environments.

Figure 20. Static Average Terrestrial and Aquatic Impact. a) absolute b) by economic activity

a) Average Dynamic Terrestrial and Aquatic Impact by sector



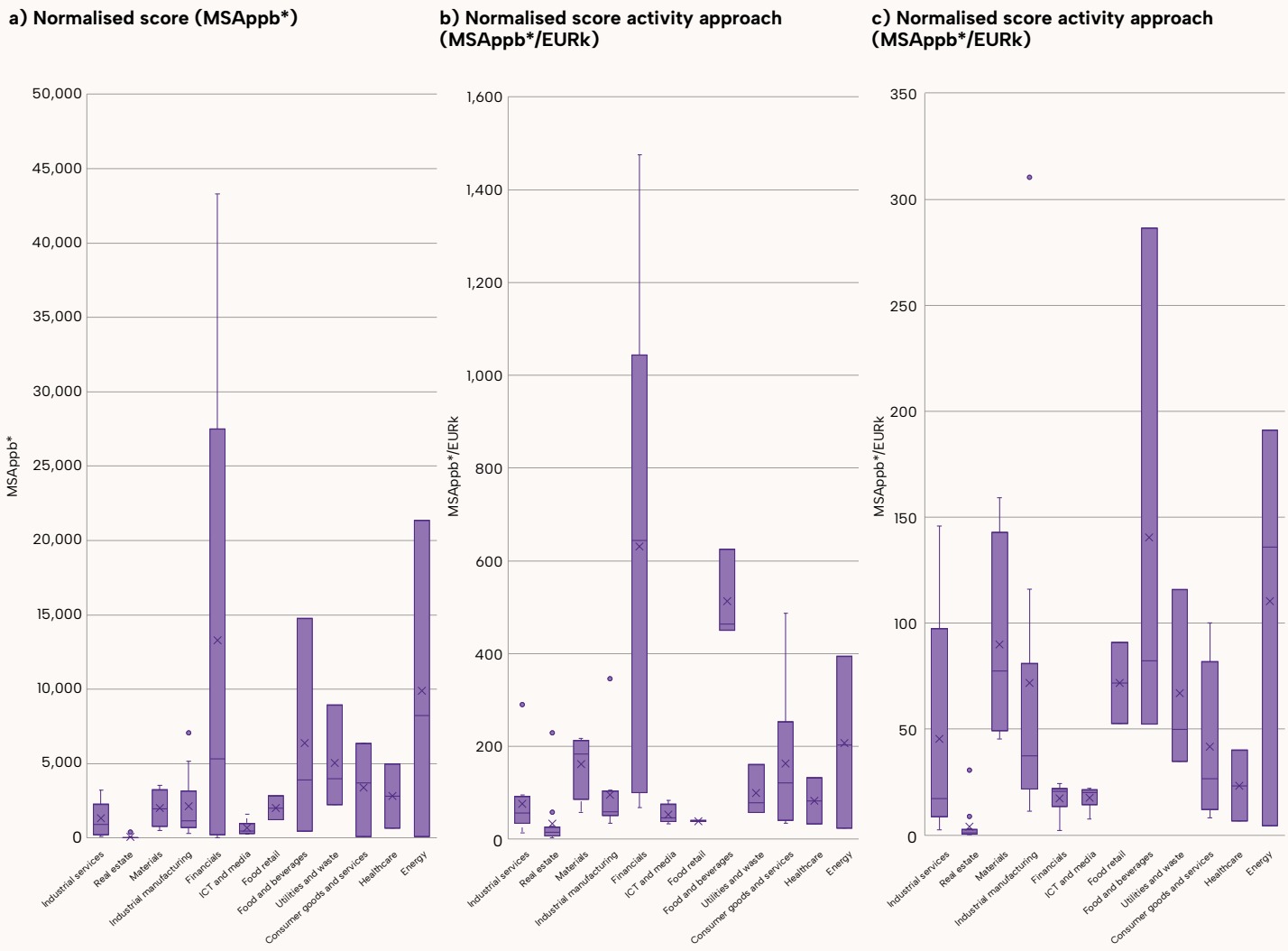
b) Average dynamic terrestrial and aquatic impact by sector (activity approach)



To consider static and dynamic impacts of both aquatic and terrestrial ecosystems in aggregated form, C4F offers the normalised score measured in MSA parts per billion time integrated (MSAppb*). The financial sector (n=15) has the largest range of biodiversity impact in absolute terms (see Figure 21 a&b). This can be reconciled by the fact that the financial sector, by its dynamic impact, outstripped the rest and in the normalised score the static impact is relatively underrepresented.[26] For the normalised score distribution by economic activity, the following sectors have companies that deviate starkly from the mean: industrial services (n=11), real estate (n=13) and industrial manufacturing (n=10).

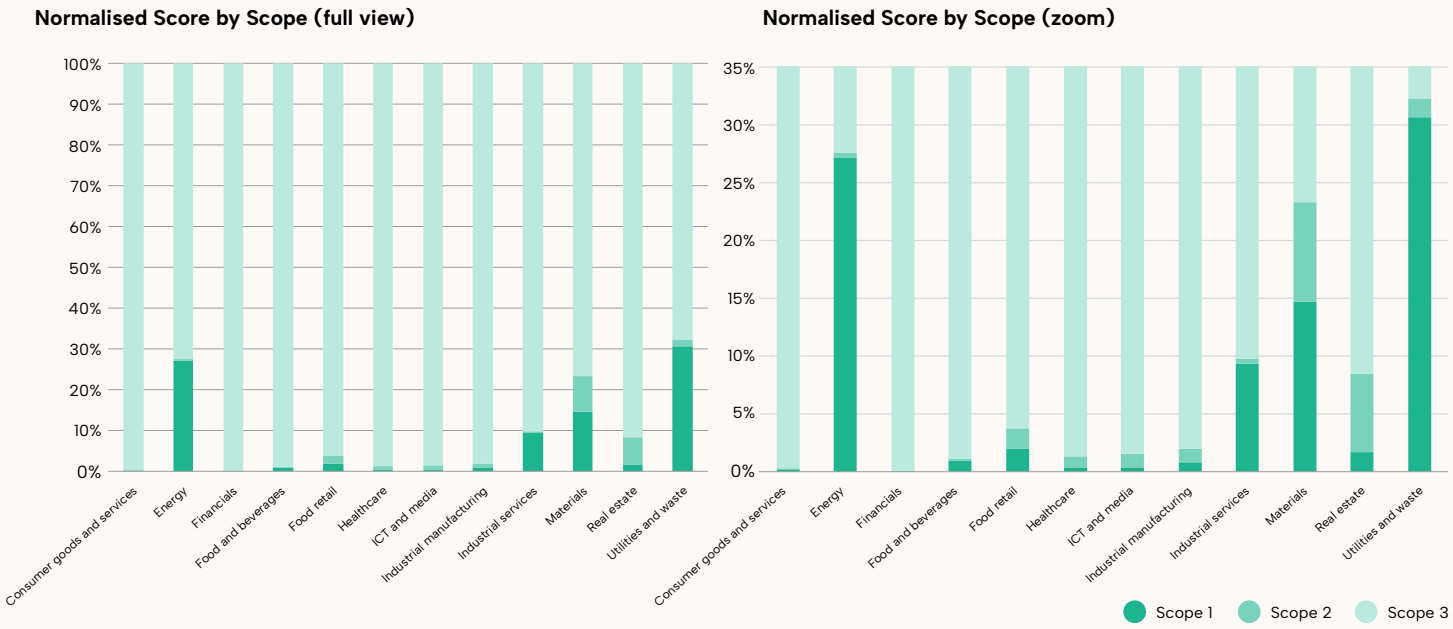
26. The static impact is normalised using the hypothesis that an ecosystem needs 50 years to recover. So in one year of analysis, we lost the opportunity to recover 1/50.

Figure 21. Normalised score a) absolute b) activity approach c) value approach



Breaking down the normalised score shows that on average, activities rooted in entities' scope 3 in all sectors are the largest contributor to the entities' biodiversity footprint. As expected, for the financial entities, virtually 100% of its normalised score stems from its scope 3 activities, i.e. its financing activities (see Figure 22a). By zooming into the relationship between scope 1 and scope 2, energy sector entities, on average, have around 27% of their normalised biodiversity score derived from scope 1 activities. For entities in the utilities & waste sector that is just over 30% (see Figure 22b). For real estate companies, on average, scope 2 contributes four times as much to the overall normalised score compared to scope 1.

Figure 22. Normalised score by scope (share of contribution of each scope to overall normalised score)

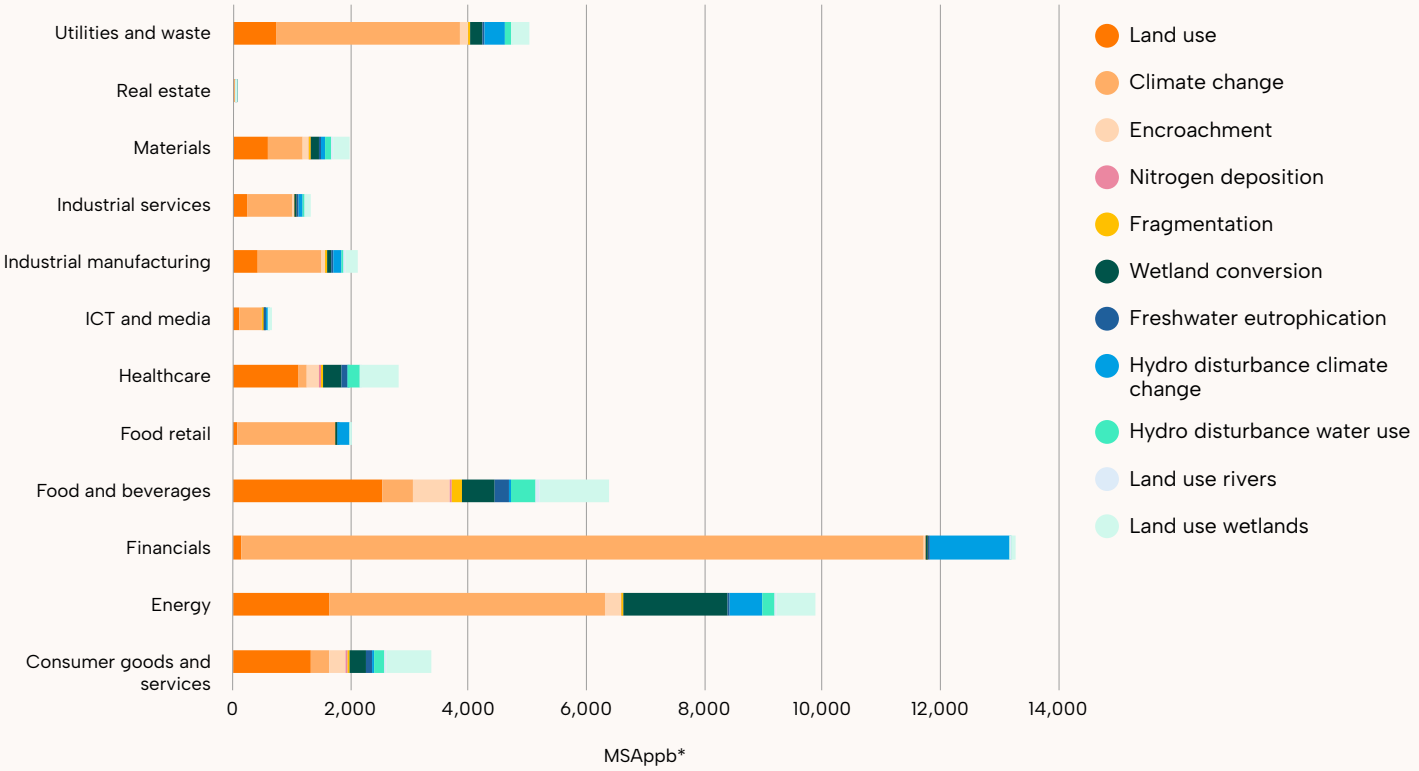


To better understand the impact that different entities have on biodiversity and which kind of transition risks they may be exposed to, it is important to consider the specific drivers through which they negatively impact nature and biodiversity. Figure 23 illustrates the average share of the different nature loss pressures, as part of the overall normalised score, for each sector. The cooler colours illustrate freshwater-related drivers and the warmer colours terrestrial-related nature loss drivers. Generally, terrestrial nature loss drivers make up a bigger share than aquatic nature loss drivers. For the 15 entities in the financial sector, on average, the most important nature loss driver is climate change. Sectors where land-use makes up a bigger share within terrestrial pressures are healthcare, food & beverages, and consumer goods & services. On average, for companies in these sectors, freshwater pressures make up a relatively important share compared to entities in other sectors.

Within freshwater pressures, wetland conversion and wetland land use tend to constitute the biggest shares across sectors. The exceptions to that are entities in food & retail (n=2) and the financial sector, where climate-change driven hydrological disturbance make up the most important share for freshwater-related pressures. Entities in the real estate sector on average show a negligible impact on biodiversity. This is the case primarily because of methodological reasons. The construction of real estate is classified as a temporary activity and therefore its land-use change is ascribed to the entity/sector that ends up using that infrastructure for its activities and therefore, is no longer attributed to the real estate sector. This distinguishes the real estate sector entities from other sectors and affects the methodology of static impact accounting. Furthermore, EXIOBASE does not provide scope 1 land use impacts for the construction activities that underpins the real estate sector.

Overall, this figure shows that having a climate-centred approach is also relevant for addressing broader environmental risk and impacts. However, it is not sufficient as there are other important drivers of nature loss, such as land-use and freshwater ecosystem conversion that would be neglected but yet may be the most important pressures for certain companies. This is also important to consider in the context of companies' climate change mitigation measures, as they should not be at the cost of fuelling nature loss via other pressures (e.g. land use change).

Figure 23. Average Sector Normalised Score by Nature loss driver (MSAppb*)



C&E integrated impact and transition risk

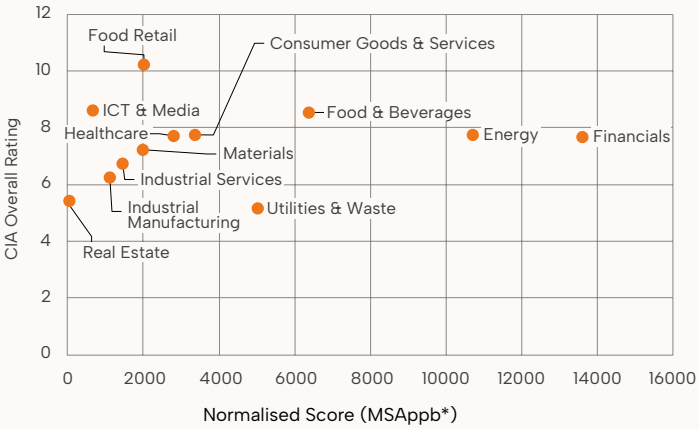
Considering integrated approaches for assessing impact on climate change and nature can also garner more insights than if they were considered separately. Figure 24 below maps the CIA overall rating with aggregated and normalised BIA-Impact indicators quantifying biodiversity impact (n=70). For the overall normalised biodiversity score (in MSAppb*) that considers all scopes, the financials sector stands out as the sector with highest MSAppb* (higher values mean higher impact on biodiversity) and an above average CIA overall rating (higher numerical ratings mean stronger exposure to climate change and poorer contribution to climate change mitigation). This is mainly driven by the Scope 3 MSAppb* as is shown in Figure 24c. It is also important to recall Figure 23 that breaks down the normalised score by biodiversity pressure showing that, on average, the most important nature pressure from the entities in the financial sector is climate change.

Entities in the energy sector, on average, are marked with a relatively high normalised score and slightly above average CIA overall rating. This is mainly due to the elevated Scope 1 & 2 normalised score of the energy sector (see Figure 24d). The energy sector's most significant terrestrial biodiversity pressure is climate change (ca. 40% of total). When accounting for economic activity (see Figure 24b) the picture becomes diverse and elevates the relative negative impact of the entities in the food & beverage sector. Nonetheless, the food & beverage sector on average has the majority of its negative biodiversity impact driven by land-use. Therefore, the interaction with CIA rating is less linear as opposed to entities in the energy and financial sector, for example.

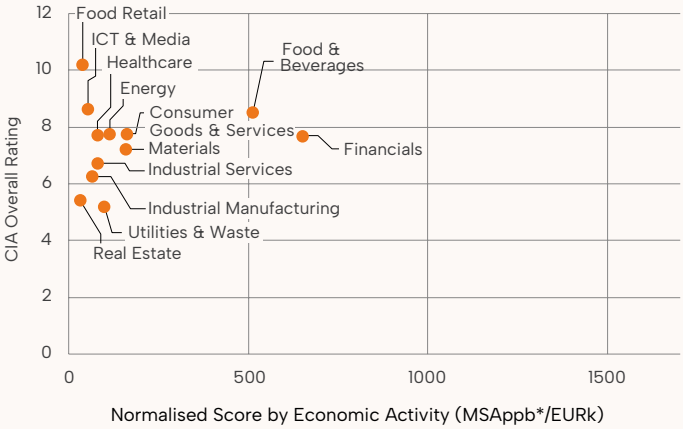
Overall Figure 24 shows that companies that are part of sectors that have both high MSAppb* score and CIA rating, are most likely driving the negative biodiversity impact by climate change contribution. Companies with a high biodiversity negative impact but low CIA rating are most likely driving biodiversity loss via other key pressures (see Figure 23).

Figure 24. Scatter Plot CIA Overall Rating and BIA-Impact Normalised Biodiversity Impact Score (a) overall, b) by activity and c) d) by scope.

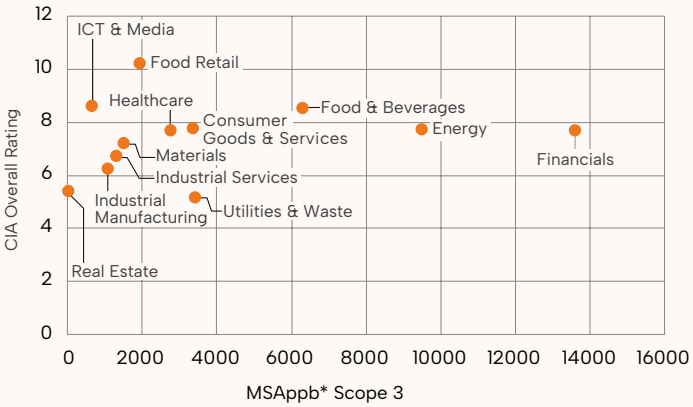
Average CIA Rating and Biodiversity Impact Normalised Score by Sector



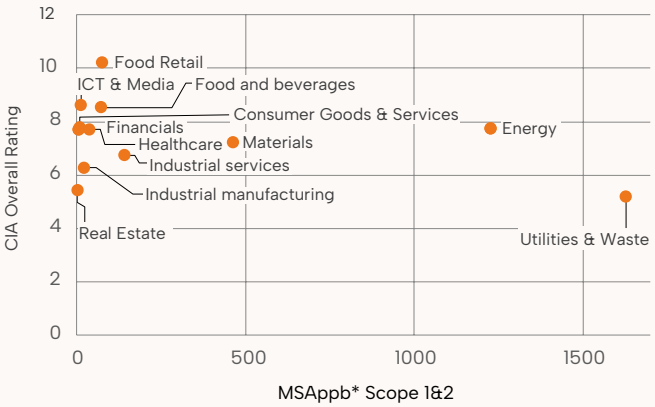
Average CIA Rating and Biodiversity Impact Normalised Score by economic activity by Sector



Average CIA Rating and Biodiversity Impact Normalised Score Scope 3 by Sector



Average CIA Rating and Biodiversity Impact Normalised Score Scope1&2 by Sector



6.3 Case study of Company A in the food and beverage sector

C&E physical risk profile

Company A[27] is prone to heightened risks of sea level rise, heatwaves and heavy rainfall. Heightened risk of sea level rise is due to the geographic location of its activities, which are based mostly in Europe with the rest based in 5 countries across North America, South East Asia and Europe. Company A can also mitigate the C&E impact of its activities which could in turn decrease its physical risks. Concretely, this could entail that activities by Company A directed at soil regeneration could help with increasing resilience against heavy rainfall while enhancing carbon sequestration. Furthermore, Company A has an overall average ecosystem services dependency score of 28% for scope 1, and 26% for scope 3 upstream. Comparatively ground and surface water are the ecosystem services that Company A has the highest dependency on. For scope 1, Company A on average depends 100% on both ground and surface water. Via its upstream supply chain Company A depends, on average, 56% on both groundwater and surface water. Company A is not only dependent on water-related ecosystem services, notwithstanding potential adaptation strategies, it is also at risk given that freshwater ecosystem services are at risk of collapse.[28] That is the case both from a freshwater quantity as well as freshwater quality perspective: with the backdrop that 90% of freshwater consumption comes from agricultural and

27. The case study refers to a real company, but the name is redacted since the focus is not on this company, but rather the methodology to assess this company that could be applied to other companies in the same sector.
28. Namely that freshwater on earth has already surpassed the freshwater safe operating space as according to the Stockholm Resilience Centre's update on the planetary boundaries in 2023.

industry use, it is predicted that by 2030 we can expect a 40% supply shortfall assuming current production and consumption processes (Harvey, 2023). Furthermore one of the biggest threats to the freshwater ecosystem is eutrophication[29] which is detrimental to water quality upon which Company A has a high (60%) average dependence on, for its direct operations. In order to determine risk, a bottom-up spatially explicitly assessment considering hazard, exposure and vulnerability would be necessary. However, evidence shows that both freshwater quantity and quality challenges are globally imminent with few exceptions (Ceres, 2022).

C&E impact and transition risk profile

Company A conducts business in the food and beverage sector, namely in food for 84% of activities and beverages for 16% of activities by turnover. Scope 1 and 2 GHG emissions are calculated based on the reported energy consumption, that includes the location of the activities. Depending on the country location of its activities, the electricity consumption for scope 2 emission intensity is calculated according to local market rates. For Scope 3, intensity is calculated across the value chain and the following dimensions are taken into account: deforestation, agricultural raw materials, packaging, transport, supermarkets and end of life. Some products, in addition to induced emissions related to their production, lead to avoided emissions because they replace more carbon intensive products. Company A intends to meet the Paris goals by contributing in two respects: developing regenerative practices by increasing carbon sequestration of soils and reducing its carbon footprint throughout the production process. The latter includes replacements of dairy products (more carbon intensive) by plant-based alternatives (less carbon intensive), purchasing products from regenerative agriculture, fighting food waste, or efforts to reduce the impacts of packaging and transportation. Part of the company's CapEx and R&D expenditures are allocated to the development of low-carbon technologies, infrastructure or projects, but they do not account for the majority of the investments. The overall carbon impact score given past, present and future performance of Company A is 7.1/C+, that is defined as insignificant contribution to climate change mitigation.

The normalised biodiversity impact score of Company A is above the average compared to its food & beverage peers, at 625 MSAppb* (see Figure 21). The most important pressures linked to its biodiversity footprint are land use, followed by land use and conversion of wetlands, and two further terrestrial pressures, that are encroachment and climate change. When disaggregated by static and dynamic impact, land use has been the most significant induced pressure for the accumulated terrestrial impact (ahead by a factor of about 3), followed by encroachment. This is relevant considering potential upcoming regulatory developments aimed at restricting land-use change as well as regulation aimed at restoring[30] or expanding protected land (e.g. of wetlands). Nonetheless, Company A's dynamic terrestrial impact assessment indicates that climate change contribution is the primary driver of nature loss caused by the company. This is important to consider with respect to transition risk exposure in conjunction to the findings of CIA, given that Company A is providing an insignificant contribution to climate change mitigation.

This brief case study about Company A from the food & beverage sector, illustrates that C&E risks and impacts are inextricably connected and therefore, need to be considered in an integrated manner in order to obtain a more complete risk profile.

29. The industries most significantly driving eutrophication in water systems are food & beverage, household products and textiles (Ceres, 2022).
30. For example, see EU Nature Restoration Law: https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en

7. Discussion

7.1 Integrated physical risk

For the analysed companies in the Banque de France collateral sample, climate change emerges as the biggest driver of ecosystem degradation, affecting ecosystem services critical for resilience against increasing climate-related physical risks (e.g., heatwaves, sea level rise, drought). These risks are particularly acute for entities in industries like energy, real estate, and healthcare, where location and operational dependencies on coastal or drought-prone areas magnify their risk profile.

With respect to the ecosystem dependency analysis, this study of sample companies in the Banque de France collateral pool corroborates other studies' findings that groundwater and surface water is repeatedly found to be the ecosystem service with highest dependency across sectors (Svartzman et al, 2021; Van Toor et al, 2020). The result is not surprising since virtually all economic activities directly or indirectly need water. At the same time, it is also indicative of how critical this resource is. Freshwater cycles are being significantly altered by climate change and nature loss. Evidence shows that the safe operating space for freshwater has been breached (Stockholm Resilience Centre, 2023) and that the majority of areas in the world are experiencing freshwater availability changes driven by climate change and other human impacts (Ceres, 2022; Famiglietti et al, 2022).

Therefore, the entities' exposure to climate-related risks, such as droughts, is significantly amplified by their reliance on ecosystems like freshwater supplies. This dual vulnerability stems from both their direct activities and the broader value chain. The companies in the food & beverage industry exemplify this, particularly by their significant direct and indirect operational dependency on freshwater services. As seen in the case of Company A from the food and beverage sector, critical reliance on water-related ecosystem services makes it vulnerable to such ecosystem degradation. While the BIA-Dependency assessment only gives an indication on dependency (i.e. the potential exposure to an ecosystem service degrading or collapsing) there is evidence that the ecosystem services that contribute most critically to entities' operations and supply chains are in fact collapsing.

Since all entities to some extent are affected by this change, it can become a source of concentration risk for the Eurosystem collateral. What would be necessary for a granular risk assessment, but goes beyond the scope of this study, is a spatially explicit element that would overlap the occurrence of, for example, drought and water dependence. However, the reality is that such hydrological extreme weather events and chronic changes affect most regions and sectors – "with only few exceptions" (Caretta et al, 2022). Therefore, even without a spatially explicit assessment, the ECB can already take precautionary measures in parallel with developing more sophisticated risk management assessment methodologies. From these assessments it is important that the applied risk control measures to mitigate physical risks reflect the fact these risks are endogenous, as they are influenced by today's impact and adaptation investments. It is therefore critical that central banks in the collateral valuation process and application of risk control measures ultimately incentivise an entire plethora of transition, green and adaptation finance (see Dafermos, 2024).

7.2 Integrated impact and transition risk

An integrated view of climate and biodiversity impacts is crucial. Entities, especially in the financial services sector, must account for its biodiversity impact as their financing (in)directly contributes to ecosystem degradation. Research shows that "the ten banks with the highest financing share are responsible for financing around 40% of the total global [biodiversity] impact of euro area firms" (Ceglar et al, 2024).

For many sectors, tackling biodiversity loss must go hand-in-hand with addressing climate change to mitigate overall transition risks. The results indicate that by substantially reducing the emissions of financed activities, these entities can, to a large extent, mitigate their adverse effects on biodiversity. However, if other pressures are not considered, climate mitigation approaches could have adverse consequences on biodiversity and nature (e.g. switching from fossil fuel energy source to hydropower that has large-scale negative effects on freshwater ecosystems). It is also important to note, that for some companies land-use change phase-out, as opposed to GHG abatement, could have the largest benefit to biodiversity impact mitigation.

In analysing the impact, the activity and value approaches complement each other, providing both sector-specific insights and overarching portfolio-level risks that need to be addressed for sustainable, long-term risk management. In the activity approach, when analysing an entire portfolio, specific sectors show heightened exposure to C&E risks and impacts. For example, sectors such as energy, utilities and waste are highly exposed to transition risks due to their dependence on fossil fuels and carbon-intensive processes. Meanwhile, sectors like food & beverages, and energy are exposed to transition risks related to both terrestrial and freshwater biodiversity, given their high impact on these ecosystems. These pockets of transition risk indicate that certain entities in these sectors are at greater risk of failing to transition smoothly in response to climate and nature-related regulations.

The way through which entities are exposed to transition risk is diverse depending on their most important pressures to biodiversity loss. On average entities in the utilities & waste sector and energy sector drive biodiversity loss through climate change contribution which subject these entities to climate-related transition risk (e.g. carbon pricing and other climate-related regulation) as well as potential reputational and litigation risks for dual damage (contributing to climate change and damaging nature). The three entities in the food and beverage sector more considerably affect biodiversity through land-use change, which typically may be in the form of deforestation. The new EU Regulation on Deforestation-Free Products (EUDR),[31] which requires products placed in the EU market and exported to be deforestation-free, will particularly affect entities with high exposure to deforestation. These entities will need to shift their operations to comply with the regulation, which may become a source of credit risk affecting collateral value. Another regulatory development that companies in the food & beverage sector would likely be exposed to is emerging stringency in food safety and pollutant regulation. For example, the EU has established a maximum permissible level of particular per- and polyfluoroalkyl substances (PFAS) compounds in specific foods starting January 1, 2023,[32] given their extensive risk to human health and the environment. Foods exceeding these limits cannot be sold, but products already on the market before this date can stay until they expire. In parallel, building on an initiative by member states, the EU is

31. From 29 June 2023, operators and traders have 18 months to comply with the new regulations. Micro and small enterprises will be granted a longer period to adapt, along with additional specific provisions.
32. See Regulation (EC) 2023/915 https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32023R0915.

planning to ban all PFAS chemicals, with few exceptions (Willige, 2024). This may raise compliance costs and risk of litigation for affected companies.

From a perspective of market signalling, accepting and highly valuing collateral associated with land-use change & deforestation or land and water pollution is sending a misleading signal to the market. Instead, market participants should be encouraged and strive to mitigate and adapt to these risks by phasing out deforestation and pollution from their supply chains.

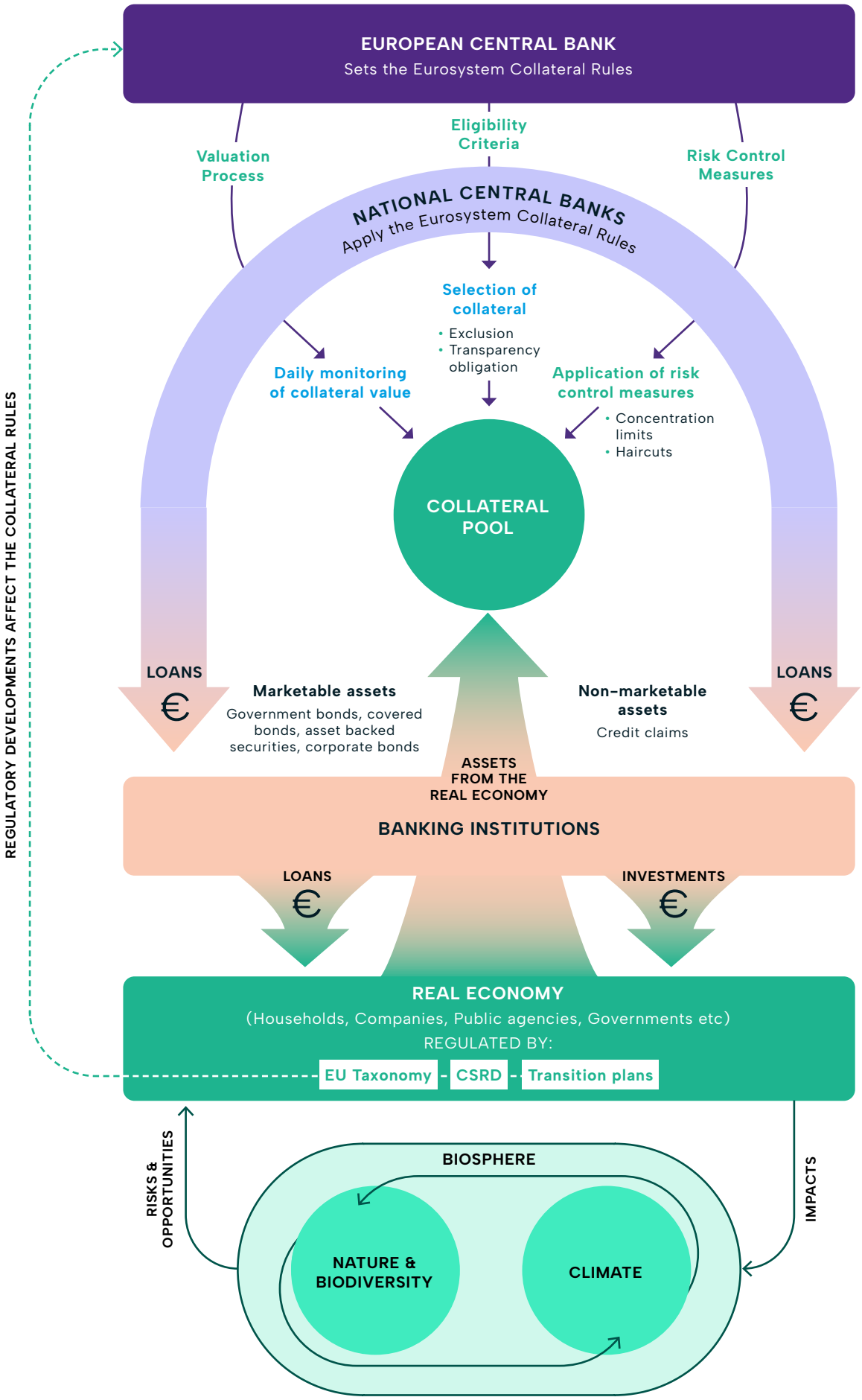
7.3 Implications for collateral risk management and signalling

Addressing C&E risks within financial systems is a highly intricate task due to the interconnected nature of physical and transition risks. The first step is recognising that the collateral framework, through its market signalling effect, influences climate change and ecosystem degradation, which in turn are a source risk that needs to be properly integrated into collateral risk management (Figure 25).

The current methodologies for assessing C&E risks are evolving. They focus primarily on climate-related risks but need further improvement, particularly in integrating further environmental risks such as biodiversity loss, which remains largely underexplored. In this paper we provide a detailed analysis of how C&E risks could be analysed hand-in-hand. While it is only based on the Banque de France sample, our methodology can be replicated and applied to the analysis of other NCBs in the Eurosystem to get a complete picture. Additionally, the ECB and NCBs have information that can further augment such an analysis that were not accessible for this study (e.g. collateral value). Therefore, the ECB and NCBs have the power to conduct entity level analysis on C&E risks and impacts using available data (e.g. by C4F) and calibrate the findings with collateral valuation information.

Furthermore, current regulatory development, such as the CSRD, will enable the ECB and NCBs to benefit from company-specific data to support integrating of C&E risks in the collateral framework. In particular, CSRD, which is applicable to large companies including banks and other financial institutions, is introducing several important aspects in its disclosure requirements, such as target setting and transition plans. Under the European Sustainability Reporting Standards 1, 3 and 4 (ESRS), companies will have to disclose their transition or action plans on matters including climate change mitigation, biodiversity and ecosystems. These disclosures will be made following a standardised digital format and will have to obtain external assurance provided by independent auditors, ensuring the level of standardisation and quality to facilitate data integration and comparison.

Figure 25. Greening the Eurosystem Collateral Framework



The ECB must extend its risk assessment approach to incorporate environmental risks. This integrated approach would better capture how climate physical and transition risks are interconnected with ecosystem services, especially for entities highly dependent on natural resources like water and land, either directly or indirectly. From a systemic risk perspective, the ECB's primary mandate includes safeguarding financial stability. Ecosystem-related risks pose a threat to long-term stability, especially to entities in sectors like energy, real estate, and food & beverage. The ECB's secondary mandate, without prejudice to the primary mandate, also demands alignment with broader EU policy objectives, particularly around climate change and biodiversity loss. Mis-signalling and underpricing risks obstruct the EU's goals for a green transition. The cost of inaction is rising as both climate and ecosystem degradation accelerate.

Is exclusion an effective measure to influence companies to reduce their negative environmental impact?

There is a fierce debate whether policies aimed at cutting off financing to polluting firms is an effective strategy towards the intended outcome of reducing GHG emissions. On the one hand, stopping finance to these polluting companies is a testament to the lack of future of a certain activity. It could be argued, on the other hand, that there is the risk that another market player will step in to provide the financing and so the problem has only shifted the portfolio rather than being phased out in the real world. Nevertheless, the expectation is that this financing will less likely be given at a low cost to the polluting company. Another argument against simple exclusions is that omitting capital allocation towards activities that have the potential to transition, is also a missed opportunity for delivering the needed impact. Depending on the specific context, such as the perceived importance of the financial actor opting for exclusion or the ability and credibility of a polluting company to transition, one argument may be more convincing than the other. Ultimately, the financial system should support the phase out of "always environmentally harmful activities" and provide transition/adaptation finance to viable economic activities.

Regardless of argument, it is important to keep in mind that the collateral framework is not an investment portfolio. Exclusions in eligibility criteria of collateral frameworks do not directly reduce financial flows to the underlying issuer of the security pledged, it is 'merely' a signal to the market that certain issuers are more-risk prone and less valuable. In other words, the collateral framework can support recalibrating a financial system running on market failures that are currently underpricing C&E risks and impacts.

It is true that, debt by corporates and financial institutions constitute a small fraction of the overall eligible and mobilised collateral used by the Eurosystem (see Figure 1).[33] Exactly because it is a rather small fraction, it can serve as a good sandbox environment to roll out ways through which to integrate C&E risks and impacts. Moreover, all corporates and financial institutions analysed in this paper constitute some of the largest listed corporates and systemically important financial institutions (see Annex). These entities have global supply chains and as such exposed to C&E risks while also having positive or negative effects on the biosphere. From this perspective, this paper highlights the significance of the signalling role of central bank collateral. As this study exemplifies, there is already available data and methods that the ECB and the Eurosystem NCBs have access to in order to expand the integration of C&E aspects in the collateral framework.

33. For Eurosystem aggregate collateral data, see https://www.ecb.europa.eu/mopo/coll/charts/html/index.en.html.

8. Policy recommendations

The policy recommendations in this paper are based on the core findings of this analysis that an integrated risk and impact approach for climate change and nature/biodiversity loss are feasible and necessary for the ECB collateral framework. The recommendations below urge the ECB and NCBs to act now, within the next 6 months, in the lead up to the strategy review in 2025. Further measures are proposed for the medium-term horizon (1-2 years) to expand and deepen the integration of C&E risks and impacts into the upcoming unified collateral management system (ECMS).

8.1. Act now

Go beyond climate-related risks in the collateral framework. Adopt an integrated approach and assess broader environmental risks, such as biodiversity loss and ecosystem degradation, alongside climate-related risks. Take into account C&E risks and impacts to account for interdependencies. Recognise that today's climate and nature impacts are increasing exposure to transition risks and amplifying tomorrow's physical risks from climate change and ecosystem dependency, especially on those at-risk of collapse.

Make transparency a prerequisite for eligibility. Apply a margin of conservatism and assume that a lack of data is a source of risk. No longer accept assets as collateral that are issued by companies who do not report according to the Corporate Sustainability Reporting Directive (CSRD) but are subject to pre-disclosure conditions as of mid-2025. This precautionary measure will indirectly provide additional incentives to companies to disclose their C&E risks and impacts.

Exclude assets from climate and environmentally harmful entities. Exclude assets from entities whose activities are inherently unsustainable, such as fossil fuel exploration and extraction or activities adversely impacting ecosystems at-risk of collapse, when their business models are unlikely to transition.[34]

Limit the share of high GHG emission and environmentally harmful assets accepted as collateral. Use concentration limits to encourage the diversification of collateral pools. Expand the use of concentration limits to mitigate physical and ecosystem dependency risk, starting from sectors heavily dependent on vulnerable ecosystem services (e.g. freshwater) and to reduce systemic risks, stemming from both high impact and high dependency, linked to the degradation of critical natural resources.

Recalibrate haircuts to reflect interdependent C&E risks and impacts. Apply additional precautionary measures in the haircut valuation process by applying higher haircuts to assets issued by companies with high climate-related and/or environmental risk and/or impact, especially those lacking transparent and science-based transition plans. Regularly adjust these haircuts to reflect evolving C&E risks.

34. Refer to "always environmentally harmful' economic activities, companies and sectors" in WWF (2022b).

8.2. Act over the medium-term

Progressively adapt scope of eligible collateral with the EU Taxonomy. Gradually align the collateral eligibility criteria to take into account upcoming data on the EU Taxonomy (alignment of revenues, CapEx and OpEx). Use the data to expand eligibility to greener and more sustainable issuers, provided that they fulfil all other eligibility requirements.

Expand in-house expertise in C&E risks and impacts assessment. Reduce reliance on external credit rating agencies by expanding the ECB's Internal Credit Assessment System (ICAS) to include C&E risks and impacts. Develop internal rating systems for all marketable and non-marketable assets, ensuring they account for both C&E risks and impacts and include certain indicators already in the upcoming unified collateral management system (ECMS).

Monitor future regulatory changes and their impact on collateral quality and value. Closely monitor the impacts of evolving regulations (e.g. the EUDR). Adjust collateral frameworks accordingly to avoid sending misleading signals to markets, and minimise credit risks arising from non-compliance with environmental regulations.

9. Limitations

Despite the insights gained through this analysis it is important to interpret these by being mindful of the limitations. A core limitation of this study is that we did not have access to information on the collateral value which would give a better indication of the weight of certain securities and their issuers. In particular, this poses a limitation from the risk management perspective. Nonetheless, since Banque de France, other NCBs and the ECB have access to this information they could augment our methodology with collateral value information.

Furthermore, this study did not evaluate how the official Eurosystem External Credit Assessment Institutions (ECAIs) may be integrating these C&E risks and impact into creditworthiness assessments and impacts, leading to potential duplications. Given the uncertainties and complexities in fully integrating C&E risks, it's warranted to err on the side of caution and ensure they are sufficiently considered. In parallel, it is important to expect and further strengthen methodological transparency of ECAIs.

Furthermore, like any tools and data providers there are methodological limitations associated with the data and metrics used in this analysis. Entity-level analyses are conducted using best available data which, depending on the case, may mean that it relies on sectoral averages, bottom-up assessments or a hybrid approach. Nevertheless, the assessments are never carried out at spatially-explicit asset-level (e.g. a specific production site location). For environmental and climate-related physical risks, where immediate surroundings play a major role, this is a limitation, especially in aspiring towards granular risk assessments. Nonetheless, C4F data allows a quick scan of entities that enables for further deep-dives and targeted data collection where materiality is the highest.

Also, the assessment of non-financial corporates is more straightforward than for financial institutions. C4F is currently working on further developing the methodology for financial institutions. Therefore, especially the results from entities in the financial sector need to be interpreted with caution.

This study conducted an entity (issuer) level rather than a security level analysis. As a result, securities labelled as green or sustainable (i.e. green or sustainable bonds) that offer instrument-level disclosures were not analysed. Market-led guidance on green and sustainable bonds is still evolving and the EU green bond standard (EU-GBS), will only become available to market participants in December 2024. It is still under further development, as currently these tend to be issued mostly by energy intensive sectors, such as gas, utilities, infrastructure and real estate. However, with the development of the methodology the ECB can explore how, and to what extent the EU green bonds standard, and related (voluntary) disclosure templates could be applied as the benchmark within the eligibility criteria for green bonds as collateral.

10. Areas for further research

When looking at additional impactful areas in greening the collateral framework, in terms of private sector collateral, embedding C&E risks and impact into credit claims, covered bonds and asset-backed securities is crucial. Given that almost all of the covered bonds and close to half of asset-backed securities are packaged mortgages (constituting 44% of accepted collateral) it would be important to integrate considerations of physical and transition risks and impacts of this segment of collateral. Moreover, further research should seek to analyse C&E dimensions of the public sector debt in the collateral.

References

Abdelli, M., & Batsaikhan, U. (2022). Driving sustainability from within: The role of central banks' credit rating in mitigating climate and environmental risks. Brussels, Positive Money Europe and WWF, https://www.positivemoney.eu/publications.

Adkins, F. (2024). How restoring rivers' natural curves can prevent flooding. [online] Bbc.com., https://www.bbc.com/future/article/20240918-how-restoring-rivers-natural-curves-can-prevent-flooding.

Almeida, R.M., Fleischmann, A.S., Brêda, J.P.F., Cardoso, D.S., Angarita, H., Collischonn, W., Forsberg, B., García-Villacorta, R., Hamilton, S.K., Hannam, P.M., Paiva, R., Poff, N.L., Sethi, S.A., Shi, Q., Gomes, C.P. and Flecker, A.S. (2021). Climate change may impair electricity generation and economic viability of future Amazon hydropower. *Global Environmental Change*, 71, p.102383, https://doi.org/10.1016/j.gloenvcha.2021.102383.

Almeida, E., Dikau, S. and Robins, N. (2022). Central banking and supervision in the biosphere: an agenda for action on biodiversity loss, financial risk and system stability – Grantham Research Institute on climate change and the environment. [online] Grantham Research Institute on climate change and the environment, https://www.lse.ac.uk/granthaminstitute/publication/central-banking-and-supervision-in-the-biosphere/.

Benschop, T. (2023). Deforestation: Accelerating climate change and threatening biodiversity. [online] World Bank Blogs, https://blogs.worldbank.org/en/opendata/deforestation-accelerating-climate-change-and-threatening-biodiversity#:~:text=CO2%20emissions%20caused%20by%20loss.

Bindseil, U., Corsi, M., Sahel, B., & Visser, A. (2017). The Eurosystem collateral framework explained (No. 189). ECB Occasional Paper, https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op189.en.pdf.

Boermans, M., Bun, M. J., & van der Straten, Y. (2024). Funding the Fittest?: Pricing of Climate Transition Risk in the Corporate Bond Market. De Nederlandsche Bank NV, https://www.dnb.nl/en/publications/research-publications/working-paper-2024/797-funding-the-fittest-pricing-of-climate-transition-risk-in-the-corporate-bond-market/.

Boldrini, S., Ceglar, A., Lelli, C., Parisi, L., & Heemskerk, I. (2023). Living in a world of disappearing nature: physical risk and the implications for financial stability. ECB Occasional Paper, (2023/333), https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op333~1b97e436be.en.pdf.

Breitenstein, M., Ciummo, S., & Walch, F. (2022). Disclosure of climate change risk in credit ratings: An analytical framework to perform a status-quo assessment of the disclosure of climate change risks in rating methodologies and ratings reports by selected credit rating agencies (No. 303). ECB Occasional Paper, https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op303~eaa6fe6583.en.pdf.

Carbon4 & CDC Biodiversité (2023) 'Measuring biodiversity-related risks and impacts with BIA-GBS: Methodological guide for Biodiversity Impact Analytics powered by the Global Biodiversity Score', https://www.financeforbiodiversity.org/wp-content/uploads/Finance-for-Biodiversity_Guide-on-biodiversity-measurement-approaches_3rd-edition-1.pdf.

Caretta, M.A., A. Mukherji, M. Arfanuzzaman, R.A. Betts, A. Gelfan, Y. Hirabayashi, T.K. Lissner, J. Liu, E. Lopez Gunn, R. Morgan, S. Mwanga, and S. Supratid, 2022: Water. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner,

Ceres (2022). The Global Assessment of Private Sector Impacts on Water. [online] Ceres. Available at: https://www.ceres.org/resources/reports/global-assessment-private-sector-impacts-water.

Caswell, Graham (2022) 'Drought poses increasing risk for Brazil's financial system'. Green Central Banking, https://greencentralbanking.com/2022/12/05/drought-increasing-risk-brazil/.

Ceglar, A., Parker, M., Pasqua, C., Boldrini, S., Gabet, M., & van der Zwaag, S. (2024). Economic and financial impacts of nature degradation and biodiversity loss. *Economic Bulletin Articles*, *6*, https://www.ecb.europa.eu/press/economic-bulletin/articles/2024/html/ecb.ebart202406_02~ae87ac450e.en.html.

Dafermos, Y., Gabor, D., Nikolaidi, M., Pawloff, A., & van Lerven, F. (2020). Decarbonising is easy: Beyond market neutrality in the ECB's corporate QE, https://www.greenpeace.de/publikationen/decarbonising_is_easy_-_beyond_market_neutrality_in_the_ecbs_corporate_qe.pdf.

Dafermos, Y., Gabor, D., Nikolaidi, M., Pawloff, A., van Lerven, F. (2021). Greening the Eurosystem collateral framework: how to decarbonise the ECB's monetary policy, New Economics Foundation, https://neweconomics.org/2021/03/greening-the-eurosystem-collateral-framework

Dafermos, Y., Gabor, D., Nikolaid, M., and Van Lerven, F. (2022) 'Greening Collateral Frameworks'. SOAS Centre of Sustainable Finance, LSE Grantham Research Institute on Climate Change and the Environment, https://www.soas.ac.uk/research/greening-eurosystem-collateral-framework.

Dafermos, Y. (2024). The climate crisis meets the ECB: tinkering around the edges or paradigm shift? SOAS, https://www.soas.ac.uk/sites/default/files/2024-07/economics-wp264.pdf.

Dreyer, C. (2024). The Cost of Inaction. CPI, https://www.climatepolicyinitiative.org/the-cost-of-inaction/.

ECB/ESRB (2023). Towards macroprudential frameworks for managing climate risk by ECB/ESRB Project Team on climate risk, https://www.esrb.europa.eu/pub/pdf/reports/esrb.report202312~d7881028b8.en.pdf.

EIU (2024) 'Climate risks in the European Central Bank's collateral framework.' Economist Intelligence Unit Report, https://www.eiu.com/n/ecb-collateral-policy-threatens-eus-path-to-net-zero/#:~:text=EIU%20analysis%20shows%20that%20the,with%20new%20fossil%2Dfuel%20projects..

Eren, E., Merten, F. and Verhoeven, N. (2022). BIS Papers No 130 Pricing of climate risks in financial markets: a summary of the literature, https://www.bis.org/publ/bppdf/bispap130.pdf.

Ethz (2024). Substantial global cost of climate inaction, https://usys.ethz.ch/en/news-events/news/archive/2024/04/costs-of-climate-inaction.html.

Famiglietti, J., Sanyal, P., Xu, L., Bluhm, K., Garvey, K., Ferris, D.M., James, K., Perveen, S., Young, J. and Miller, R. (2022). Global Assessment of Private Sector Impacts on Water. CERES, https://www.ceres.org/resources/reports/global-assessment-private-sector-impacts-water.

Flores, B.M., Montoya, E., Sakschewski, B., Nascimento, N., Staal, A., Betts, R.A., Levis, C., Lapola, D.M., Esquível-Muelbert, A., Jakovac, C., Nobre, C.A., Oliveira, R.S., Borma, L.S., Nian, D., Boers, N., Hecht, S.B., ter Steege, H., Arieira, J., Lucas, I.L. and Berenguer, E. (2024). Critical transitions in the Amazon forest system. Nature, [online] 626(7999), pp.555–564, https://doi.org/10.1038/s41586-023-06970-0.

Harvey, F. (2023). Global fresh water demand will outstrip supply by 40% by 2030, say experts. The Guardian.17 Mar, https://www.theguardian.com/environment/2023/mar/17/global-fresh-water-demand-outstrip-supply-by-2030.

IPBES-IPCC (2021). IPBES-IPCC Co-Sponsored Workshop Report: Biodiversity and Climate Change, Scientific Outcome, https://files.ipbes.net/ipbes-web-prod-public-files/2021-06/20210609_scientific_outcome.pdf [Accessed 27 Aug. 2024]

Marsden, L., Ryan-Collins, J., Abrams, J., and Lenton, T. (2024). Ecosystem tipping points: Understanding risks to the economy and financial system. UCL Institute for Innovation and Public Purpose, Policy Report 2024/03,https://www.ucl.ac.uk/bartlett/public-purpose/publications/2024/apr/ecosystem-tipping-points-understanding-risks-economy-and-financial-system.

Monnin, P. (2018) 'Integrating climate risks into credit risk assessment: Current methodologies and the case of central banks.' Council on Economic Policies, https://www.cepweb.org/wp-content/uploads/2019/02/CEP-DN-Integrating-climate-risks-into-credit-risk-analysis.pdf.

Murphy, C. (2024) 'Collateral damage: Ending the ECB's support to fossil fuel companies.' Reclaim Finance, https://reclaimfinance.org/site/wp-content/uploads/2024/04/BRIEFING-2024.04.04_Reclaim-Finance_Collateral-damage-FINAL.pdf.

NGFS (2021) 'Adapting central bank operations to a hotter world' NGFS Occasional Paper, https://www.ngfs.net/sites/default/files/media/2021/06/17/ngfs_monetary_policy_operations_final.pdf.

NGFS (2022) ''Statement on the Nature-related financial risks", https://www.ngfs.net/sites/default/files/medias/documents/statement_on_nature_related_financial_risks_-_final.pdf.

NGFS (2024) '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.

Pelizzon, L., Riedel, M., Simon, Z., & Subrahmanyam, M. G. (2024). Collateral eligibility of corporate debt in the Eurosystem. *Journal of financial economics*, *153*, 103777, https://www.sciencedirect.com/science/article/pii/S0304405X23002179.

Pörtner, H.O., Scholes, R.J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W.L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M. A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P. A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A. P. F., Popp, A., Reyes-García, V., Sankaran, M., Settele, J., Shin, Y. J., Sintayehu, D. W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C.,Val, A.L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D.C., Rogers, A.D., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N., Ngo, H.T. (2021). Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change; IPBES secretariat, Bonn, Germany, DOI:10.5281/zenodo.4659158. https://zenodo.org/records/5101133.

Schoenmaker, D. (2021). Greening monetary policy. *Climate Policy*, *21*(4), 581-592. https://www.tandfonline.com/doi/pdf/10.1080/14693062.2020.1868392.

Stockholm Resilience Centre (2023). Planetary boundaries. Available at: https://www.stockholmresilience.org/research/planetary-boundaries.html.

Svartzman, R., Espagne, E., Julien, G., Paul, H.-L., Mathilde, S., Allen, T., Berger, J., Calas, J., Godin, A. and Vallier, A. (2021). A 'Silent Spring' for the Financial System? Exploring Biodiversity-Related Financial Risks in France. SSRN Electronic Journal. Doi: https://doi.org/10.2139/ssrn.4028442.

Thomä, J. (2024). How climate stress-tests may underestimate financial losses from physical climate risks by a factor of 2-3x. [online] 1 in 1000, https://theiafinance.org/wp-content/uploads/2024/03/1in1000_finstab_final_v0.pdf.

Van Toor, J., Piljic, D., Schellekens, G., Van Oorschot, M., & Kok, M. (2020). Indebted to nature: Exploring biodiversity risks for the Dutch financial sector. De Nederlandsche Bank, https://www.dnb.nl/media/4c3fqawd/indebted-to-nature.pdf.

Vestergaard, J. (2022). Monetary Policy for the Climate? A Money View Perspective on Green Central Banking. Institute for New Economic Thinking Working Paper Series, 188, https://www.ineteconomics.org/uploads/papers/WP_188-Vestergaard-Green-monetary-policy.pdf

Weiskopf, S.R., Isbell, F., Arce-Plata, M.I., Di Marco, M., Harfoot, M., Johnson, J., Lerman, S.B., Willer, B.W., Morelli, T. L., Mori, A.S., Weng, E., and Ferrier, S. Biodiversity loss reduces global terrestrial carbon storage. Nature Communications 15, 4354 (2024), https://doi.org/10.1038/s41467-024-47872-7.

Willige, A. (2024). What are PFAS chemicals? [online] World Economic Forum, https://www.weforum.org/agenda/2024/03/pfas-forever-chemicals-eu-ban/.

WWF (2022a). Our climate's secret ally: Uncovering the story of nature in the IPCC Sixth Assessment Report, https://wwfint.awsassets.panda.org/downloads/wwf_our_climates_secret_ally_uncovering_the_story_of_nature_in_the_ipcc_ar6.pdf.

WWF (2022b). Central Banking and Financial Supervision Roadmap: Transitioning to a Net Zero and Nature Positive economy. WWF International, https://wwfint.awsassets.panda.org/downloads/wwf_gfri_roadmap_2022_nov_2022.pdf.

Annex

I: Specific Data Processing Steps

Step		Sample size ISINS / Entities
Download ECB collateral 01.01.2024-31.01.2024		-
Filtering I: FR-denominated collateral IG2 and IG5 Issuer groups, respectevely "Central government" and "regional/local government" No duplicate ISINS		6915 Unique ISIN
Mapping with Carbon 4 data: Covered at Parent level Covered at Issuer level Excluding asset level data	CRIS	ISINs: 2396 Entities: 85
	CIA	ISINs: 2469 Entities: 101
	BIA Dependency	ISINs: 2339 Entities: 78
	BIA Impact	ISINs: 2770 Entities: 82
Filtering II: exclusion of Carbon4 denominated Sovereigns (covers public, regional banks and corporations)	CRIS	ISINs: 2140 Entities: 84
	CIA	ISINs: 2228 Entities: 99
	BIA Dependency	ISINs: 1930 Entities: 76
	BIA Impact	ISINs: 1999 Entities: 80
Filtering III: exclusion of NACE denomination "General Public administration activities"	CRIS	ISINs: 2111 Entities: 81
	CIA	ISINs: 2225 Entities: 97
	BIA Dependency	ISINs: 1481 Entities: 75
	BIA Impact	ISINs: 1550 Entities: 79

Filtering IV: exclusion of ECB denominated AT10-13, respectively "EEA legislative covered bonds", "Asset-backed securities (ABS)", "Multi-cédulas", "Non-EEA G10 legislative covered bonds"	CRIS	ISINs: 1573 Entities: 81
	CIA	ISINs: 1667 Entities: 93
	BIA Dependency	ISINs: 1481 Entities: 75
	BIA Impact	ISINs: 1550 Entities: 79
Filtering V: only inclusion of ECB denominated L1C and L1D, respectively "Debt instruments issued by corporate and other issuers" and "Unsecured debt instruments issued by credit institutions"	CRIS	ISINs: 1537 Entities: 81
	CIA	ISINs: 1630 Entities: 93
	BIA Dependency	ISINs: 1481 Entities: 76
	BIA Impact	ISINs: 1514 Entities: 79
Filtering VI: deleting null values	CRIS	ISINs: 1537 Entities: 81
	CIA	ISINs: 1630 Entities: 93
	BIA Dependency	ISINs: 1479 Entities: 75
	BIA Impact	ISINs: 1512 Entities: 79

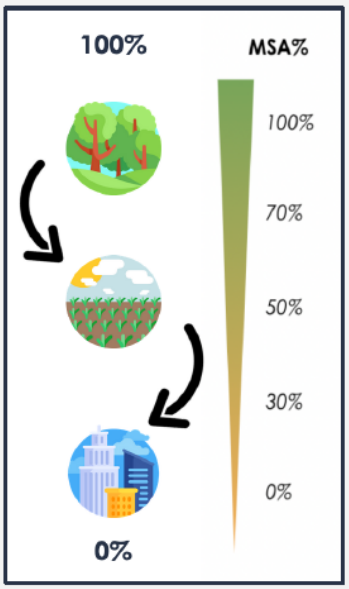
II: MSA Example

MSA explained, retrieved from Carbon4 & CDC Biodiversité (2023)

What is an MSA.km²?

MSA ranges from 0% to 100%, where 100% represents an undisturbed ecosystem (e.g. a primary forest) and 0% a fully artificialized ecosystem (e.g. a parking lot).

An impact of 1 MSA.km² is equivalent to the artificialization of 1 km² of undisturbed natural areas. For example, 1 km²-area of primary forest transformed into a parking lot is a loss of 100% MSA, i.e. 1 MSA.km².



Source : CDC Biodiversité

Table 1: IPBES Framework and Carbon4 Coverage.

	IPBES	BIA-GBS
Nature realms	Terrestrial, freshwater, marine	Terrestrial, freshwater
Pressures	Land use change, overexploitation, climate change, pollution and invasive alien species	Terrestrial: Land use fragmentation, encroachment; pressures due to resource extraction; climate change; atmospheric nitrogen deposition Freshwater: Wetland conversion; Hydrological disturbance due to direct water use; Hydrological disturbance due to climate change; Land use in catchment of rivers & wetlands; Freshwater eutrophication

Table 2: Number of entities and securities by sector and database.

	CIA			CRIS			BIA-Dependency			BIA-Impact		
	Entities	Securities	Securities per entity	Entities	Securities	Securities per entity	Entities	Securities	Securities per entity	Entities	Securities	Securities per entity
Food & Beverages	3	34	11.3	3	34	11.3	3	34	11.3	3	34	11.3
Financials	22	787	35.8	17	772	45.4	13	744	57.2	15	750	50.0
ICT & Media	7	64	9.1	7	64	9.1	7	64	9.1	7	64	9.1
Utilities & Waste	4	125	31.3	3	122	40.7	3	122	40.7	3	122	40.7
Consumer Goods & Services	6	110	18.3	6	58	9.7	6	58	9.7	6	58	9.7
Industrial Services	12	189	15.8	11	184	16.7	10	165	16.5	11	185	16.8
Energy	5	28	5.6	3	18	6	3	19	6.3	3	19	6.3
Real Estate	16	124	7.8	13	105	8.1	13	105	8.1	13	105	8.1
Industrial Manufacturing	9	91	10.1	10	104	10.4	9	91	10.1	10	98	9.8
Healthcare	2	21	10.5	2	21	10.5	2	21	10.5	2	21	10.5
Materials	5	34	6.8	4	32	8	4	33	8.3	4	33	8.3
Food Retail	2	23	11.5	2	23	11.5	2	23	11.5	2	23	11.5
Total	93	1630		81	1537		75	1479		79	1512	

Table 3. Assessed entities in collateral sample

	Entities
Consumer Goods & Services	Elis SA
	JCDecaux SE
	Kering SA
	L'Oréal SA
	LVMH Moët Hennessy Louis Vuitton SE
	Sodexo SA
Energy	Gestion Sécurité de Stocks Sécurité SA
	Orano SA
	Schlumberger NV
	Teréga SAS
	TotalEnergies SE

Financials	AXA SA
	Banque Fédérative du Crédit Mutuel SA
	BNP Paribas Fortis SA/NV
	BNP Paribas SA
	BPCE SA
	Caisse Régionale De Crédit Agricole Mutuel Brie Picardie
	Caisse Régionale de Crédit Agricole Mutuel Centre Loire
	Caisse Régionale de Crédit Agricole Mutuel Toulouse 31
	Coface SA
	Confederation Nationale Crédit Mutuel SA
	CRCAM Alpes Provence
	CRCAM Atlantique Vendée
	CRCAM d'Aquitaine
	CRCAM Normandie-Seine
	Crédit Agricole SA
	Crédit Industriel et Commercial SA
	Crédit Mutuel Arkéa SCFA
	Dexia Holding SA
	Edenred SE
	HSBC Holdings Plc
	Société Générale SA
	The Fédération des caisses Desjardins du Québec
	Tikehau Capital SCA
	Wendel SE
Food & Beverages	Danone SA
	Pernod Ricard SA
	Rémy Cointreau SA
Food Retail	Carrefour SA
	Elo SA
Healthcare	EssilorLuxottica SA
	Sanofi

ICT & Media	Capgemini SE
	Dassault Systèmes SA
	Orange SA
	Publicis Groupe SA
	Vivendi SE
	Worldline SA
	WPP Plc
Industrial Manufacturing	Alstom SA
	Compagnie Générale des Établissements Michelin SCA
	General Electric Co.
	Legrand SA
	Renault SA
	Safran SA
	Schneider Electric SE
	SEB SA
	Stellantis NV
	Thales SA
	Valeo SE
Industrial Services	Abertis Infraestructuras SA
	Aéroports de Paris ADP
	Air France-KLM SA
	ALD SA
	APRR SA
	Bouygues SA
	Eiffage SA
	Indigo Group SA
	La Poste SA
	Mundys SpA
	Régie Autonome des Transports Parisiens EPIC
	Société Nationale SNCF
	VINCI SA

Materials	Air Liquide SA
	Arkema SA
	Compagnie de Saint-Gobain SA
	Semapa Sociedade de Investimento e Gestão SGPS SA
	Verallia SA
Real Estate	Accor SA
	Altarea SCA
	Altareit SA
	Argan SA
	Carmila SA
	CDC Habitat SEM
	Covivio Hotels SCA
	Covivio SA
	ERILIA SA
	Gecina SA
	Icade SA
	In'li SA
	Klépierre SA
	Mercialys SA
	Société Foncière Lyonnaise SA
	Unibail-Rodamco-Westfield SE
Utilities & Waste	Électricité de France SA
	ENGIE SA
	Saur SAS
	Veolia Environnement SA

positivemoney

Positive Money EU
Rue Ducale 67
1000 Brussels
Belgium

www.positivemoney.org

Positive Money Europe is a non-profit association/
association sans but lucratif registered in Belgium

Enterprise number: 0718.859.377