STAFF

CLIMATE

NOTES

Embedded in Nature: Nature-Related Economic and Financial Risks and Policy Considerations

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Glossary

Aichi biodiversity targets

The 2011-2020 Strategic Plan for Biodiversity, adopted at COP10 in 2010, is comprised of a shared vision ("by 2050, biodiversity is valued, conserved, restored and widely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people"), a mission, four strategic goals and 20 targets, collectively known as the Aichi Targets (available here). Although National Biodiversity Strategies and Action Plans were developed by Parties to support the delivery of the Strategic Plan and deliver the Aichi Targets, analyses of progress towards the Aichi Targets have shown major shortfalls, with a failure to achieve almost all targets (Maney and others 2024).

Biodiversity

Biodiversity is "the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (CBD 2006).

Biosphere

The biosphere is the "relatively thin life-supporting stratum of Earth's surface, extending from a few kilometers into the atmosphere to the deep-sea vents of the ocean. The biosphere is a global ecosystem composed of living organisms (biota) and the abiotic (nonliving) factors from which they derive energy and nutrients" (Encyclopædia Britannica 2024).

Carbon sinks

There are reservoirs (natural or human, in soil, ocean, and plants) where greenhouse gases (or aerosols) are stored. By absorbing greenhouse gases, carbon sinks remove them from the atmosphere and offset emissions. In the Staff Climate Note, we refer to natural carbon sinks, e.g., forests.

Do no harm

The principle that there should not be trade-off between policies that protect nature and address climate objectives.

Earth system

This refers to the Earth's interacting physical, chemical, and biological processes (that include the five systems of Earth, i.e., geosphere, biosphere, cryosphere, hydrosphere, and atmosphere). These systems are deeply intertwined, as they overlap and are interconnected; what affects one can affect another.

Ecosystem services

Ecosystem services are "a range of material and non-material benefits that humans, directly and indirectly, obtain from nature and that sustain and fulfil human life (Millennium Ecosystem Assessment, 2005), also described as 'nature's benefit to people' in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) conceptual framework (Díaz et al. 2015)" (NGFS 2022a).

Global Biodiversity Framework

The Kunming–Montreal Global Biodiversity Framework, described as the equivalent of the Paris Agreement for nature, was adopted at COP15 in 2022. It encompasses a comprehensive plan with 23 action-oriented global targets aimed at addressing urgent biodiversity concerns by 2030, setting a pathway toward achieving long-term goals by 2050. These targets are categorized into three main themes: (1) reducing threats to biodiversity, (2) meeting people's needs through sustainable use and benefit-sharing, and (3) tools and solutions for implementation and mainstreaming (available here).

Harmful subsidies

Harmful subsidies consist of a wide range of subsidies (agricultural support, pesticide and fertilizer subsidies, water subsidies, fisheries support, and subsidies in energy and mining, transport, forestry, and infrastructure) that can negatively impact biodiversity in various ways, both directly (e.g., land conversion) and indirectly (e.g., climate change).Target 18 of the Global Biodiversity Framework is to identify by 2025, and eliminate, phase out or reform incentives, including subsidies, harmful for biodiversity, in a proportionate, just, fair, effective, and equitable way, while substantially and progressively reducing them by at least US$500 billion per year by 2030, starting with the most harmful incentives, and scale up positive incentives for the conservation and sustainable use of biodiversity.

Mega-biodiverse countries

Mega-biodiverse countries are those that house greater than 60 per cent of the world's biodiversity, including a large number of endemic species (so-called biodiversity hotspots) and the associated indigenous knowledge.

Natural capital

Natural capital can be defined as the "stock of renewable and non-renewable resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people" (NGFS 2022a).

Nature

Nature can be defined as the "natural world with an emphasis on the diversity of living organisms and their interactions among themselves and with their environment. […] It includes categories such as biodiversity, ecosystems, ecosystem structure and functioning, the evolutionary process, the biosphere, living natural resources, shared evolutionary heritage, and biocultural diversity" (Díaz and others 2015). Nature enables the provision of food, energy, and medicines, among other materials fundamental for well-being.

Nature conservation

Nature conservation involves the protection, preservation, management, or restoration of natural environments and the ecological communities that inhabit them. Biodiversity conservation involves the management of human interactions with genes, species, and ecosystem to provide the maximum benefit to the present generation while maintaining their potential to meet the needs and aspirations of future generations. It encompasses elements of saving, studying, and using biodiversity (IPBES Glossary).

Nature loss and degradation

Nature loss and degradation refers to biodiversity loss and environmental degradation, that is, transformation of nature that reduces its benefits to people. Biodiversity loss is a “decrease in biodiversity within a species, an ecosystem, a given geographic area, or Earth as a whole. […] Biodiversity loss describes the decline in the number, genetic variability, and variety of species, and the biological communities in a given area. This loss in the variety of life can lead to a breakdown in the functioning of the ecosystem where decline has happened” (Encyclopædia Britannica 2024).

Physical risks

Risks stemming from nature loss and transformation and its interaction with other environmental risks. For example, the risk of lower agricultural yields as a result of decreases in pollinator populations.

Planetary boundaries

The planetary boundaries framework defines a "safe operating space for humanity" based on environmental limits related to nine interrelated phenomena: climate change, the erosion of biosphere integrity, biogeochemical cycles of nitrogen and phosphorus, land-system change, freshwater use, ocean acidification, stratospheric ozone depletion, atmospheric aerosol loading, and introduction of novel entities into the biosphere (Rockström and others 2009, Steffen and others 2015, Richardson and others 2023). Crossing these boundaries can lead to irreversible changes, destabilizing the Earth system and making the planet uninhabitable for humans.

Restoration

Any activity that initiates or accelerates the recovery of an ecosystem from a degraded state. It includes a range of human interventions aimed at influencing and accelerating natural successional processes to recovery ecosystem service provision (IPBES Glossary).

Soil degradation

Refers to a decrease in the quality of soil, including the loss of nutrients and vital minerals, that are necessary to support life. Soil degradation can be driven by intensive agriculture, and as nutrients are depleted yields can decline until the soil can no longer support crop cultivation.

Tipping points

Ecological – or ecosystem – tipping points are “non-linear, self-amplifying and irreversible changes in ecosystem states that can occur rapidly and on a large scale” (Marsden and others 2024). Risks of tipping points are increased by pressures on nature from human activity – such as land use change and pollution, as well as climate change. Examples of key tipping points that could “threaten Earth system stability include the dieback of the Amazon rainforest into a non-forested state; transitions in boreal forest cover; tropical peatland collapse; coral reef die-off to marine deserts; and mangroves dying back to tidal flats” (Marsden and others 2024).

Transition risks

Risks to the economy and financial system stemming from policies aimed at addressing nature loss. For example, the risks associated with trade restrictions on wood products made from timber in regions that are deemed biodiversity hotspots.

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Summary

The economy is embedded in, and dependent on, nature. Yet, economic activity is degrading nature at an unprecedented pace. Interacting with climate change, nature loss and transformation can generate significant threats to the global economy and financial system. Work on the implications of nature-related risks for macroeconomic and financial sector policies is at an early stage. This note seeks to contribute to this emerging policy space in three main ways. First, it proposes a conceptual framework for understanding nature-related risks by mapping out macroeconomic transmission channels, emphasizing their impact on the economy and financial systems through "double materiality." Second, it conducts empirical analysis, finding that nearly 38 percent of bank loans of the 100 largest global banks are extended to harmful subsidies-dependent sectors and 44 percent are exposed to conservation areas under the Global Biodiversity Framework, and that industries most exposed to nature degradation are not well prepared to manage these risks. Third, it discusses takeaways for macroeconomic and financial sector policies and frameworks.

Introduction

The economy is embedded in nature: it is part of, and dependent on, natural resources and processes for its existence and functioning. Nature is defined as the "natural world with an emphasis on the diversity of living organisms and their interactions among themselves and with their environment. […] It includes categories such as biodiversity, ecosystems, ecosystem structure and functioning, the evolutionary process, the biosphere, living natural resources, shared evolutionary heritage, and biocultural diversity" (Díaz and others 2015). The stability of ecosystems ultimately underpins all economic activity (Marsden and others 2024).

Over the past two centuries, economic activity has been driving an ultimately self-destroying process by causing unprecedented nature destruction and degradation. The demands on nature generated by economic activity have exceeded the planet's ability to provide ecosystem services, causing a degradation of nature at unprecedented rates (UNCBD 2022).[1] As a result of the cumulative impacts of economic activity on the environment, the world now faces a "planetary crisis" characterized by the triple emergency of climate change, biodiversity loss, and pollution (Robinson and others 2023).[2] Out of the nine planetary boundaries identified by the scientific community as those within which humanity can safely operate, six planetary boundaries—related to biosphere integrity, climate change, land system change, biochemical flows (nitrogen

[1] At the global level, the direct drivers of nature loss and transformation are in descending order: changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species. These direct drivers stem from indirect drivers, which are themselves underpinned by "societal values and behaviors that include production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance" (IPBES 2019).

[2] The interconnection between climate change and broader nature-related risks is generally referred to as the "climate–nature nexus." Reflecting the dependency of the economy on nature and earth system stability, the 1992 United Nations Conference on Environment and Development, also known as the Earth Summit, recognized "the integral and interdependent nature of the Earth, our home" (United Nations 1992), and opened for signature three interrelated and legally binding agreements: the United Nations Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and the United Nations Convention to Combat Desertification.

and phosphorus), freshwater, and novel entities (synthetic chemicals and substances)—have been crossed (Steffen and others 2015; Richardson and others 2023).

Scientific evidence suggests that biodiversity is declining at a faster rate than at any time in human history, and researchers document that we are experiencing the sixth great biological extinction since life began about 3.7 billion years ago (Kolbert 2014; IPBES 2019; Dasgupta 2021).[3] Extractive land-use change through industrial and agricultural activities accounts for over 90 percent of biodiversity loss and water stress (Oberle and others 2019; UNEP 2024a). This led to the adoption by 196 countries of the 20 Aichi Biodiversity Targets for 2011–20, which no country achieved. In 2022, accelerating nature loss spurred the adoption by over 200 countries of the Global Biodiversity Framework (GBF), an international agreement that aims to halt and reverse nature loss (UNCBD 2022).[4]

Deep interlinkages between climate change and nature loss can exacerbate threats to the global economy and financial system. The joint occurrence and acceleration of climate change and nature loss, if it continues, could uncover previously hidden dependencies of the economy on natural systems, generating major social costs (Krogstrup and Oman 2019).[5] A further cause for concern relates to tipping points and cascading nature-climate impacts. Cascading risks can trigger political instability and geopolitical confrontation (Gardes-Landolfini and others 2023). Catastrophic nature-climate outcomes or "endgames"—such as regional systems failure that cascade to other regions—are plausible scenarios that are very hard to quantify, and therefore dangerously unexplored (Kemp and others 2022).

In this context, nature-related risks can be defined as resulting from the interaction of nature-related hazards, exposures, vulnerabilities, and responses, involving any natural process, including climate, weather, and biodiversity loss, or a combination of these and other natural phenomena (IPCC 2022; NGFS 2022). Reflecting the relevance of these risks, nature loss is growing on the global policy agenda (FSB 2024; G20 forthcoming). Several studies have found that nature loss is a source of financial risk through both the loss of ecosystem services and the devaluation of assets resulting from nature loss (van Toor and others 2020; Svartzman and others 2021; Boldrini and others 2023; Prodani and others 2023).

The structural issues described previously raise important questions for macroeconomic and financial policies. They relate in particular to (1) the complex set of dependencies between economic and financial systems and nature (and the impacts they have on each other), on which there is a growing literature; (2) the macroeconomic and macrofinancial implications of nature-related risks; and (3) risks to financial stability through transition and physical risk channels. This note focuses on the last two elements and considers policy implications and issues related to global coordination. The note emphasizes three key messages: (1) nature's continued degradation calls for system-wide changes in the global economy; (2) biophysical stress and policy changes to address it could have implications for macroeconomic and financial stability; (3) this points to the need for policy frameworks in advanced, emerging, and developing economies to evolve to embrace environmental sustainability.

The note is organized as follows: the first section provides an overview of nature-related risks and proposes a conceptual framework to analyze them, connecting nature to the macroeconomy and the financial system, and vice versa. The second section presents empirical results on both transition risks (risks to the economy and financial system stemming from policies aimed at addressing nature loss) and physical risks (risks stemming from nature loss and transformation and its interaction with other environmental risks). The third section takes stock of emerging policy initiatives to address nature-related risks and efforts to align financial flows with the

[3] Fourteen of the eighteen critical ecosystem services have been declining since the 1970s, or what the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services calls "nature's contribution to people" (IPBES 2019).
[4] The Kunming–Montreal Global Biodiversity Framework (GBF) has been described as the equivalent of the Paris Agreement for nature.
[5] For instance, the World Economic Forum (2020) estimates that more than half of global GDP is highly or moderately dependent on nature.

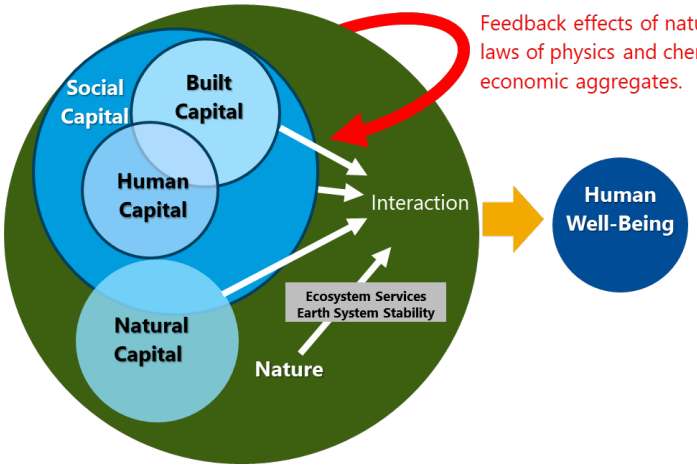
GBF. The fourth section discusses preliminary takeaways for the global community regarding macroeconomic and financial sector policies and policy frameworks.

Background and Conceptual Framework

Background: Nature Loss and Macroeconomic and Financial Policies

The economy is embedded in nature. As shown in Figure 1, the economy is intrinsically part of nature, and dependent on ecosystem services and the stability of the Earth system. However, nature and economic value operate within different frameworks: economic value is generated through human interactions and institutional arrangements, while nature operates independently of markets and is governed by scientific laws. Natural capital straddles the economy and nature, as its basic elements are natural. However, the economic valuation of goods and services produced by extracting natural resources and using ecosystem services occurs within markets. Critically, the major feedback effects that nature has on the economy are governed by the laws of physics and chemistry, which humanity cannot control. The essential role of natural systems in economic value creation and their feedback effects on economic aggregates (such as social capital, human capital, built capital) underscore nature's macro-criticality.

Figure 1. Nature and the Economy



Source: IMF staff, adapted from Costanza and others (2014).
Note: The economy (composed of built and human capital) is embedded within society, which is itself embedded in nature. Ecosystem services and Earth system stability interact with the economy and society to enable human well-being.

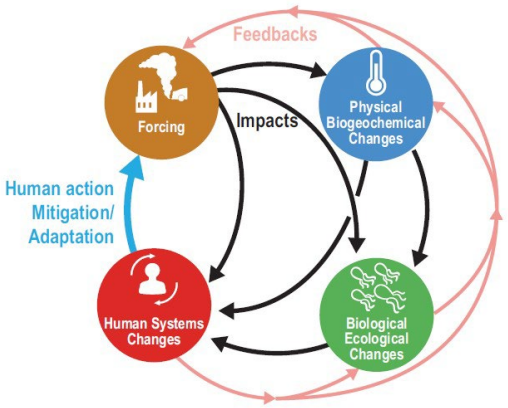
Nature loss challenges macroeconomic policy centered on the productive sphere. As economies rely on ecosystem services, nature loss impacts resilience-centered policy goals. The nonlinear feedback effects resulting from continued nature loss would inevitably cause the economy to run into severe and system-wide resource constraints, and increasingly large and frequent macroeconomic shocks.[6] The relationship between natural resources, climate change, and economic growth is well documented (Jevons 1865; Boulding 1966; Daly 1968; Ayres and Kneese 1969; Solow 1971; Meadows and others 1972; Nordhaus 1974, 1994; Cline 1992; Stern 2006). Yet the specific focus on nature loss (and its interaction with other environmental threats such as climate change and pollution) and macroeconomics is an emerging area, known as ecological macroeconomics (see Svartzman and others 2019 for an overview), that warrants further research. Reflecting these challenges,

[6] Emphasizing these consequences, US Treasury Secretary Janet Yellen remarked in a G20 conference that "neglecting to address climate change and the loss of nature and biodiversity is not just bad environmental policy, it is also bad economic policy" (Yellen 2024).

the questions that environmental change raises for IMF work were the focus of IMF Executive Board discussions as early as 1991.[7]

Nature loss is interlinked with climate change. The relationship between nature loss and climate change is inherently bidirectional. This is due to interconnectedness among the different parts of the Earth system, notably the feedback effects between the biosphere and climate (or radiative) forcing (Figure 2). Such linkages can generate cascading effects in which changes in one element in the system trigger changes in other parts of the system. For instance, nature loss caused by deforestation can directly contribute to greenhouse gas emissions when carbon and other greenhouse gases stored in forests and soils are released. Conversely, nature is also vulnerable to climate change, as illustrated by rising ocean temperatures that result in coral bleaching (Pörtner and others 2023). Overall, these cascading effects amount to a vicious cycle, indicating a potential acceleration of climate change and nature loss. For instance, there is evidence that forests and soils absorbed 1.5–2.6 Gt of CO_2 in 2023, down from 9.5 Gt in 2022, largely because of poor forest and soil health (Ke and others 2024). Despite these interconnections, climate change and nature degradation continue to be largely addressed in their own domains (Pörtner and others 2021).

Figure 2. Cascading Effects Linking Climate Change and Nature Degradation



Source: Abram and others (2019), Figure 1.1e.
Note: "Cascading effects, where changes in one part of a system inevitably affect the state in another, and so forth, ultimately affecting the state of the entire system. These cascading effects can also trigger feedbacks, altering the forcing" (Abram and others 2019, p. 82).

Nature-related financial risks share many commonalities with climate-related financial risks. Most notably, they arise from physical and transition sources of risk (NGFS 2023a, 2023b). Physical risks stem from nature loss (notably the ongoing decline in biodiversity and the disruption of ecosystem services[8]) and nature transformation (including desertification, degradation of forest health, ocean acidification, increasing pollution, and novel entities including microplastics, endocrine disruptors, radioactive materials, genetically modified organisms) (Richardson and others 2023). Transition risks stem from the misalignment of economic activities with actions and developments (new laws, regulations, and policies; changes in human behavior and technology) aimed at protecting, restoring, and reducing negative impacts on nature (NGFS 2023a).[9] Similar to climate risks, nature-related risks can materialize either over time or as shocks, characterized by nonlinearities, complexity, tipping points, and irreversibility at local and global scales (Ranger and others 2023). And they can be transmitted through both domestic (more damaging floods) and global channels (commodity price shocks). Another parallel with climate change is that policies aimed at halting nature degradation can affect macroeconomic outcomes.

[7] Minutes of a 1991 IMF Executive Board Seminar (IMF 1991) emphasized that "Linkages between environmental concerns and macroeconomic and structural policies have been identified in studies by the World Bank, the Organisation for Economic Co-operation and Development (OECD), and other international and national institutions. During previous discussions on this topic, Directors generally agreed that the Fund should not ignore the role of environmental preservation in promoting balanced and sustainable growth. In that connection, the Fund needs a deeper understanding of the linkages between macroeconomic and structural policies and the quality of the environment and the way in which Fund-supported policies could have immediate environmental consequences in member countries."
[8] Ecosystem services fall into two main categories (in addition to cultural services). *Provisioning services* include the provision of essential materials and energy (food, freshwater, fuel, fiber, biochemicals and pharmaceuticals, genetic resources). *Regulating and maintenance services* include the regulation and maintenance of ecosystem services, the regulation of the gaseous composition of the atmosphere and of local and global climates, erosion control, water flow regulation, water purification, waste decomposition, disease regulation, plant pollination, storm protection, nutrient recycling, and maintaining primary oxygen production (Dasgupta 2021, p. 61).
[9] While environmental degradation stems from both nature loss (as in biodiversity loss) and nature transformation (as in the desertification of soils or the dieback of rainforests), for convenience, this note refers to "nature loss" to refer to both nature loss and nature transformation.

Nature-related risks differ from climate-related risks in four main ways, however. First, they can be more acute than climate risks, as major tipping points may be crossed sooner, such as the Amazon rainforest dieback (Flores and others 2024). Second, quantification of key risks is more challenging compared with climate change because nature is multidimensional.[10] Unlike climate change, which mainly stems from the accumulation of greenhouse gases in the atmosphere, nature loss is driven by impacts to many ecosystems, highlighting the systemic effects of crossing planetary boundaries. Third, uncertainty around nature-related risks is higher. It stems from incomplete knowledge on (1) biosphere processes (Dasgupta 2021, p. 143); (2) Earth system dynamics (Richardson and others 2023); (3) the dependence of sectors on nature (Ranger and others 2023); and (4) the nature and magnitude of socioeconomic consequences of nature shocks (Kemp and others 2022). Fourth, even more so than for climate risks, nature-related risks require a deep understanding of local nature-related patterns (NGFS 2023a).

Nature-related risks could have significant macroeconomic implications (NGFS 2022b, see also NGFS 2022a, 2023a, 2023b, 2024). A general framework for conceptualizing risks from nature loss and related policies is provided by the Dasgupta Review on the economics of biodiversity (Dasgupta 2021) and related contributions (NGFS 2023a, 2023b; Ranger and others 2023; Marsden and others 2024), which assess the economic effects of nature loss and the need for transformative changes in macroeconomic models and policies (Annex 1).

Conceptual Framework: Nature-Related Macroeconomic and Macro-Financial Risks

We propose a conceptual framework to analyze nature-related risks and their feedback mechanisms. Drawing on the Dasgupta Review, the macroeconomic framework features four main components (Figure 3). First, it connects the four types of capital (nature, social, produced, and human) to economic and financial flows. Second, it relates these flows to potential states of the world based on production sustainability over time (sustainable, unsustainable, and irreversible collapse), with the last two approaching or exceeding natural capital's tipping point, risking irreversible damage. Third, it describes the main nature-related risks associated with each state of the world. Fourth, it maps out macroeconomic transmission channels linking nature-related risks to the real economy—including impacts on quantities and prices—and vice versa, and the financial sector, emphasizing the "double materiality" principle whereby financial institutions both affect and are affected by nature-related risks (Figure 4). The conceptual framework is described in greater detail in Annex 1.

Nature-related risks manifest themselves through physical, transition, litigation, and institutional channels that impact at the microeconomic and potentially macroeconomic levels (see second column of Figure 3) and propagate to the financial system (Figure 4). Nature-related risks fall into four main categories: (1) physical, corresponding to the disruption of economic activities stemming from ecosystem service degradation, nature-related shocks, and their related economic and financial effects; (2) transition, arising from adjustments in policy and market forces;[11] (3) litigation, stemming from higher compliance costs, materialization of transition risks, and legal and related costs and their impact on firms;[12] and (4) institutional, arising from changes in governance and trust. These risks, often initially localized, can escalate to systemic threats because of the global nature of local environmental impacts (NGFS 2023a; Ranger and others 2023).

Although less commonly identified as a source of risk, the threat of "derailment" is potentially significant and applies to both nature and climate. Specifically, the worsening consequences of the instability of the Earth system reduce the ability of societies to carry out environmental action, in turn preventing

[10] One way to view nature through an economic lens involves recognizing it as a series of market failures at play: fisheries and freshwater resources are subject to common pool resource challenges; water, air pollution, and land-use change are subject to externalities and information asymmetries; pollination can be seen as a positive externality. Another view argues the primary goal of economic policies should be not to internalize externalities (assumed to be correctly identifiable *ex ante*, which is not always the case [Kapp 1950], especially in the case of complex and mutually reinforcing environmental externalities subject to "deep structural uncertainties" [Weitzman 2009, 2011]) but to minimize tail risks. It calls for viewing nature degradation as a systemic challenge requiring unprecedented coordination among multiple actors (Oman and Svartzman 2021, Oman, Salin, and Svartzman 2024).

[11] This also includes policies and regulations to protect, restore, or reduce negative impacts on nature, changes in consumer and investor preferences, potential changes in technology, and the degree of alignment or misalignment of those uncertainties, often between market and nonmarket driving forces (Ranger and others 2023).

[12] See Annex 1 for further details on litigation risks and their relevance for the financial sector.

the stabilization of natural systems (see Laybourn, Evans, and Dyke 2023 for an overview). For instance, a rapid dieback of a rainforest could culminate in a regional food system crisis and knock-on effects on economic, political, and social stability, and ripple effects on global supply chains. This could undermine political support for environmental measures by diverting policy action toward addressing immediate socioeconomic impacts, thereby accelerating the destabilization of biophysical systems—a type of derailment.

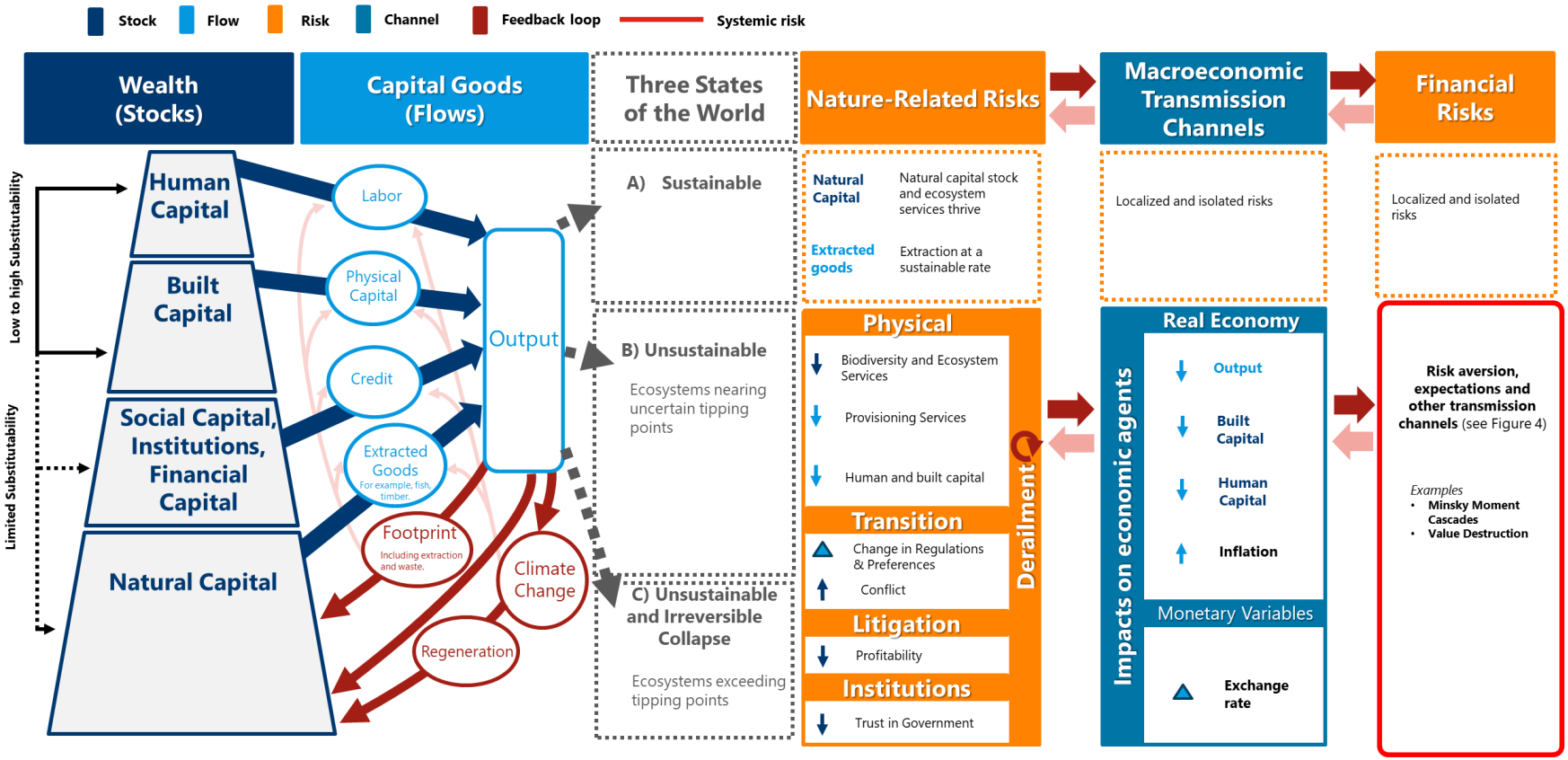
Local nature impacts, while seemingly isolated, can have far-reaching global consequences and often result from global drivers, underscoring the interconnected nature of our ecological systems (IPBES 2019; NGFS 2023a). Global economic activity has degraded nature at an unprecedented scale and pace, turning local risks into global threats. The scientific consensus suggests that we are in a critical phase—either state B (unsustainable) or state C (irreversible collapse) as shown in Figure 3—where urgent action is needed (IPBES 2019; Pörtner and others 2021; Richardson and others 2023). Nature loss occurring in specific locations impacts countries through the real economy and the financial sector. Amplification effects from globalization, commodity market structure,[13] and agriculture sector dynamics affect global supply chains, trade, and capital flows, with nature loss and climate change creating adverse feedback loops. For example, Amazon rainforest dieback, though a local event, would have a profound impact on biodiversity loss, alter regional and distant climates, disrupt the global carbon cycle, accelerate climate change, and affect global weather patterns (Dasgupta 2021).

Efforts to estimate the impact of nature-related risks on GDP are still in their early stages and vary considerably based on the drivers of nature loss captured and modeling techniques employed.[14] Most estimates cover only a subset of nature loss drivers (that is, land-use change, resource extraction, and climate change) and ecosystem services (for example, ground water, pollination, air quality, and water quality) (NGFS 2023a). There is growing recognition that estimates of macroeconomic costs are likely conservative (NGFS 2023a, p. 60). A key reason is the inability of models to represent complex interactions between ecosystem services, and between ecosystem services and the economy. Most models are skewed toward capturing selected ecosystem services that relate to the provisioning of food, water, and bioenergy (Salin, Kedward, and Dunz 2024). In contrast, regulation and maintenance services are less captured in models. Key assumptions—such as possibilities for substitution between inputs and rapid technological change—might downplay the macroeconomic impacts of nature loss (NFGS 2023a). Finally, there is uncertainty associated with nature-related risks, as discussed in the previous section.

Although the magnitude of modeled effects varies, estimates uniformly predict that under current policies GDP will be reduced compared with scenarios that omit the decline in natural capital. Ranger and others (2023) estimate[15] the value of nature at risk of five ecosystem services, finding that water-related risks dominate at 7 to 16 percent of GDP, whereas effects on pollination, air, and water quality are about 1 to 3 percent of GDP. Johnson and others (2021) assess the impact of partial collapses in three ecosystems and estimate an annual loss equivalent to 2.3 percent of global GDP by 2030. Impacts are larger in low- income and lower-middle income countries, where the drop in GDP is expected to reach up to 10 percent in 2030.[16]

[13] Key commodity market features include, but are not limited to, the degree of market concentration, nature of market participants, factors influencing price formation (supply and demand, speculation), available trading mechanisms and financial instruments (spot and futures markets, OTC trading, derivatives), regulatory environment, geographic scope, seasonality/cyclicality, and degree of vertical integration.
[14] Economic valuation of environmental services is often useful for cost-benefit analysis at a micro scale. However, such estimations can prove misleading when it comes to valuing the biosphere, as the mutual dependency among species is often not considered in such estimations (Dasgupta 2021).
[15] As stressed by Ranger and others (2023), estimates should be interpreted with caution as (1) they do not represent the interactions between ecosystem services and the economy, (2) they do not originate from a complete macroeconomic model, and (3) they capture only five ecosystem services, with excluding some macro-critical services such as soil erosion.
[16] This analysis may underestimate results, however, as it considers only some ecosystem services, uses a model that likely overestimates the ability of economies to adjust to nature-related shocks, and excludes direct negative effects of climate change on ecosystem services, knock-on effects of output declines (such as societal conflicts), and nonquantifiable socioeconomic impacts of vital ecosystem services loss.

Figure 3. Granular Conceptual Framework: Nature-Related Macroeconomic and Financial Risks



Source: IMF staff based on Dasgupta (2021), NGFS (2023a), and Svartzman and others (2021).
Note: See Annex 1 for a detailed description of the conceptual framework.

Effects can be seen affecting real, fiscal, monetary, and external sectors (see macroeconomic channels in Figure 3). The next paragraphs describe mechanisms through which nature loss affects economic aggregates, both directly and indirectly, and provide further estimates that—while likely conservative—illustrate the relevant dynamics. Micro- and macro-level effects of nature loss and policies to address it are examined in NGFS (2023b). To inform macroeconomic policies, the discussion that follows distinguishes between impacts on the real, fiscal, external, and monetary sectors.

In the *real sector*, nature-related economic risks can influence near- and long-term growth prospects through impacts on labor, capital, and productivity.[17] Examples include natural capital impacts on water, land/forests, and biodiversity that are taking place in multiple regions and may particularly affect countries heavily reliant on natural resources. Nature loss can amplify physical risks from natural disasters. Immediate and direct impacts include damages to infrastructure, private property, and other assets (see third column of Figure 3). For instance, mangroves and coastal wetlands act as barriers against flooding and storm surges, and their degradation leads to more destructive storm property damage with knock-on effects on economic activity and employment. Regions with average mangrove protection experience a more pronounced decline in economic activity post-storm, with a cumulative growth rate drop of 6.1 to 8.2 percent, compared to 2.6 to 5.5 percent in well-sheltered mangrove regions (Hochard, Hamilton, and Barbier 2019). Medium-term indirect effects could lead to only partial recovery, particularly if economic recovery efforts intensify pressures on resource extraction and nature degradation. Biodiversity loss and the associated loss of important ecosystem services—such as natural pest control by bats—has led to higher insecticide use and infant mortality resulting from internal causes (Frank 2024). Impacts of nature loss on capital accumulation and education affect long-term economic growth.

Interactions with climate change and climate policies could exacerbate these effects (Figure 3, Annex Figures 1.1 and 1.2). Soil degradation has led to a collapse in forests' carbon sink role, which if it persists would accelerate climate change (Garric 2024; Ke and others 2024). Accelerated climate change can, in turn, drive more forest loss—sea level rise is already contributing to mangrove degradation, for example (Ward and others 2016). In addition, efforts to address climate change could place further pressures on nature. Mining for critical minerals for global decarbonization can lead to deforestation, including in biodiversity hotspots, marine ecosystem disruption, and water scarcity (Sovacool and others 2021; NGFS 2023a). Moreover, land-use change generates synergies between climate change (forest loss, burning forests to clear land) and biodiversity loss that has led to significant emerging diseases (IPBES 2020). Finally, a disorderly transition to address nature loss from agriculture (rapid reduction in pesticide use) could adversely affect agricultural output, at least in the near term.

Labor productivity can be affected through persistent changes in ecosystem provisioning and regulation services. Pollution, viewed as a depreciation of natural capital assets, affects labor productivity with impacts on economic output in both the short term and the long term. Pollution affects labor productivity in both physically and cognitively demanding occupations, such as in agriculture and services, respectively, with strong implications for aggregate economic performance (Hanna and Oliva 2015; Chang and others 2019). Changes in maintenance and regulation services such as instability of local climates, reduced water, and air purification, could further impact productivity through adverse consequences on health, physical, and cognitive abilities. Labor productivity can also be affected through changes in provisioning services such as freshwater and through biochemicals stress, with knock-on effects on agriculture and medicine and thus food production and health. As is the case for climate change effects, impacts can result from both a gradual deterioration in ecosystem services (such as a decline in pollinator abundance and diversity or soil erosion, reducing crop yields) and acute impacts.

[17] Estimates of the impact of nature related risks on GDP vary significantly depending on the ecosystems studied and the modeling approach used. Crucially, there is growing recognition that most estimates of the macroeconomic costs are likely underestimates. A key limitation is that models typically take a "weak sustainability" approach that assumes the ability of agents to substitute nature loss with increases in labor and human capital, even in cases of major ecosystem disruption, which is highly debatable (NFGS 2023a).

Productivity can also be affected by disruptions to production processes and supply chains. Damaged infrastructure and essential logistical assets, as previously discussed, result from heightened physical risks from natural disasters because of nature loss, leading to significant near- and medium-term supply chain disruptions. Disruptions to the water cycle from agriculture and other land-use changes can reduce output in many sectors (agriculture, energy, technology, manufacturing, mining, utilities, timber), with potential knock-on effects on global supply chains, especially where substitutability of forms of natural capital is limited (NGFS 2023a). Indirect impacts can emerge through regional and international conflicts over access to resources, trade restrictions, and embargos, highlighting the need for an orderly climate and nature transition.

Fiscal pressures are set to intensify owing to revenue losses from nature degradation and increased expenditures on recovery and restoration. Fiscal pressures will rise with revenue losses (nature loss and degradation leads to lower productive capacity, lower receipts from tourism and other exports, and lower growth) and higher spending (infrastructure repair, social spending, and ecological restoration) (Kumar 2010). For instance, global receipts from visits to protected natural areas represented 8 percent of the tourism market in 2015 (Balmford, Green, Phalan 2015); nature degradation can reduce the appeal of these areas as tourism destinations. Funding for nature protection and restoration could be sourced partially by relocating funds from existing inefficient subsidies (such as those for fuel, electricity, water), which generally lead to unsustainable outcomes. Governments can also transfer some of these financial risks to the insurance sector. However, so-called common risks (which are perfectly correlated at the level of a country), such as nature- and climate-related risks, can limit the effectiveness of insurance mechanisms, causing large-scale losses to a country's produced capital and productive and fiscal capacity, especially in low-income countries (Dasgupta 2021).[18] Adaptive climate investments exhibit synergies with nature protection and can, to some extent, reduce future fiscal risks. However, adaptive investments can inadvertently harm natural ecosystems or crowd out nature-based solutions (seawalls can damage marine ecosystems, intensive irrigation to adapt to droughts can lead to water scarcity). Inadequate and insufficient investment in climate adaptation and nature loss could exacerbate fiscal pressures.

In turn, fiscal pressures and weaker economic growth can raise debt-to-GDP ratios and sovereign debt premia (see Annex 1, Annex Figure 1.7). As debt levels rise, governments may face higher borrowing costs and reduced access to international capital markets, further straining public finances. Natural resource depletion may entail higher commodity imports, straining the balance of payments and the sustainability of external debt.

Shifts in nature's provisioning services can impact inflation through effects of supply-side shortages on food and other essential commodities. Exacerbated by nature loss and climate change, droughts and floods are considered a root cause of global food price fluctuations. Commodity price changes, including in energy and water, can translate into inflation (Weber and others 2024).

Nature loss can also impact external balances, and vice versa (Annex Box 1). Nature loss and ecosystem collapse can disrupt international trade and global value chains (World Economic Forum 2020), reduce investment, and affect countries' terms of trade, foreign direct investment inflows, and export competitiveness, with especially large impacts on resource- and nature-based sectors (Dasgupta 2021). As noted previously, ecological shocks can originate in a country or region and influence global markets, affecting exchange rates and sovereign debt ratings (see Annex 1 on the links between debt sustainability and nature loss). For instance, in 2010–12, the droughts in China, Russia, and Ukraine disrupted the global wheat supply, doubling prices and affecting terms of trade (Sternberg 2012, NFGS 2023a).

[18] Although reinsurance mechanisms could enable cross-border transfers of common risks, should their frequency and severity increase they may not be available or affordable. This would lead to governments assuming the insurer's role as a last resort, thereby increasing fiscal pressure through contingent liabilities.

Nature loss can trigger macroeconomic risks that amplify macro-financial vulnerabilities. Figure 4 presents our macro-financial conceptual framework that serves as a foundation for the assessment of nature-related risks in the policy and supervisory community.[19] Similar to climate-related financial risks, nature-related risks are endogenous**.** Financial institutions and companies contribute, to varying degrees, to the build-up of nature-related risks to which they are exposed. Activities that are harmful to nature may thus leave companies exposed to changes in legislation and regulation aimed at curbing or prohibiting certain activities and types of financing. Although some sectors may not be directly exposed to physical risks, their impact on nature may increase risks to the economy and financial system.

Nature-related risks affect the economy through damages to real and financial assets, and legal liabilities. Macroeconomic effects could increase as households, nonfinancial corporations, and sovereigns adjust to growing nature-related shocks through consumption, production, investment, and loss-sharing (for example, price adjustments, contingent liabilities). Interdependencies within and across sectors and countries could amplify or mitigate economic disruptions. For instance, the shock-absorbing role of sovereigns could crowd out spending on productive investment and social protection or lead to higher taxes on some sectors, affecting households and nonfinancial corporations. Cross-border effects could further amplify or mitigate nature shocks through trade and supply chains.

Nature-related risks could transmit to the financial sector through five main channels:

1. **Credit risks** are driven by an increase in counterparty risks, including by financial portfolios' exposure to companies active in protected areas or whose operations impact nature, and disruptions to production processes and supply chains.
2. **Market risks** can be triggered by abrupt changes in asset prices from nonfinancial sector losses, subsequent shifts in investor demand, and updated nature transition paths at the national, regional, or company level.
3. **Liquidity risks** are driven by funding withdrawal to financial institutions with high exposures to nature-related risks.
4. **Underwriting risks** faced by insurers (catastrophe, property, health insurance) could rise because of a nature-related rise in asset damages or human health deterioration, resulting in increasing claims by policyholders and changes in insurance services provision (availability and premia).
5. **Operational risks** faced by financial institutions are driven by disruptions in their processes (for example, facilities, suppliers, technologies) and nature-related litigation that may also entail reputational risks.

Both banks and nonbank financial institutions are exposed to some transmission and amplification channels. While banks tend to be mainly exposed to credit risks, nonbank financial institutions are more vulnerable to market risks, especially in advanced economies (NGFS 2024a). Nature-related shocks may impact future insurability following unexpected underwriting losses in catastrophe, property, and health insurance lines**.** Higher premiums to reflect nature loss impacts could lead to reduced insurability. This may cause risks to be transferred to other actors, notably governments. Potentially large redistributive impacts and additional effects on financial stability should be considered given the ineluctable involvement of public actors in this area.

Second-round effects could result in systemic risks (EIOPA 2023; FSB 2024).[20] They may arise from interactions between credit, market, liquidity, and underwriting risks, with changes in expectations and risk aversion as the main transmission channels. Nature-related risks could propagate within the financial sector through sudden changes in expectations (regarding asset prices or the profitability of firms or sectors) or risk aversion. Other relevant factors are changes in views on nature transition-related costs or economic damages to real assets from actual or expected changes in the frequency/intensity of physical effects affecting bank

[19] Annex Figures 1.4 and 1.5 present more granular transmission channels focusing on asset classes and litigation risks, respectively.
[20] The Task Force on Nature-related Financial Disclosures (TNFD) classifies systemic risks into ecosystem-stability risk and financial stability risk, where the instability or collapse of ecosystems can generate both physical and transition risks that can in turn potentially compound to generate financial stability risk (TNFD 2023).

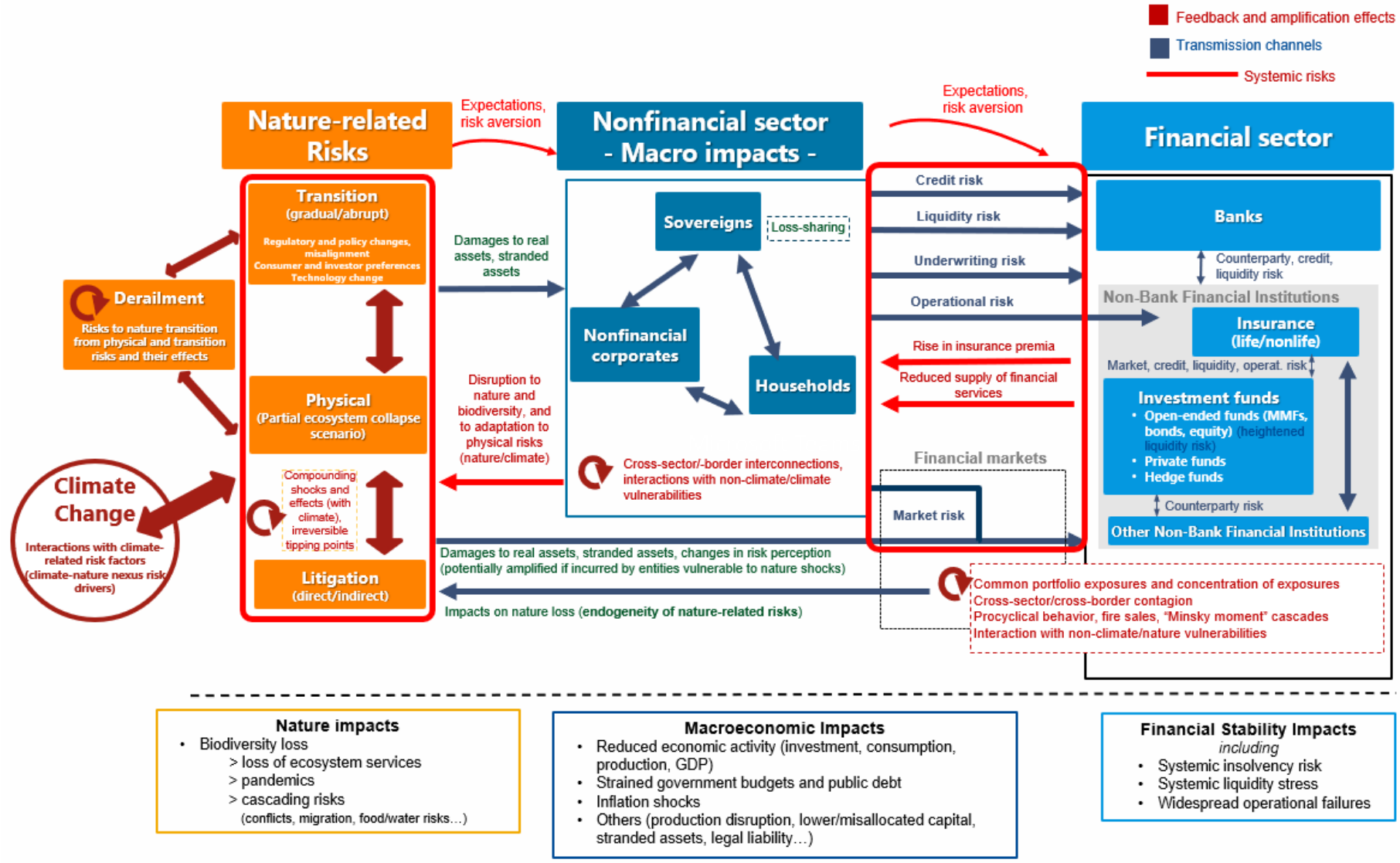
operations, and legal liabilities. The devaluation/revaluation of assets driven by expectation shifts and increased risk aversion could cause cascading "nature Minsky moments."[21] These could potentially lead to a systemic financial crisis, causing widespread value destruction, and stranded assets and jobs. The magnitude of price changes would depend on the extent to which capital re-allocation occurs under more stringent constraints to economic activity from growing nature-related shocks.[22] In our framework, abrupt asset price changes triggered by one or more nature shocks and nature-related policy shifts could lead to a systemic financial crisis.[23]

Feedback loops could, in turn, potentially influence the economy. The ability of the financial sector to finance the real economy could be hampered, with knock-on effects on production, including cross-sectoral and cross-border amplifications resulting from production interconnections. Mutually reinforcing amplifications could weaken the financial system and ultimately trigger a protracted economic contraction.

Finance plays a decisive role in determining both the stock of natural capital and the extent of human demands on the biosphere (Dasgupta 2021, p. 467). At the same time, empirical analysis on the financial sector's contributions and exposures to nature degradation remains at an early stage. In this context, the next section aims to provide evidence on the magnitude of both physical and transition sources of financial risks facing large financial institutions and nonfinancial companies globally.

[21] There are also cross-border financial risks. Interdependencies among financial institutions and changes in expectations could generate destabilizing dynamics with fire sales, reinforced by correlated procyclical behavior and common portfolio exposures. For example, a nature shock affecting exposures of investment funds could propagate to other financial institutions, amplifying the initial shock through interconnectedness. Insurers with their own assets invested in such investment funds would suffer lower net assets as the net asset values of the funds decline following the climate or nature shocks. Similarly, banks that lend to investment funds would face higher credit and liquidity risks if funds struggle to repay amid falling asset valuations and growing redemption demand. See also Bolton and others (2020).
[22] These channels are similar to conventional ones but arise from nature shocks and can be amplified if incurred by entities that are vulnerable to nature shocks.
[23] Work by the Financial Stability Board, Swiss Financial Market Supervisory Authority (FINMA), Hong Kong Monetary Authority (HKMA) and Banco Central do Brasil (BCB) highlights cross-border nature-related risks' materialization through global disruptions and financial system interconnectedness. The European Insurance and Occupational Pensions Authority (EIOPA) notes that insurance availability may be affected by global nature shocks, emphasizing systemic impacts.

Figure 4. Granular Conceptual Framework: Macro-Financial Linkages



Source: IMF staff.
Note: See Annex 1 for a detailed discussion on the conceptual framework on macro-financial linkages, including litigation sources of risks.

Empirical Analysis: Transition and Physical Sources of Nature-Related Financial Risks

In this section, we present empirical analyses on two of the four types of nature-related sources of risk identified in the conceptual framework, and more specifically in Figure 4 on macro-financial linkages: transition risks and physical risks. Nature-related risk analysis should ideally involve scenarios of varying complexity to ensure comprehensiveness and granularity. It should assess plausible paths the world could take in the future, and facilitate collaboration among economists, natural scientists, and other experts and stakeholders relevant to scenario design.[24] Specifically, scenario analysis should cover key macroeconomic transmission channels, including the impacts of nature loss and policies, addressing it to systemically important prices (Weber and others 2024) and financial stability (FSB 2024). However, this is beyond the scope of this note. Instead, our goal is to illustrate our conceptual framework and contribute to the literature on assessing nature-related financial risks, focusing on transition and physical risks.

Transition Sources of Risks

Following our conceptual framework (Figure 4), we focus on transition risk in the banking sector, using the GBF as a proxy for realistic, nature-related future policy changes. Nature-related transition risks are gaining prominence as global policy efforts to halt biodiversity loss intensify, a development reflected in the GBF and its comprehensive set of 23 targets.[25] One of the main sources of transition risk stems from the misalignment between economic activities and market forces (for example, investment trends) and the environmental actions required or expected of society (for example, policy and regulatory measures and societal expectations). These risks have macro-implications, including for nonfinancial corporations, transmitting through potential stranded assets and impacts on financial market participants' expectations and risk appetite. These can create counterparty, credit, and liquidity risks for banks.

We evaluate the dependence of the 100 largest global banks on sectors that are most exposed to transition risk sources, focusing on their portfolio allocation across economic sectors and linking their lending portfolios to underlying economic activities (Figure 5). Analyzing the 100 largest global banks allows coverage of a substantial segment of global consolidated financial assets, including global systemically important banks. The details on methodology and data sources are described in Annex 2, including an explanation of how our approach differs from the literature. Our analysis focuses on two sources of transition risk emanating from GBF targets, which we identify as the main policy transmission channel: **(1) the phasing out of subsidies that are harmful for biodiversity** (GBF Target 18) and **(2) the goal of conserving and managing at least 30 percent of land and water areas by 2030** (GBF Target 3).[26] We provide an overview of the main results of our analysis pertaining to GBF Targets 18 and 3. They involve potentially significant policy and macroeconomic impacts on key sectors of the economy, given their primary role in the GBF and their quantitative nature.

[24] One of the main challenges in designing nature scenarios is what has been described as the "local-global trade-off." This challenge stems from the fact that nature-related scenarios "require a greater consideration of locally specific biomes, sectors and firms to understand how distinct policies and processes may drive changes at the smallest level; and on the other hand, an aggregation of local socio-economic and environmental changes in order to account for the global drivers and impacts of those local changes, as well as maintain their tractability" (NGFS 2023a). This trade-off highlights the need to reflect both local specificities (so that nature-related risks are accurately captured) and the global macro-financial criticality of nature loss and policy changes to address it. For recommendations on the development of consistent scenarios to understand and assess nature-related risks, see NGFS (2023a).

[25] Despite its limitations—targets not being sufficiently ambitious to halt and reverse biodiversity loss at the necessary scale and speed, and the agreement's nonbinding nature—the Kunming–Montreal Global Biodiversity Framework (GBF) stands as the credible proxy for potential sources of global economic policy-related transition risks. The GBF encompasses a comprehensive plan with 23 action-oriented global targets aimed at addressing urgent biodiversity concerns by 2030, setting a pathway toward achieving long-term goals by 2050. These targets are categorized into three main themes: (1) reducing threats to biodiversity, (2) meeting people's needs through sustainable use and benefit-sharing, and (3) tools and solutions for implementation and mainstreaming. Greater details on the GBF's goals and targets are provided on the website of the Convention on Biological Diversity: 2030 Targets (with Guidance Notes).

[26] Specifically, Target 18 aims to "identify by 2025, and eliminate, phase out or reform incentives, including subsidies, harmful for biodiversity, while substantially and progressively reducing them by at least US$500 billion per year by 2030, starting with the most harmful incentives, and scale up positive incentives for the conservation and sustainable use of biodiversity;" and Target 3 seeks to "ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed" (UNCBD 2022).

Harmful subsidies (GBF Target 18)[27] are a significant source of transition risk. They lead to significant nature degradation and biodiversity loss and are often associated with threats to indigenous peoples and local communities. Harmful subsidies reached $1.7 trillion in 2022, driven by an increase in fossil fuel consumption subsidies (UNEP 2023; Black and others 2023). GBF Target 18 addresses a fundamental policy challenge, as phasing out harmful subsidies would have structural economic impacts, especially on extractive industries and agriculture given their reliance on subsidies.[28] The subsidies are estimated at $640 billion in energy, $520 billion in agriculture, $350 billion in water, $155 billion in forestry, and $50 billion in fisheries (UNDP and BIOFIN 2024). These subsidies lead to the underpricing of natural resources use, overconsumption, overproduction, thus leading to an unsustainable transformation of ecosystems (other impacts include political economy effects, such as entrenching powerful vested interests). There are many types of subsidies (direct government spending, tax breaks, price support) and their impacts on nature vary considerably (for example, overexploitation of resources, habitat destruction, contribution to climate change).[29]

Our evaluation finds that agriculture, forestry, fishing, and mining sectors face the highest transition risks. These risks are primarily because of their dependence on harmful subsidies, compared with manufacturing and energy sectors that benefit from less harmful subsidies. Nearly 38 percent of bank loans are extended to sectors that are heavily reliant on harmful subsidies, notable among them being the mining sector (which receives the most harmful subsidies), accounting for about 6 percent of total bank loans (Figure 5, panel 1). The potential phasing out of harmful subsidies could adversely affect the revenues of firms, thereby increasing the probability of default on their bank loans.

Likewise, conservation of 30 percent of land and water by 2030 (GBF Target 3) is another potential source of transition risk. This target aims to conserve 30 percent of the Earth's surface through protected areas and other area-based conservation measures.[30] While there are significant political, economic, and logistical challenges (for example, land rights, financing conservation efforts, need for international cooperation), this target represents a significant source of transition risk through the establishment of protected areas and enforcement of sustainable management practices, especially in biodiversity-rich and carbon sink areas. We use indicators from MSCI on companies' vulnerability to measure impacts on ecosystems to estimate company-level exposures to highly fragile marine and land areas. Sectoral average levels are derived from companies in our sample (see Annex 2 for more details on our methodology). We find that, on average, 44 percent of bank loans are exposed to fragile areas targeted for protection under GBF Target 3 (Figure 5, panel 2), implying transition-related financial risks associated with conservation-oriented policies.

Going beyond exposure to a more advanced risk assessment would require two main steps. The first step involves bridging data gaps to understand the characteristics of transition risk sources, for example, breakdown of allocation and elasticity effects of harmful subsidies, substitutability of economic activities' operations in biodiversity-sensitive areas, specific effects on countries depending on their income level, indirect effects across supply chains, and feedback effects with physical risks (including dependencies on ecosystem

[27] A wide range of subsidies (agricultural support, pesticide and fertilizer subsidies, water subsidies, fisheries support, and also subsidies in energy and mining, transport, forestry, and infrastructure) can negatively impact biodiversity in various ways, both directly and indirectly. Direct effects include land conversion to biofuel crops or road construction in biodiversity-rich areas, whereas indirect effects include climate change and indirect land-use change. These impacts can be immediate, over time, or spread over generations, and can occur at all scales. Some subsidies may also appear benign but can have negative effects depending on their design or beneficiaries' responses (Matthews and Karousakis 2022).

[28] In addition, if implemented, Target 18 would also entail an important just transition dimension, given the socioeconomic contexts of emerging market and developing economies and potentially disproportionate impacts of subsidy phaseout on specific sectors and communities, and related redistribution needs.

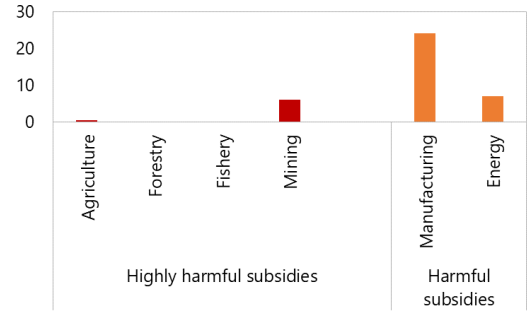
[29] We identify sector groupings based on estimated adverse impacts of subsidies on nature, their price, and supply elasticity, given the data constraints on the geographical, subindustry, and company size breakdown of subsidies (see Annex 2 for greater detail on the methodology). The complexity of the analysis makes a granular quantification of impacts on nature challenging. There are often several contributing factors to harmful impacts on nature, making it challenging to identify causal links between subsidies and harmful effects. In addition, nature characteristics are location-specific, and most areas lack both precise data on species and spatial data (see Annex 2 on data and methodological gaps). Furthermore, the monetary amount of a subsidy does not necessarily correspond to the extent of its harmful effect: even relatively small subsidies can have major negative impacts, and vice versa (UNDP 2024). Impacts on nature also depend on the subindustry, company size, and region of operation.

[30] This is a major expansion on the previous conservation-related international target, Aichi Target 11, which aimed to protect 17 and 10 percent of terrestrial and marine areas, respectively.

services) (see Annex 2[31]). Second, models and scenarios must be improved to assess resilience to combined policy and nature shocks (NGFS 2023a) and develop a granular understanding of transmission channels to the banking system.

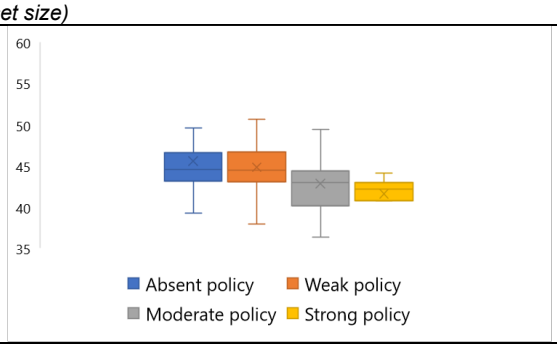
Figure 5. High Level of Exposure of Largest Global Banks to Potential Nature-Related Transition Risks

1. Share of Loans to Sectors Exposed to Harmful Subsidies Target
(Percent of total loans to NFCs, 100 largest global banks by asset size)

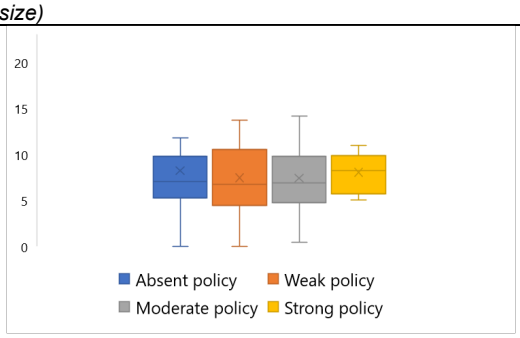


2. Share of Loans Exposed to Conservation Target
(Percent of total loans to NFCs, 100 largest global banks by asset size)

3. Bank Loan Vulnerability to Conservation Target by Banks' Policy Strength
(In percent of total loans to NFCs, 100 largest global banks by asset size)



4. Bank Loan Impacts to Conservation Target by Banks' Policy Strength
(In percent of total loans to NFCs, 100 largest global banks by asset size)



Sources: MSCI; Dealogic; and IMF staff calculations.
Note: (1) The difference between harmful and highly harmful subsidies is explained in the methodology in Annex 2. It is based on the direct or indirect nature of the subsidy, its impact on nature and biodiversity, its estimated size, and its impact on price and supply elasticity. The agriculture, fisheries, mining, and forestry sectors were found to be most at risk, whereas manufacturing and energy sectors were less at risk. (2) The bank sample is composed of the 100 largest global banks as ranked by Standard & Poor's (S&P) Global (by consolidated assets). (3) Loan data limitations: considering that the exposures from individual companies can be transmitted to banks through loan defaulting, we use bank loan data from Dealogic to measure bank exposures. Given the data availability limitations, we use syndicated loans rather than bilateral loans, which in and of itself reveals the risky nature of lending that requires syndication. We also assume that the leading banks underwrite the same amount of tranche proceedings because of data gaps. All outstanding syndicated loans underwritten by the 100 largest global banks amount to $18 trillion in total, as of July 2024. (4) We assume that company operations in highly fragile ecosystems will be completely discontinued, and the percentage of operations being affected equals the percentage of bank loans being defaulted on. The chart in panel 3 is constructed by multiplying loan values by the percent of debtor revenues gained in highly fragile ecosystems. The chart in panel 4 is calculated by multiplying loan values by the percent of debtor operations disturbing highly fragile ecosystems. NFCs = nonfinancial corporations.

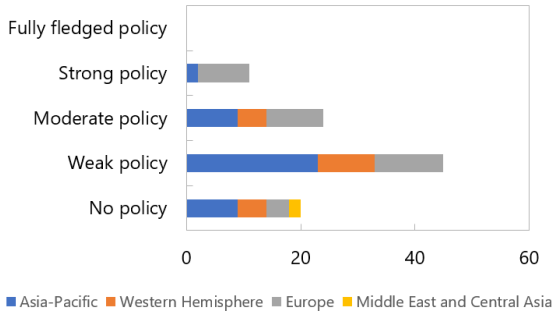
We have observed that, while some banking practices for managing nature-related risks are beginning to emerge across various regions, there is significant variation in their depth and breadth (Figure 6). In our assessment of nature-related disclosures, strategy documents, investment policies, and environmental and social risk management frameworks of the top 100 global banks across four regions,[32] we found an unequal landscape of policy strength across banks. While only a fifth of the banks have no published policy on nature or are in preliminary stages of including nature in future iterations (labeled as absent policy), a third of our sample has initiated steps to integrate nature into their strategy, risk management framework and reporting (labeled as

[31] This analysis provides a general indication of banks' exposure to possible nature-related transition risks, but because of data gaps and lack of third-party verification, it should be used as a starting point for more in-depth analysis. Data constraints on harmful subsidies, their geographical, subindustry, and company size breakdown, and the variety of factors affecting nature impacts also require further research. Further details are provided in Annex 2.
[32] See Annex 2 for more information on the methodology and anonymized results of the assessment.

moderate or strong policy). Banks that have made the most headway in integrating nature into their due diligence and risk management frameworks—between 10 percent and a third of our sample, depending on the degree of policy strength—are predominantly in Europe[33] and, to a lesser extent, the Asia-Pacific region[34] (Figure 6, panel 1). Banks with stronger policies related to natural ecosystems tend to have lower loan exposures to fragile ecosystems (Figure 5, panel 3). However, they tend to focus solely on project finance, which accounts for a small portion of their portfolios and with limited exposure to economic sectors that are most vulnerable to nature-related transition risks (Figure 6, panel 2). Furthermore, while some banks have policies targeted at specific industries (forestry, agriculture, mining, energy), they vary in consistency and ambition. Our analysis indicates that when these banks incorporate nature in their risk management frameworks, the coverage is typically limited (for example, UNESCO World Heritage and Ramsar sites) and overlook the potential consequences of the climate–nature nexus on transaction risks. Moreover, no bank in our sample has a fully-fledged policy that spans across sectors and forms of financing operations, including general corporate purpose lending and bond underwriting. This points to a general lack of understanding of nature-related risks among these institutions.

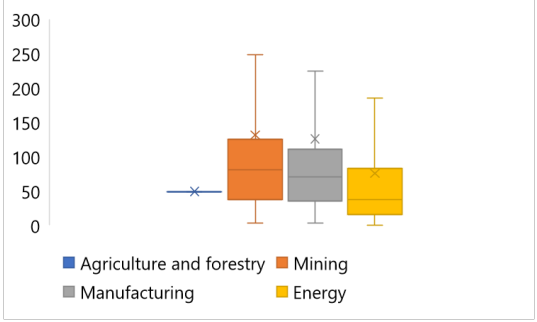
Figure 6. The Integration of Nature-Related Risks in Banks' Policies Is Improving, Albeit Unevenly and with a Focus Limited to a Subset of Financing Activities

1. Number of Banks by Level of Policy Strength across Regions



2. Project Finance Debt by Sector

(In millions $)



Sources: 100 largest banks' disclosed policies (e.g., ESG strategy, sectoral due diligence policies, risk management policies); Refinitiv; and IMF staff calculations.
Note: The methodology to assess policies for the 100 largest global banks as ranked by S&P Global is described in Annex 2 and Annex Table 2.1. The main difference between a "strong" policy and a "fully fledged" policy lies in the scope of financial instruments (project finance versus all types of instruments). The scope of nature-related risks in this assessment is wider than transition-related risks. Panel 2 uses aggregated amounts of project finance loans and bonds.

[33] The European Central Bank conducted a thematic review of significant financial institutions' (within the Single Supervisory Mechanism) good practices for environmental risk management (November 2022). Section 5.5. of the review concluded that some banks generally started by assessing environmental risks from a high-level macro point of view (qualitative expert judgment), in specific sectors (for example, agriculture), and did not assess concrete transmission channels at the portfolio level or used a quantification approach. Policies would often use an exclusion-based approach and only a few conducted assessments of the biodiversity impacts of individual projects or corporate clients.

[34] The assessment reveals two issues in comparing and evaluating banks' policies: (1) endogeneity: banks initially less exposed to nature-related risks and those headquartered in regions (for example, the EU) with more stringent environmental policies and regulations may publish more ambitious policies; and (2) temporality: the recent focus on nature, since the adoption of the GBF, may explain some delay in banks' policy update and, therefore, ambition. These would be important to consider from a supervisory perspective.

Our conceptual framework also aims to bridge the gap in the literature on nature-related risks by including the insurance sector's vulnerability. Insurance firms may be exposed to risks from both their investments and risk coverage operations (underwriting and possible insurance gap risks), which can impact policyholders and the companies in which they invest. To understand how insurance firms manage nature related risks, we assessed their policies and practices (see Annex table 2.2). Further analysis is needed on insurance firms' holdings of corporate and government bond and equity focusing on sectors most exposed to nature-related transition risks, thereby identifying potential sources of risk (Annex 3).

Physical Sources of Risks

Following our conceptual framework, physical risk analysis would ideally start from Ψ^*—the tipping point beyond which nature irreversibly enters a degraded state—for countries or biomes. As noted in Annex 1, Ψ^* (tipping point) is the minimum value of S_t (natural capital) needed to avoid irreversible collapse. Tools that incorporate a strong sustainability approach (that is, that assume limited substitutability between natural and other forms of capital) exist to try to identify the level of degradation of ecosystems and their functions, and which ones are more degraded than others (see NGFS 2023a). This can be done at the level of the country or biome, or other relevant scales. These tools can be combined to identify sectors most exposed to physical hazards. The analysis would ideally assess the magnitude of shocks to the economy and prices, notably agricultural prices, and infer financial stability risks, also considering the impact of a gradual deterioration in ecosystem services (for example, pollination, soil erosion).

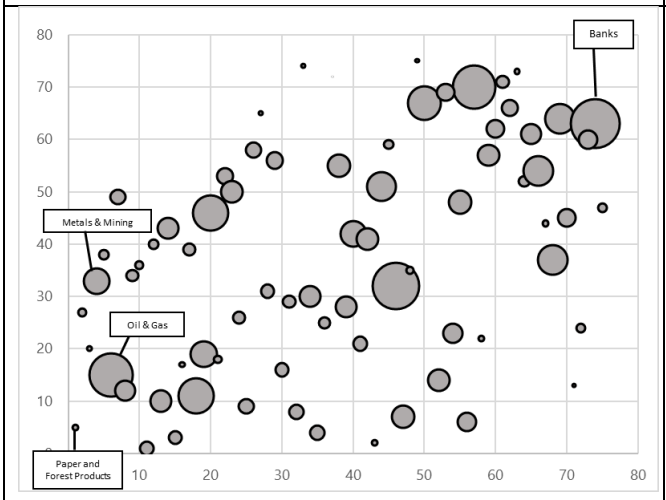
Given data constraints (see Annex 2), we seek to understand the insights provided through private vendor datasets regarding companies' voluntary reporting on indicators relevant for physical risk analysis. Scenario analysis requires large datasets, especially when applied to a wide geographic scope. Specifically, we analyze key aspects of data on nature-related indicators available through one of the primary vendors, MSCI, to assess nature-related physical risks. We examine two aspects of physical risks: (1) companies' exposure to nature loss and its potential impact on business operations; and (2) the degree to which companies are prepared to manage reliance on natural resources, and mitigate the potential risks associated with nature loss. We develop two industry-level index measures to describe the business impact of physical risks.[35] First, we develop an index that describes business dependence on the use of natural capital to measure the industry-wide exposure to risks associated with nature loss. Second, we construct a preparedness and mitigation index that measures the degree of self-reported readiness to manage exposures to these risks.

Results demonstrate a weak correlation between exposure and preparedness scores. We present our results as a ranking by industry, with the highest scores in each category ranked first. Figure 7 (panel 1) shows each industry, with the exposure ranking on the *x*-axis and the preparedness ranking on the *y*-axis. A correlation coefficient of only 0.37 implies that the industries most exposed to nature loss are not correspondingly prepared to respond to or manage those risks, as compared with industries that are less exposed, according to these self-reported scores.

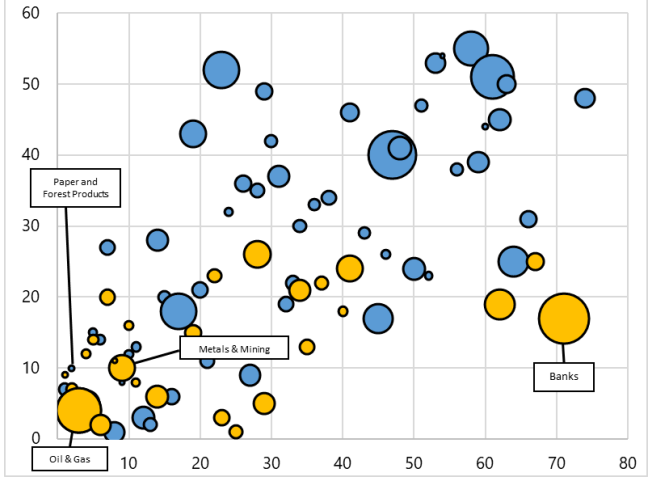
[35] A detailed methodology is described in Annex 2.

Figure 7. Industry-Level Exposure to Nature-Related Physical Risks and Readiness to Manage Them

1. Exposure versus Prepardness Ranking: Full Sample, with Industry Size by Market Capitalization



2. Exposure versus Preparedness Ranking: Largest Companies within each Industry, with Industry Size by Market Capitalization



Sources: ENCORE; MSCI; and IMF staff calculations.
Note: In panel 2, two subsets of companies are represented: the top 50 largest companies in each industry (blue), and the largest companies in each industry that together form 75 percent of total market capitalization (yellow).

The expectation is that the largest companies within each industry, by virtue of their position and access to resources, should exhibit the highest level of preparedness in managing risk exposure. These companies typically wield influence on policymakers and value chains, hold pricing power and market share, and are historically the primary targets of reporting regulations. Therefore, we reconstruct the above industry scores for two subsets of companies: (1) the 50 largest companies in each industry by market capitalization,[36] and (2) the largest companies in each industry that collectively account for a total of at least 75 percent of the total market capitalization.

Our refined analysis reveals higher correlation coefficients of 0.70 and 0.50, respectively, for the two subsets of companies. This suggests that within these segments the largest companies in each industry exhibit a preparedness score that corresponds with their risk exposure. In other words, the largest companies that are most exposed to risks from nature loss tend to report higher preparedness score, reflecting their responses to nature-related risks or efforts to mitigate those risks, compared to the largest companies in industries that are less exposed to nature losses. Figure 7 (panel 2) plots rankings for these two subgroups.

The high correlation between scores for the largest companies may mask outsized exposure risks, inadequacies in preparedness and in disclosure requirements and standards. Exposure scores for the top 50 group in each industry are on average 33 percent higher than those for the full sample, although with wide variation across industries. On the preparedness front, the scores for the top 50 group in every industry in our sample are well below those of their respective industry average, by an average of 47 percent. It is important to note that this difference may be attributed in part to a lack of systematic reporting, considering these data are voluntarily self-reported by companies. As a result of the underlying data gaps, these results may not be representative of the overall state of preparedness. The voluntary nature of reporting results in a dataset that is biased, and potentially skewed toward a more positive representation of companies' preparedness. Nevertheless, this analysis suggests that, across industries, large companies not only face greater exposure to

[36] See Annex 2.

physical risks from nature loss compared to their within-industry peers but also lag in their capacity to effectively address or mitigate those risks.

Our analysis raises questions about adequacy of governance and disclosure requirements on nature-related risks across industries. Although there is generally a high level of coverage for the variables indicating exposure risk, the low level of coverage across different types of resource management indicators in Environmental, Social, and Governance (ESG) metrics indicate deficiencies in the transparency of how companies manage their exposures to nature-related risks. As the framework presented in Figure 3 describes, two of the transmission channels through which the depletion of natural capital has macroeconomic implications is the reduction in output and damage to physical capital. Failure to recognize and integrate these channels into risk management frameworks could reduce companies' ability to effectively manage these risks and mitigate their impact. Among our preparedness variables, carbon emissions management is the only area in which more than 50 percent of companies report. This shows that voluntary reporting programs may not provide sufficient incentive for companies to date to incorporate nature-related risk management into their business strategy and risk management frameworks.

Large deficiencies in disclosures on nature-related risk management make it difficult to discern the degree of systemic risk in the economy that may, stem from exposure to sources of nature-related physical risks. Companies that respond to open-ended questions have described various mechanisms for incorporating water and forestry management activities in their business strategies, including linking executive compensation to sustainability achievements, establishing independent targets, greater engagement with stakeholders on ESG topics, and integrating ESG metrics into their performance measures. Just under 55 percent of companies that report on water risk management say they have integrated water-related issues into their long-term business plans.[37] Among the companies that do report, there are no uniform criteria for measuring the effectiveness nature-related risk management. As previously described, risks associated with degradation of nature represent a potential threat to macroeconomic and financial stability because of the unpredictability of tipping points and the degree to which our economic system relies on nature. It is, therefore, critical that the scope of disclosures and reporting on how companies are managing their exposures be broadened to identify potential points of weakness. This necessitates the introduction of specific indicators on governance, such as board and management oversight, incentives to board members and management for the management of nature-related risks and strategic planning, including nature-related policies across key economic activities with time-bound and quantifiable targets and measures, and the incorporation of supply chain issues.

Nature-Related Financial Sector Policies and Initiatives across Countries

Stemming from the conceptual framework and the empirical analysis in the previous sections, nature's role in economic value creation and the associated risks deriving from nature loss present significant challenges and opportunities for the financial sector and financial sector policy developments worldwide. In theory, it should be possible for societies to define a set of essential values, including the conservation of nature and the reversal of biodiversity loss, on which citizens can unite. A corollary of such an agreement would be prohibitions on nature-destroying activities, akin to the Protocol on Environmental Protection to the Antarctic Treaty, the current United Nations negotiations on deep-seabed mining regulations, and laws that prohibit human trafficking and other illegal activities. An institutional change of this magnitude would impose limits on the actions of financial institutions. However, the implementation of updated rules for economic activity of this type remains a distant prospect. In this context, we review initiatives across countries to develop nature-related financial sector policies within an institutional paradigm that does not hinder financing incompatible with nature protection at the required scale.

[37] Carbon Disclosure Project (CDP) Global: Water Questionnaire.

The need to phase out harmful economic activities and for large investments to transition to a nature-positive economy underscores the critical role of financial sector policy instruments. These include (1) informational and market conduct policies related to the development of an information architecture to address the underpricing and lack of transparency of nature-related risks and promote the development of impact-based financial securities focused on conservation and restoration, (2) supervisory approaches and tools to facilitate the quantification and management of nature-related risks, and (3) enhancing financial institution governance frameworks to mitigate short-term biases.

Regulatory and supervisory authorities are at varying stages. In jurisdictions where supervisory guidance exists, it sometimes covers nature-related risks as a part of the overall focus on environmental risks, including climate (FSB 2024). Global collaborative initiatives by the Financial Stability Board, Network of Central Banks and Financial Supervisors for Greening the Financial System (NGFS), Group of Seven (G7), and Organisation for Economic Co-operation and Development (OECD) seek to identify, assess, and manage nature-related financial risks, with the NGFS and the OECD having developed nonregulatory frameworks to assess biodiversity-related financial risks.[38] Regional and national initiatives span several countries across income-levels, including emerging market and developing economies (Brazil, Chile, China, Honduras, Malaysia, Mexico, Morocco, Nepal, Nigeria, Peru, and the Philippines), in some cases with World Bank support. They include incorporating nature in thematic reviews and developing supervisory frameworks, sometimes as a part of their broader environmental framework. Some authorities in advanced and leading emerging economies are also considering nature-related risks as part of their broader frameworks (for example, European Central Bank,[39] Australia, China, Saudi Arabia). Although some authorities recognize that nature-related risks constitute a financial risk (a conclusion based on their analytical work),[40] many are still at the monitoring stage, and a few have not initiated work due to data and methodological deficiencies, and questions about financial materiality of nature-related risks (FSB 2024).

In this context, financial institutions' efforts to effectively manage nature-related risks remain at a nascent stage, and not as advanced as those for climate-related risks. Nevertheless, some authorities have issued supervisory guidance for financial institutions on how to specifically manage nature-related risks, and some others as part of their overall environmental frameworks. Three examples include the following:

1. **Brazil:** The central bank has strengthened its prudential regulatory framework on environmental risks,[41] notably by implementing since 2008 exclusion rules for the granting of concession on rural credit to protected or embargoed areas, and indigenous lands.[42]
2. **Hong Kong Special Administrative Region:** Since 2020, the monetary authority has required banks to manage environmental risks including risks stemming from environmental degradation, biodiversity loss, and deforestation, as part of a common assessment of the banking sector.
3. **European Union:** The Capital Requirements Directive and Regulation for banks, in its latest amendment,[43] further implements ESG risks requiring disclosures, governance, and management of

[38] The G7 Climate Change Mitigation working group discusses analysis of nature-related macro-financial risks (2024 work program).
[39] The European Central Bank's climate and nature plan 2024–25 includes advancing analytical work on nature-related financial risks.
[40] The authorities include European Union, France, Germany, Hong Kong SAR, Indonesia, Italy, Mexico, the Netherlands, South Africa, and Switzerland.
[41] Banco Central do Brasil, Report on Social, Environmental and Climate-related Risks and Opportunities, Volume 3, December 2023.
[42] Published by the Brazilian National Monetary Council in February 2008, Resolution 3545 conditioned the concession of rural credit for use in agricultural activities in the Amazon Biome upon presentation of proof of borrowers' compliance with environmental legislation, as well as of the legitimacy of their land claims and the regularity of their rural establishments. The measure, aimed at restricting credit for those who infringed environmental regulations, applied to all establishments in municipalities located entirely within the Amazon Biome. This resolution has led to a decrease in rural credit that has proven to curb deforestation, especially in municipalities where cattle ranching is the main economic activity (CPI 2013). The rules require financial institutions to establish a social, environmental and climate responsibility policy and disclose environmental risks, including for biodiversity.
[43] EU Regulation 2024/1623 of the European Parliament and of the Council of 31 May 2024.

ESG risks, including specified factors such as environmental degradation of ecosystems and biodiversity loss.[44]

The challenges in addressing nature loss within the information architecture and related financial sector policies remains significant. This includes disclosures and taxonomies, which translate into nonfinancial and financial corporate disclosure, planning, and governance practices and related challenges. In recent years, there has been a push toward promoting corporate disclosures on nature, including efforts by the G20 Sustainable Finance Working Group. In 2023, the Task Force on Nature-Related Financial Disclosures (TNFD)[45] published a set of disclosure recommendations and guidance encouraging nonfinancial corporations and financial companies to assess, report, and act upon their nature-related dependencies, impacts, risks, and opportunities (FSB 2024). The guidance for financial institutions includes metrics tailored to banks', (re)insurance companies', and asset managers' dependencies and impacts on nature. In April 2024, the International Sustainability Standards Board launched a disclosure project on nature-related risks and opportunities. A few jurisdictions in Europe and large emerging market economies (Brazil, China, Türkiye) have endorsed TNFD recommendations or implemented nature-related disclosure requirements for listed companies.[46] For instance, China's National Biodiversity Strategy and Action Plan, published in January 2024, encourages companies to develop biodiversity conservation action plans and promotes the inclusion of biodiversity-related information in legal disclosures of corporate environmental information.

Efforts to develop biodiversity measurement methodologies are underway, targeting financial institutions (Finance for Biodiversity 2024) at both asset and portfolio levels. These methodologies are developed jointly by global institutions and scientific bodies (for example, IUCN), public biodiversity agencies, and data providers. They include sector-screening methods to identify sectors with moderate or high nature dependencies, revealing potential financial exposure to risks and opportunities.[47] They also include location-screening methods to determine with which biomes and specific ecosystems institutions' priority portfolio sectors interact or interface, including ecologically sensitive locations.[48] In addition, tools are being developed to evaluate dependencies and assess impacts.[49]

Currently, few taxonomies include nature-related objectives and criteria, but the trend toward their incorporation is gaining momentum. Among the 17 countries considered as mega-biodiverse, most have either adopted or are in the process of developing taxonomies. Other existing taxonomies or ongoing projects include nature, either as a standalone objective or by establishing environmental performance metrics or thresholds specific to nature. However, progress remains limited in this area (Table 1).

[44] The review underlines the importance of banks incorporating ESG risks, with a specific emphasis on biodiversity and nature-related, into their strategies and processes for evaluating internal governance and capital needs. It requires banks to disclose transition plans, report on governance arrangements, and manage environmental risks. The European Banking Authority issued draft guidelines in 2024 establishing minimum standards for banks to identify, measure, manage, and monitor ESG risks, including those from ecosystem degradation and biodiversity loss. Banks must have internal procedures to assess their counterparties' ESG risk profile, identify natural capital dependencies in nature-related or biodiversity risks analyses, and assess additional risk-based metrics and targets in their transition plans.
[45] The Task Force on Nature-Related Financial Disclosures is a market-led and government-supported global initiative.
[46] To date, only France mandates investors for the disclosure of biodiversity-related risks and a strategy to eliminate biodiversity-related impacts, in addition to EU rules (Corporate Sustainability Reporting Directive, Sustainable Financial Disclosure Regulation).
[47] The most used approach is Exploring Natural Capital Opportunities, Risks and Exposure.
[48] These include the Integrated Biodiversity Assessment Tool and the Nature and Biodiversity Metrics.
[49] These include the Biodiversity Footprint Financial Institutions, the Biodiversity Impact Analytics, the Biodiversity Impact Assessment Tool, Corporate Biodiversity Footprint, the Global Biodiversity Score for Financial Institutions, and the Global Impact Database.

Table 1. The Inclusion of Biodiversity and Ecosystem Preservation in Taxonomies Is on the Rise but Remains Undeveloped Relative to Climate

	Taxonomy Adopted	Taxonomy under Development	No Taxonomy under Development
Biodiversity and ecosystem protection is fully or partially incorporated (as a standalone objective, with substantial contribution criteria for priority or a broad range of economic activities)	ASEAN, **China, Colombia,** Dominican Republic, Egypt, European Union, Georgia, Kazakhstan, Korea, Mongolia, Panama, Russian Federation, Singapore, Sri Lanka, Thailand	Costa Rica, Latin America and Caribbean Common Framework (coordinated by UNEP)	
Biodiversity and ecosystem protection is a broad objective, sometimes supported by "do no significant harm" criteria	Bangladesh, Ecuador, **Indonesia, Malaysia, Mexico**, **Papua New Guinea, South Africa**	**Brazil,** Chile, **India,** Kenya, **Peru,** Rwanda, Senegal, Vietnam	
Biodiversity and ecosystem protection is listed as a future objective		New Zealand, **Philippines**, Türkiye, United Arab Emirates, United Kingdom	
Biodiversity and ecosystem protection is not yet included		Argentina, **Australia,** Canada, Hong Kong SAR, Kyrgyz Republic	**Democratic Republic of the Congo, Madagascar, United States, Venezuela**

Source: IMF staff, based on taxonomy data collection for 44 jurisdictions and regions.
Note: Data as of July 30, 2024. While the "no taxonomy under development" category would encompass a wider range of jurisdictions, we focus here only on those considered mega-biodiverse. Countries in bold blue are mega-biodiverse according to the United Nations World Monitoring Conservation Center. ASEAN = Association of Southeast Asian Nations; UNEP = United Nations Environment Programme.

Takeaways for the Global Community and Policy Recommendations

Policy Considerations

Nature loss has implications for macroeconomic and financial sector policies.[50] The combination of nature- and climate-related uncertainty implies that worst-case scenarios—whose probability cannot be quantified—cannot be ruled out. This should inform policymaking and points to the need for a proactive approach to economic and financial policymaking. Given Earth system dynamics and positive and negative synergies between climate change and nature loss, an integrated approach to nature and climate is needed. A "do no harm" principle could be developed to ensure that climate objectives do not harm nature objectives, and vice versa. The objective should be to ensure that climate mitigation and adaptation policies are conceptualized jointly with nature-related policies at the highest level of government. This would enable coordination at the needed scale at the country, regional, and international levels. Recognizing the importance of proportionality and prioritization of national objectives, at the very minimum, authorities in countries where nature-related risks are significant should consider these policy suggestions at the earliest.

At the global level, there is a need for a rapid, orderly phasing out of harmful economic activities (Kunming–Montreal Global Biodiversity Framework Targets 4, 6, 7, 10, 14, and 18), policies, and financing to avoid irreversible nature loss and a disorderly phasing out in the future. However, the complexity of the issues, the positive and negative synergies with other international policy objectives (notably mitigating climate change), and the heterogeneous incidence of policy interventions across and within countries make this objective exceptionally challenging. Given the cross-country differences in nature loss embodied in trade discussed in Annex 1, global policy discussions should acknowledge differences in consumption, production, and trade patterns across countries. Harmful subsidies and financing activities in different countries and regions have cross-border implications for nature loss that should also be considered.

[50] For detailed policy recommendations, especially on the financial sector, see Annex 5.

Policy frameworks in advanced, emerging, and developing economies need to evolve to embrace environmental sustainability, with suitable proportionality and prioritization considering capacity, risk severity, and time horizon. Recognizing the importance of planetary boundaries, economic policy frameworks need to acknowledge that economic activities can have far-reaching environmental impacts across borders through supply chain structures and potentially trigger cascading effects, as discussed in the first section. Policy frameworks need to recognize the systemic effects of crossing planetary boundaries and the existence of biophysical tipping points. Two potential implications stand out. First, the existence of ecological tipping points suggests the need to build social and political consensus on transitioning away from non-sustainable economic activities. Second, there is a need to reorient policies to prioritize the rapid transformation of the productive structure of the economy to align with planetary boundaries.

Policy choice can be informed by the market failure at play but may crucially depend on non-linearities in processes that govern the biosphere, as well as the level of uncertainty regarding ecosystem regime shifts. In some cases, pricing instruments and the creation of markets can help internalize part of the external costs. Economic valuation efforts can also be helpful for conservation efforts, public investment decisions, and cost-benefit analyses. However, such approaches should be complemented by changes in governance and institutional structures (Ostrom 2010, Koenig and Deenapanray 2024). Moreover, the pervasiveness of non-linearities in the processes that govern the biosphere, and the level of uncertainty regarding possible ecosystem regime shifts, mean that markets may not always be an adequate institution to achieve biosphere protection. In such cases, quantity restrictions, rather than price instruments, may be more effective to prevent possible regime shifts in ecosystems (Dasgupta 2021, pp. 83, 434). Finally, in some cases "mixed" price-quantity approaches may be most appropriate (Weitzman 1974).

A "do no harm" principle would require ensuring that nature and climate objectives be targeted simultaneously through a global and de-siloed approach to policies, to avoid support for climate objectives being detrimental to nature objectives, and vice versa. Nature-based solutions, when feasible, could support both adaptation to climate and nature protection. Moreover, the focus on nature should not be restricted to nature policies, but also extend to the impact of core macro, fiscal, and financial sector policies on nature.

Addressing financial flows' misalignment with nature is a critical priority (see Annex 4). The dual imperative of halting financing that is harmful to nature while closing the financing gap for nature underscores the broader policy framework outlined in the GBF.

Policy Recommendations: Financial Sector Focus

The findings of this paper suggest a need for policymakers to start incorporating nature-related risks in their policy frameworks, complementing ongoing work on climate to reflect the climate–nature nexus. This may entail a wide range of policy tools, including informational policies (an integrated nature/climate information architecture) in the short term, and prudential and conduct policies in the long term.

Robust global reference frameworks for nature are needed to scale up nature finance and drive nature-oriented transition planning and risk assessment, building on robust taxonomies and data. Mitigating nature-related risks and identifying financing needs involve bridging nature-related data challenges and ensuring a common understanding of harmful and beneficial economic activities. Taxonomies should prioritize nature-related objectives and screening criteria, putting at their core the "do no harm" principle. They would support transition planning and inform environmental risk assessments across financial institutions' portfolios. Taxonomy development should start with nature-relevant sectors, considering impacts on nature through primary activities and supply chains. Scenario analysis would help project science-based targets and pathways for ecosystem protection and more broadly different states of the world. Global collaboration is essential to develop and ensure access to reliable and comprehensive data on nature, which is subsequently essential for scenario analysis and effective risk management and to address financial flows' misalignment with nature (see Annex 5).

Financial regulators and supervisors have a role to play to support the alignment of the financial sector with nature-related risks and goals. Starting with countries where nature-related risks are most significant, they can support corporate disclosures that integrate nature, in line with the ongoing efforts of the Task Force on Nature-Related Financial Disclosures (TNFD) and those of standard setters such as the ISSB and IOSCO. They can also develop supervisory expectations for integrated transition plans including climate and nature-related targets, consider impact assessments, and investment pathways, and encourage supervised firms' identification and management of nature-related risks and impacts, as well as dependencies and opportunities, starting with the largest nonfinancial and financial companies and those facing the highest level of risk in the short-to-medium term. These companies could set the standard in their respective sectors, helping bridge data gaps, implement robust due diligence, investment planning, and risk management practices. Financial regulators and supervisors can also gradually enhance their own assessments of nature-related transition and physical risks, while also promoting risk analysis in the financial sector.

The largest nonfinancial corporations, starting with those most affecting nature loss, could consider publishing integrated transition plans that incorporate nature and address the climate–nature nexus, with complementary targets and an emphasis on nature and mitigation co-benefits (Cook-Patton and others 2021). The "do no harm" principle could also be at the heart of this approach. These plans would reflect the extent to which companies are adapting to climate change and building resilience to climate and nature-related risks (preparedness).[51] Such disclosures would be crucial for financial institutions to guide risk pricing, capital allocation, product development, engagement, and stewardship (Spacey Martín and others 2024).

Given transition risks, largest global banks that are significantly exposed to nature-related risks should start enhancing their practices by gradually developing nature-related due-diligence and risk management approaches. As data-related challenges are addressed, their scope could progressively expand beyond project finance to include all types of lending, investments, and underwriting activities, with particular emphasis on global corporate loans and bonds, including in syndicated transactions among lead arrangers. The assessment of nature-related risks in due diligence and risk management can also be expanded to include at least key biodiversity areas and hotspots, and knock-on effects from climate- and nature-relevant economic activities, while integrating these assessments with already implemented climate-related risks frameworks, as required by international standards.

Expanding beyond financial sector policies, it is essential for governments to transparently disclose subsidies (see Annexes 2 and 5). Introducing a consistent transparency framework across countries is essential to aligning economic policies and activities with the objective of reversing nature loss.

Areas that require further research include (1) exploring the implications of nature loss for debt sustainability, (2) analyzing the role of domestic economic and financial constraints related to the international monetary and financial architecture in locking countries into nature-degrading growth models, (3) developing the concept of a "nature Minsky moment" and understanding its implications for macroprudential policies, and strengthening financial sector vulnerability assessments, including banks and nonbank financial institutions, (4) identifying the regulatory and institutional preconditions for nature finance instruments to function in the ways and at the scale envisioned, and (5) enhancing nature scenarios and modeling to include additional ecosystem services.

[51] This preparedness is possible while working at achieving climate-related goals, since temperature goals can only be met through careful consideration of the greenhouse gas emissions arising from nature's degradation.

Annex 1. Conceptual Framework

This annex presents a comprehensive overview of key conceptual and empirical aspects of nature-related economic and financial risks. It is divided into four parts. The first section provides an overview of the conceptual building blocks introduced in the Dasgupta Review (Dasgupta 2021), on which we draw to develop our conceptual framework, discussed in the second section of the annex. The third section presents charts on stylized facts from the literature on nature loss embodied in international trade. The fourth section presents a framework on the linkages between nature loss and public debt sustainability.

Conceptual Building Blocks

As noted in the first section of the note, the conceptual framework that we propose draws on the Dasgupta Review (Dasgupta 2021). The latter contains the following conceptual building blocks (key concepts in italics):

- ***Nature* is defined as a type of capital, natural capital,** alongside produced capital, human capital, and social capital. Nature has both use value and intrinsic value—hence it is not simply an economic good.[52]
- **Nature is composed of ecosystems,** which, in turn, provide both regulating and maintenance services (climate regulation, water and air quality regulation, pollination, and pest and disease control), provisioning services (food, raw materials, and freshwater), and cultural services (recreation, mental and physical health, spiritual and religious values). To a large extent, the regulating and maintenance services create provisioning goods (Dasgupta and Levin 2023).
- **Natural capital differs from produced capital** in ways that relate to four pervasive features of nature:
    1. It is **silent** and **invisible**: regulating and maintenance services are largely hidden from view and, thus, are silent (we feel their worth only when they are absent). Provisioning and cultural services, on the other hand, have detectable outcomes or are observable and can be felt.
    2. It is **mobile**: warm water weakens ice sheets; phosphorus discharge from farms contributes to ocean acidification and ocean anoxia; and so on.
    3. It features **tipping points**, positive feedback, path dependence, irreversibility, and even catastrophic risks. Dasgupta (2021) notes that the nonlinearity of the processes that govern the biosphere are the source of these features, and that these pervasive nonlinearities are a reason that markets are "a woefully inadequate system of institutions for protecting the biosphere from overuse."
    4. These features make it hard to trace the adverse effects of many actions back to economic agents.

- ***Ecosystems* differ from produced capital in three ways:** (1) depreciation is in many cases irreversible, (2) it is not possible to replicate a depleted or degraded ecosystem, and (3) ecosystems can collapse abruptly. On the other hand, ecosystem depreciate if they are misused or overused, as is the case for produced capital.
- **The substitutability between natural capital and other forms of capital is limited.** There are "little-to-no substitution possibilities between key forms of natural capital and produced capital and for that matter any other form of capital" (Dasgupta 2021, p. 328). This "strong sustainability" approach (as opposed to the "weak sustainability" approach, which assumes that nature and the ecosystem services it provides can be replaced by labor and man-made capital) is consistent with a review of the literature that concludes that forms of natural capital that serve basic life-support functions for human beings (for example, the global climate, biodiversity) are nonsubstitutable in their totality (Neumayer 2013, p. 193), and that there is almost no

[52] This conceptualization stems from a worldview anchored in neoclassical economic theory. In other conceptualizations, it is inferred from the fact that nature is not part of the market order that nature and ecosystem services (for instance, the air we breathe) are invaluable, casting doubt on the epistemological soundness of the notion of natural capital (see Harribey 2013 for an overview of these debates). Similarly, IPBES (2019) points out that nature carries different values for different social groups; NGFS (2023a) notes that nature does not have a "fundamental" value that can be "discovered" with additional data or improved technology; and Pascual and others (2017) argue that the values of nature are continually reinterpreted and internalized through social deliberation and conflict.

substitutability between natural capital and other forms of capital, at least in the short term (see also NGFS 2023a, p. 17).

Consistent with this framework, the largest *nature-related risks* stem from nonlinear interactions among risk drivers, as well as interactions between nature and climate risks, which collectively lead to complex, cascading, and compounding risks.[53] Broader cascading effects are hard to predict and model, and include political instability, civil unrest, and geopolitical confrontation. For these reasons, risk assessments need to jointly consider nature and climate risks and take into account potential tipping points and cascading risks to avoid underestimating risks and overlooking catastrophic scenarios (see Kemp and others 2022).

***Ecosystem tipping points* (ETPs) are a key concept for thinking about nature-related economic risks**. They can be defined as nonlinear, self-amplifying, and irreversible changes in ecosystem states that can occur rapidly and on a large scale. Marsden and others (2024) assess ETP risks, with five key findings:

1. **Demands on nature as a result of economic activity are increasing the risk of ETPs.**
2. **Several ETPs could threaten Earth system stability:** Amazon rainforest dieback; boreal forest cover transitions; tropical peatland collapse; coral reef die-off; mangroves dieback.
3. **ETPs have global feedback effects on climate change.**
4. **Loss of critical ecosystems would have large adverse impacts on the global economy,** including through lower food and energy security, damaging assets including infrastructure, and health risks.
5. **ETPs are associated with major nature loss, limiting adaptation and substitution possibilities**.

The Dasgupta Review framework also rests on the following key concepts:

- ***Institutions* and *social capital* play a critical role in determining individual and collective preferences, and therefore the economics of nature.**
  - ***Institutions*** can be defined as "the humanly devised constraints that structure political, economic and social interaction," consisting of "both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)" (North 1991). They are understood to "support values and produce and protect interests" (Vatn 2005, p. 83). Economic policy decisions are shaped by institutions.
  - ***Social capital*.** Following Helliwell and Putnam (2004), social capital can be defined as the combination of mutual trust, confidence in governments and markets, and more broadly "the institutional arrangements that enable people to engage with one another for mutual benefit." Trust, cooperation, and social capital form the foundation on which institutions rest. Social capital is therefore central to the economics of biodiversity (Dasgupta 2021, p. 165).
- **The materialization of nature-related risks—such as droughts—can lead a society abruptly to shift from cooperation to non-cooperation**, as social norms work only when people coordinate on trust (Dasgupta 2021, p. 182).
- **Human relationships, shaped by institutions, generate externalities and exert a major influence on desires and choices.** The economics of nature is therefore affected by externalities that emerge from the social embeddedness of preferences. Two classes of social preferences identified in the literature are competitive and conformist.[54]
- **The financial system** facilitates investments in capital assets, including natural assets, and plays a role in determining both the stock of natural capital and the extent of societies' demands on the biosphere (Dasgupta 2021, p. 465). The financial system influences societies' demands on nature by channeling financial flows to

[53] For instance, deforestation and destruction of wetlands can increase flood risk, and climate change can exacerbate nature loss impacts (for example, fisheries are affected by both overfishing and ocean acidification) (Ranger and others 2023). On the nonlinearity of processes that govern biomes, see Levin (1999).
[54] According to Dasgupta (2021, p. 230), competitive social preferences display "a desire for high social status relative to that of others," whereas conformist social preferences "embodies a desire to be like others, to not stand out." Conformism could lead to moderation in consumption practices if this was also the practice of others. It is therefore possible to identify behavioral change patterns that would reduce humanity's impact on the biosphere without generating welfare losses that would typically arise in conventional economic models that do not account for social embeddedness of preferences (Dasgupta 2021, p. 230).

different economic activities, and it enables investment in conservation and restoration of ecosystems and their biodiversity.

Empirical analyses have quantified some significant sources of nature-related risks. Ranger and others (2023) estimate water-related, agriculture-related, and pollination-related risks at 7 to 9 percent, 14 to 18 percent, and 12 percent of global GDP, respectively. Cascading feedback could amplify these impacts and act as a risk multiplier on climate change, leading to large impacts on economies and the global financial system.[55]

Regarding policy implications, within the Dasgupta Review framework instituting Pigouvian taxes and subsidies for all nature-related externalities is not feasible, implying the need for quantity restrictions. To effectively address the enormous and pervasive externalities described above, a "socio-ecological world" where all externalities are accounted for by deploying Pigouvian taxes and subsidies would *theoretically* be needed (Dasgupta 2021, p. 192). However, the Dasgupta Review emphasizes that this is not feasible given the inability of authorities to observe or verify what agent does what at each point in time. In turn, this implies the need to introduce quantity restrictions rather than relying on Pigouvian taxes and subsidies (Dasgupta 2021, p. 193). Given the possibility a breakdown of ecosystems, it can be desirable for governments to impose quantity restrictions (Dasgupta 2021, p. 195).

Conceptual Framework: Economic and Financial Nature-Related Risks

Drawing on the Dasgupta Review, we propose a conceptual framework that connects nature to the macroeconomy and the financial system. The following discussion provides a granular description of the framework.

In the framework, natural capital is one of four types of capital, which like other types has use-value, but unlike other types has nonuse values. Natural capital, denoted by S_t in Annex Figure 1.1, refers to the biosphere's state at any period, which results from its prior state adjusted for regeneration and degradation from extraction and waste production. Natural capital has a double function in the economy. First, it provides resources that humans extract for consumption or as production inputs, denoted by R_t, and constitutes humanity's footprint in nature (provisioning services). Food, freshwater, timber, and biochemicals are classic examples of extracted goods that have market value.[56] Second, it provides maintenance and regulation services. This includes maintaining the gaseous composition of the atmosphere, regulating local and global climates, soil erosion and flood control, purifying water, regulating diseases, and pollinating plants. These are generally referred to as nonmarket ecosystem services, as they typically have a public good nature.[57]

Natural capital regenerates.[58] **However, it is bounded above, denoting that the planet is finite. The planet is also subject to planetary boundaries—**the safe operating space for humanity identified by the scientific community, which spans several interconnected natural processes regulating the Earth system (Rockström and others 2009; Steffen and others 2015; Richardson and others 2023). While nature regenerates, denoted by G_t in Annex Figure 1.1, natural resources exploitation is subject to a tipping point, Ψ^*, beyond which ecosystems cannot thrive or potentially even survive.[59] Nonlinearities and discontinuous dynamics characterize such processes[60] (see Möllmann and others 2021). A paradigmatic example of tipping points that has raised global

[55] Five ecosystem services out of 20 available are assessed; hence, the report considers that these estimates are a lower bound.
[56] Despite having market value, extracted goods such as timber are often subject to the challenges of managing common-pool resources.
[57] Arguably, biodiversity is at the intersection of public goods and commons. Provisioning services (for example, food, raw materials such as wood, freshwater) are generally rivalrous and therefore would presumably be commons, depending on the type of governance that is collectively chosen or decided on. By contrast, maintenance and regulating services (climate, water and air quality regulation, pollination, pest and disease control) tend to be public goods as they are non-rivalrous and non-excludable.
[58] While not all resources regenerate because some of them are depletable (for example, fossil fuels and other nonrenewable resources), we assume natural capital regenerates at rate G_t without loss of generality.
[59] In other words, Ψ^* represents the minimum value of S_t needed to avoid irreversible collapse.
[60] Such processes test the limits of economic modeling because traditional economic models frequently rely on linearity, continuity, and differentiability assumptions to allow the use of calculus in optimization problems.

concern is the Amazon rainforest system, which could soon reach a tipping point, with increased exposure to unprecedented stress from deforestation, warming temperatures, extreme droughts, and fires inducing large-scale collapse (Flores and others 2024).

Productivity is defined within the context of the constraints posed by nature, described in Annex Figure 1.1. Reflecting the limits imposed by Ψ^*—and Earth system stability more broadly—we define productivity as the efficiency of production subject to the preservation of the material basis for the creation of economic value, which encompasses nature. This definition implies that an increase in labor or capital productivity that is associated with nature loss or degradation is an *apparent* productivity gain rather than an *actual* one (that is, it overestimates productivity gains), as it has an adverse impact on the material conditions on which economic value creation itself depends.

The framework relates all forms of capital to output through their flows as factors of production:[61] labor, physical capital, credit, and extracted goods. The economy's output at each period can be produced sustainably or unsustainably. Production can be on an unsustainable path at any given time when the resources extracted and the waste placed back in nature exceed nature's regeneration. However, there is an important dynamic component, as it is not a single period but the unsustainable production over time that ultimately leads to an unsustainable state.[62]

We identify three possible states of the world depending on the sustainability of production over time: (A) sustainable, (B) unsustainable, and (C) irreversible collapse. In state (A), the use of natural resources does not degrade nature to a dangerously low level because production is sustainable. This implies that, as shown in equation (1) in Figure.3, the total net extraction over time remains well below the gap between nature's initial state and its tipping point. In state (B), economic output is achieved at the expense of depleting natural capital because production is unsustainable in at least some periods. While in state (B) natural capital is still above its tipping point, it is approaching the tipping point with each period of unsustainable production. Cumulative net extraction is greater than the gap between nature's initial state and its tipping point, as shown in equation (1′) of Annex Figure 1.1. However, there is high uncertainty in natural sciences over where exactly the tipping points lie, which is represented as ε in equations (2′) and (2″) of Annex Figure 1.1, where ε is randomly drawn from a distribution that allows for negative values. If ε turns out to be higher than expected, natural capital in the next period may cross the threshold of the tipping point.[63] Finally, in scenario (C), unsustainable production over time inevitably leads nature to a collapse.

Even though defining tipping points is useful from a conceptual perspective, we highlight two important conceptual and practical limitations.

[61] Note that this assumes that capital, including within each category, can be aggregated. This debate dates back to 1950; it was sparked by Joan Robinson, and extended into the Cambridge–Cambridge Capital Theory Controversies.

[62] Despite the widespread use of the aggregate production function in macroeconomic models, we opt not to use it because of its lack of robust theoretical and empirical foundations. At the theoretical level, it has been shown that the aggregate production function is simply an accounting identity to measure aggregate value added, and does not contain any information on technological relationships in the economy (Rudd 2024, Shaikh 1974, Simon 1979). Indeed, Fisher (1971) shows that the supply side of the economy can only be described using a production function under highly unrealistic conditions. Empirically, Shaikh (1974) and Fisher (1993) show that the fit with the data provided by an aggregate Cobb-Douglas production function with constant returns to scale, for any data, is a mathematical consequence of constant factor shares, an empirical result that is simply due to a law of algebra. Regarding total factor productivity (TFP), Rudd (2024) notes that "labor and capital aggregates that are relevant to production can only exist under conditions that are unlikely to ever be met by a real-world economy," meaning that "even the most carefully constructed estimates of total factor productivity will be meaningless." For these reasons, we do not introduce an aggregate production function or TFP in our framework. For an overview of the literature on aggregate production functions, see Felipe and Fisher (2003). This differentiates our framework from others in the literature (e.g., Giglio and others 2024 model the production of aggregate ecosystem services using a constant-elasticity-of-substitution production function).

[63] Another way of representing this mathematically is through the Emergency Equation from Lenton and others (2019), $E = R \times U = p \times D \times \frac{\tau}{T}$, where emergency ($E$) is the product of risk (R) and urgency (U). Risk is conventionally defined as probability multiplied by damage, while urgency is defined as reaction time to an alert τ divided by the intervention time left to avoid a bad outcome T. If the intervention time left to avoid a bad outcome is too small, this would increase the urgency to act.

1. **First, it is impossible to determine Ψ^* with certainty.** We know from the laws of physics and chemistry, the paleoclimate record, scientific understanding of relevant feedback, and model projections that Ψ^* exists (see Scheffer and others 2001; Lenton and others 2008; Lenton and others 2019); but, we do not know how to determine it.[64] Using it to justify changes to a system of relative prices as a comprehensive solution to unsustainable economic activity is therefore problematic. This justifies applying a precautionary principle when approaching a zone of ecological unsustainability. The tipping point should be defined using the most appropriate scale: global, national, regional, municipal, or biome/ecosystem, depending on the ecosystem being considered.[65] For instance, the shift of the Amazon rainforest system to a savannah would have consequences for the viability of the region as well as for food security at a regional level. Furthermore, there are synergies among ecosystem services (S_t could therefore be defined as a vector of ecosystem services whose dimensions interact in Annex Figure 1.1). A notable example is evidence of a link between degraded forests and higher atmospheric CO_2 concentration (Ke and others 2024). If the collapse in forests' carbon sink role that occurred in 2023 occurs again in the next years and forests lose their global carbon sink role, this would lead to rapid increases in atmospheric CO_2 concentration and climate change beyond model forecasts, which would cause further forest degradations (Garric 2024). Likewise, a coastal coral reefs collapse would lead to marine biodiversity loss and adverse consequences for other ecosystems and human livelihoods with a magnitude that is difficult to anticipate.
2. **Second, there are risks associated with transposing this equation to the economic analysis sphere.** These risks stem from the large number of unknowns (and "unknown unknowns") and the systemic relationships among these variables, which economics is not designed or equipped to model, quantify, and value. Multidisciplinary work could be envisaged to determine Ψ^* at the appropriate geographic scale, but such work would require extensive and high-quality data, sufficient financing, and political support, and it is likely that uncertainty will remain high.

Risk transmission channels connect nature, macroeconomic, and financial sources. These three types of risks materialize at a macro scale only in states of the world (B) and (C). Crucially, it is only in state (B) that policy interventions can effectively be implemented to mitigate and reverse environmental degradation. By contrast, in state (C), an irreversibility point is reached, rendering natural recovery unfeasible. As a result, not only would the economy falter in its sustainability, but it would also suffer from critical productivity declines, because of the excessive deterioration of natural systems that are fundamental to ongoing production activities.

Annex Figures 1.2 and 1.3 present general and detailed feedback loops, respectively:

- **General feedback loops.** In Annex Figure 1.2, we describe the main positive and negative feedback loops that link different forms of capital to output and its main ecological consequences, namely the global ecological footprint $\left(R_t S_t + \frac{Y_t}{\alpha}\right)$, climate change, and regeneration of natural capital (G_t). These feedback loops characterize the dynamics of the global economic system as it currently operates—that is, with global economic growth that is associated with an increased global ecological footprint, including higher emissions. The first set of (positive) feedback loops links output to the global ecological footprint, climate change, and regeneration of natural capital. Higher output contributes to climate change directly (through higher emissions) and by increasing the global ecological footprint, which itself contributes to climate change (notably through deforestation). Climate change, in turn, reduces the rate of natural capital regeneration—

[64] Quantifying the probability of collapse resulting from crossing a tipping point is not "scientifically discernable," which reflects the complexity of natural systems (NGFS 2023a).
[65] This amounts to defining a common good. The need for a precautionary approach is also stressed by Marsden and others (2024, p. 5). They argue that (1) the fundamental uncertainty associated with ecosystem tipping points calls for approaches beyond risk quantification; (2) the scale of environmental breakdown associated with ETPs justifies a precautionary approach; and (3) a precautionary approach must seek rapidly to eliminate negative drivers to prevent thresholds being crossed *ex ante*, and not to seek to "predict the timing and outcomes of complex Earth system changes."

which is also directly reduced by increased output (negative feedback loops). The second set of (negative) feedback loops links consequences of higher output back to different forms of capital. For instance, climate change and lower regeneration of natural capital (for example, because of soil erosion) have adverse impacts on natural capital (for example, lower soil fertility), social capital (for example, prolonged drought-induced political instability and conflicts over land and natural resources), built capital (for example, impact of water shortages on hydropower infrastructure), and human capital (lower labor productivity).

- **Detailed feedback loops.** In Annex Figure 1.3, to describe linkages between output and ecological effects in more detail, we decompose the general feedback loops in Annex Figure 1.3 into subcomponents, which we group into three steps.[66] In the first step, positive feedback loops link higher output to the global ecological footprint $\left(R_t S_t + \frac{Y_t}{\alpha} \right)$ and climate change (as discussed previously), and the latter to critical nature degradations that affect the Earth system and several planetary boundaries: freshwater depletion, soil erosion, biodiversity decline, and pollutions. In the second step, these nature degradations are linked through negative feedback loops to health-related indicators: plant health (notably agriculture), human health, animal health, and zoonoses. There is a reinforcing negative feedback loop within this step as well. For instance, economic activity can cause urban sprawl, which can lead to habitat and biodiversity loss and changes to resource availability and the structure of wildlife communities. In turn, this can lead to increased zoonotic disease transmission through increased wildlife-human contact, which can have adverse effects on animal and human health (Hassell and others 2017).[67] In the third step, positive feedback loops link the effects described previously to socioeconomic shocks: food and water security crises, conflicts, migration, and political instability (Annex Figure 1.6). Finally, negative feedback loops link the effects described in each of these steps to output, through a range of channels (supply and demand shocks, inflationary shocks, financial crises, export restrictions) depending on the effect that is being considered.

Litigation Risks and Relevance for the Financial Sector

As detailed in Annex Figures 1.4 and 1.5, litigation risks can be considered an additional source of financial risk. While litigation has historically mostly targeted states and public institutions, firms and financial institutions are already facing an increasing number of lawsuits, as detailed in NGFS (2024b).

Similar to climate-related litigation, nature-related litigation is likely to produce nature-related financial concerns through a variety of transmission channels and compounding legal points of entry (NGFS 2024b).

- Lawsuits against states and public entities can indirectly raise transition risk and compliance costs for firms by strengthening or speeding up public policies to protect nature (for example, subsidies, sectoral norms). Litigation interacts with existing international accords and national legislation (for example, GBF, corporate sustainability due diligence with a focus on deforestation, market conduct and disclosure regulations, and increasing recognition of environmental crimes[68]).

- Other indirect effects on financial institutions may stem from litigation against clients and counterparties (based on corporate sustainability due-diligence legislation, shareholder rights, tort law, and so on). Both nonfinancial and financial corporations can also be directly challenged while facing lawsuits (for example, negligence and breach of a duty), with impacts manifesting in various ways in balance sheets (for example, legal, and sanction-related costs, costs of damages, impacts on stock prices, increased

[66] These groupings are arbitrary, reflecting the fact that natural and social systems are complex adaptive systems. We chose these groupings for the sake of clarity.
[67] There are additional channels linking biodiversity loss and global public health impacts. Nature loss contributes to climate change, which, in turn, can strengthen disease vectors and the geographic distribution of pathogens. Ecosystem disruptions and the loss of natural predators can lead to population explosions of disease-carrying species.
[68] According to the International Law Commission, an ecocide is an "intentionally causing widespread, long-term and severe damage to the natural environment." The definition is qualified by lawyers as "ecocentric," in that it considers the damage or harm suffered by the natural environment itself as the basis for the crime (Higgins and others 2013, Howe 2017, Greene 2020).

insurance costs). An increasing body of legal literature focuses on directors' duties to consider firms' nature-related risks (for example, as part of their duties act with reasonable care) (Commonwealth Climate and Law Initiative 2024).

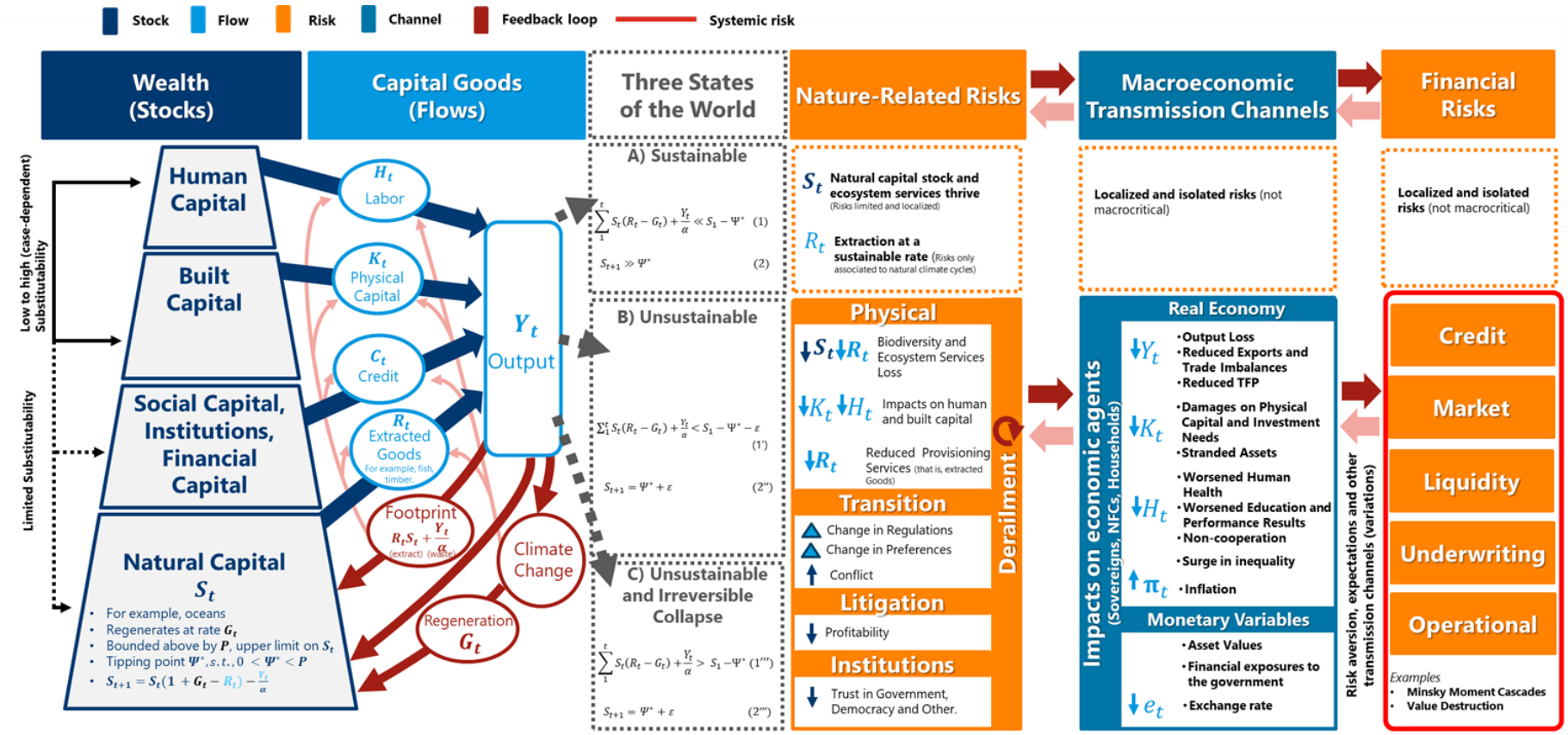
Spillover effects may also be considered, especially for companies in the same sector. Moreover, similar to climate-related litigation, nature-related litigation risk might be a driver of prudential risk categories, including credit, market, operational, and liquidity risk (NGFS 2024a). As emphasized in NGFS 2024b, given the core-periphery structure of the financial system (van der Leij, in 't Veld, and Hommes 2016), litigation may amplify physical and transition nature-related risks, with potential repercussions for other financial institutions and the financial system (through common portfolio exposures, potential cross-sector and cross-border contagion, and interactions with other nature-related risk factors).

In addition, nature litigation and climate litigation may be closely interlinked (Setzer and Higham 2024), illustrating the climate–nature nexus. This is because of the increasing focus of lawsuits on deforestation that combine forest and climate change arguments, in addition to lawsuits targeting ocean degradation and plastic pollution. Setzer and Higham (2024) also expect an increasing number of legal actions on the grounds of prudent management of climate and other environmental risks, particularly nature and biodiversity risks. Just transition cases, for instance, those related to climate change adaptation, may also increasingly embed biodiversity.

Although the NGFS predicts a rise in nature-related cases (especially rights-based nature cases against states and public entities[69] and corporate responsibility cases), it also anticipates an increase in rights-based litigation because of legal precedents and the growing focus on the climate–nature nexus. In NGFS 2024b, it advises central banks, supervisors, and financial institutions to closely monitor developments in nature-related litigation, as it could increase pressure on the financial system.

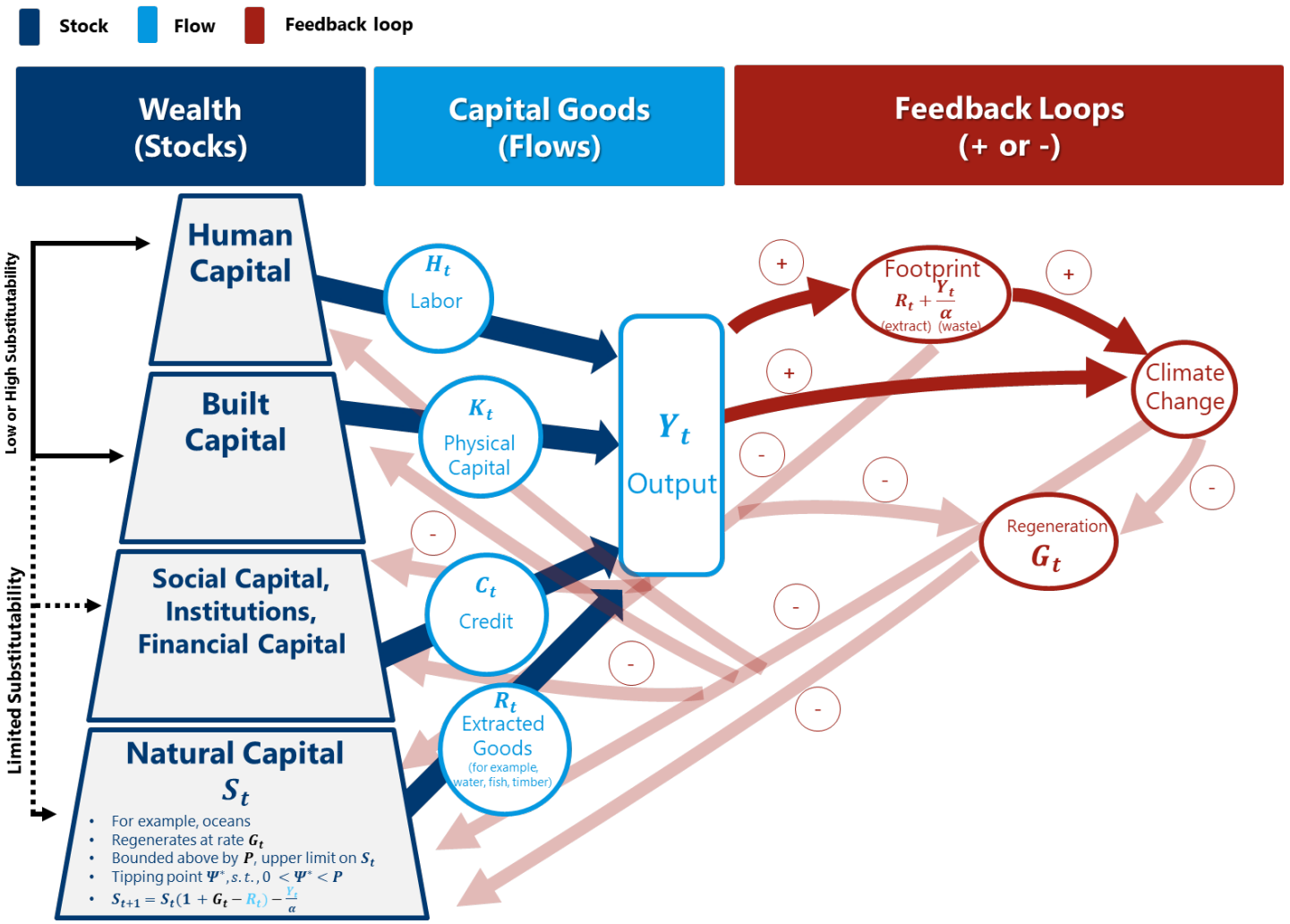
[69] This is based on human rights arguments (Knox and Pejan 2018; Rodriguez-Garavito and Boyd 2023).

Annex Figure 1.1. Granular Conceptual Framework: Nature-Related Macroeconomic and Financial Risks



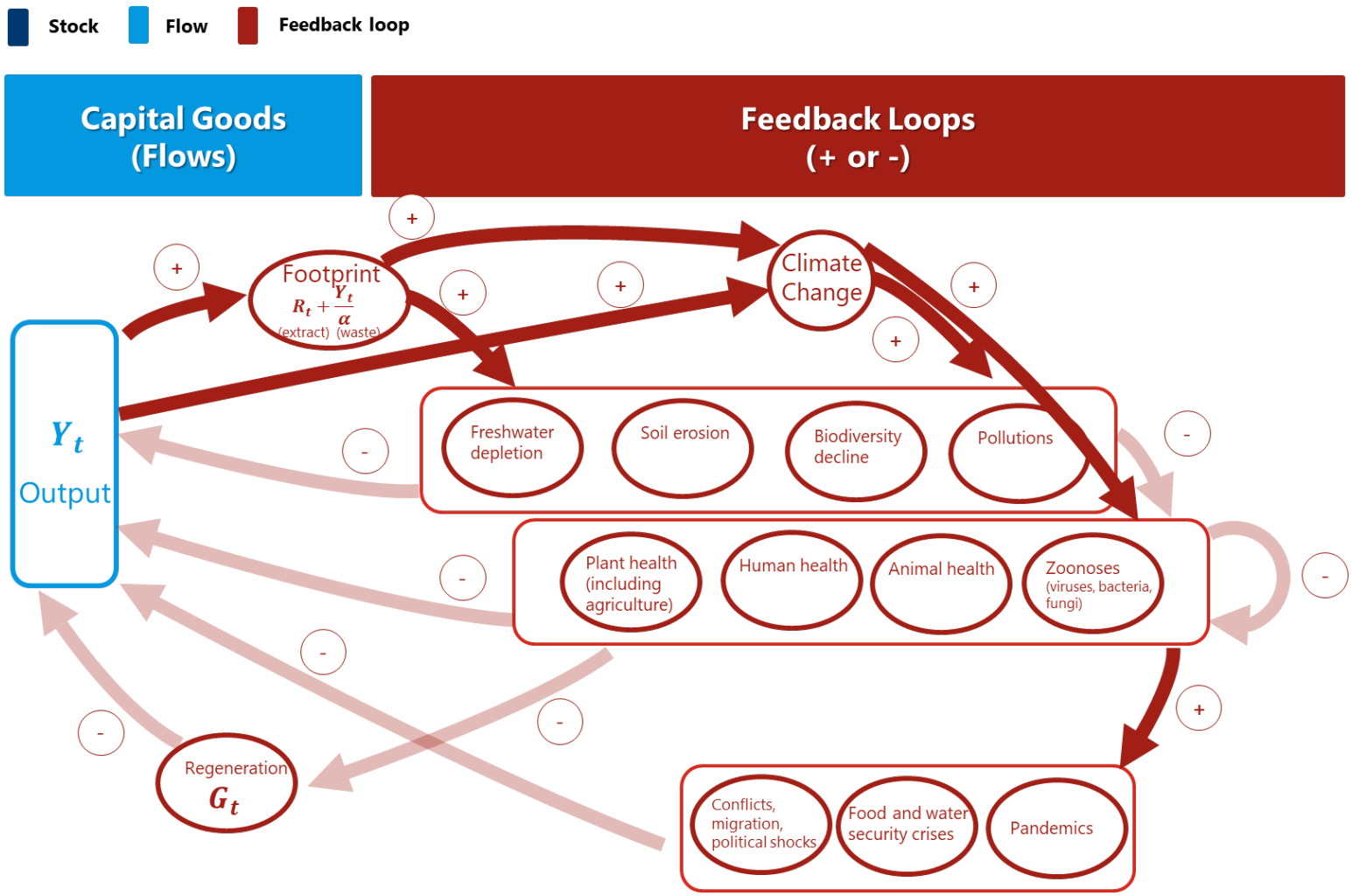
Source: IMF staff based on Dasgupta (2021), NGFS (2023a), and Svartzman and others (2021).

Annex Figure 1.2. Conceptual Framework: General Feedback Loops among Economic Activity, Nature, Climate, and Different Types of Capital



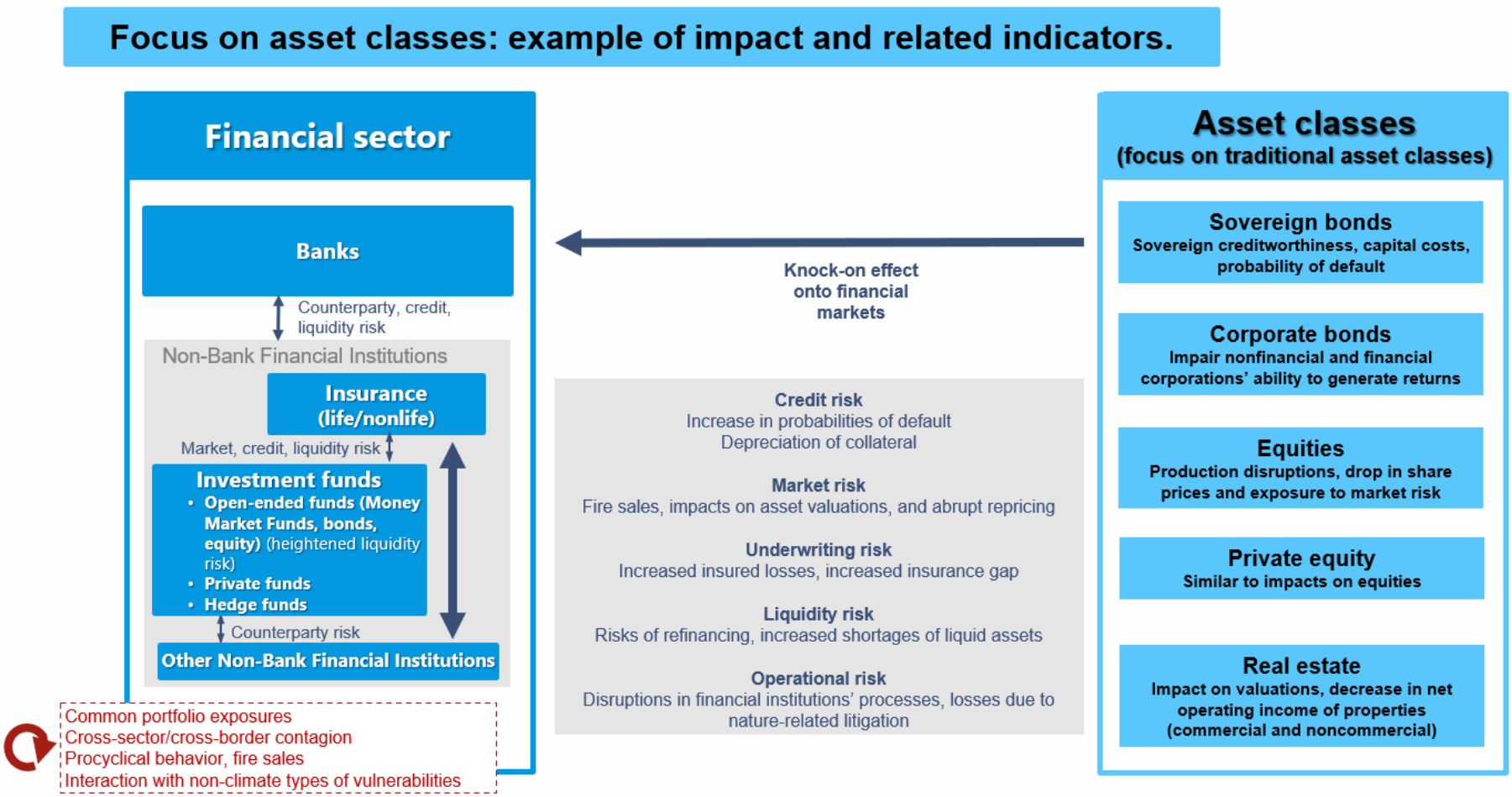
Source: IMF staff based on Dasgupta (2021).
Note: Positive and negative signs indicate (typically) positive or negative feedback loops, respectively. Positive feedback loops are also shown with solid arrows, whereas negative feedback loops are shown with translucent arrows.

Annex Figure 1.3. Conceptual Framework: Detailed Feedback Loops among Economic Activity, Nature, and Climate



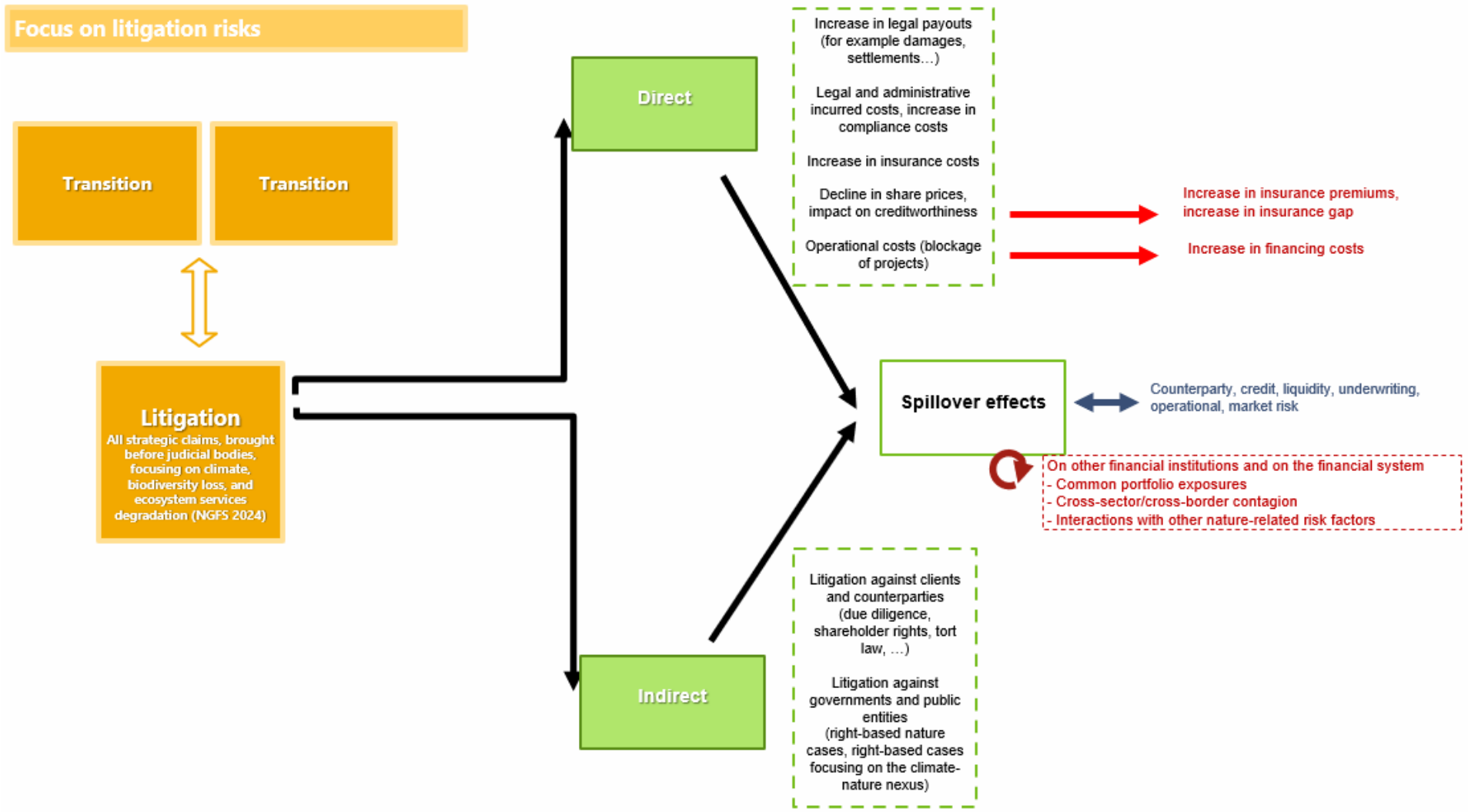
Source: IMF staff based on Dasgupta (2021).
Note: Positive and negative signs indicate (typically) positive or negative feedback loops, respectively. Positive feedback loops are also shown with solid arrows, whereas negative feedback loops are shown with translucent arrows.

Annex Figure 1.4. Conceptual Framework: Macro-Financial Channels—Asset Classes



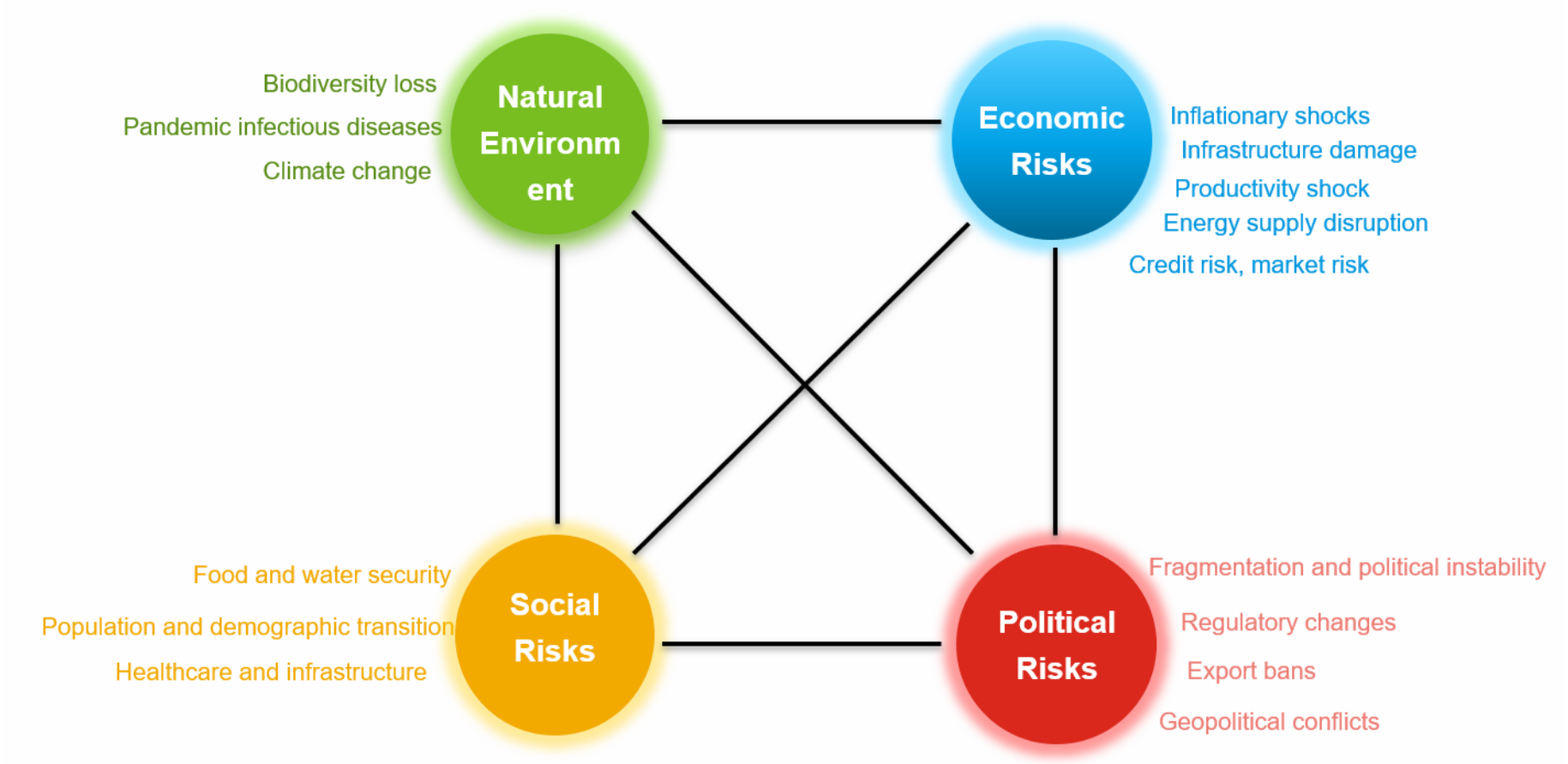
Source: IMF staff.

Annex Figure 1.5. Conceptual Framework: Macro-financial Channels—Litigation Risks



Source: IMF staff.

Annex Figure 1.6. Conceptual Framework: Broad Linkages between Nature and Economic, Social, and Political Risks



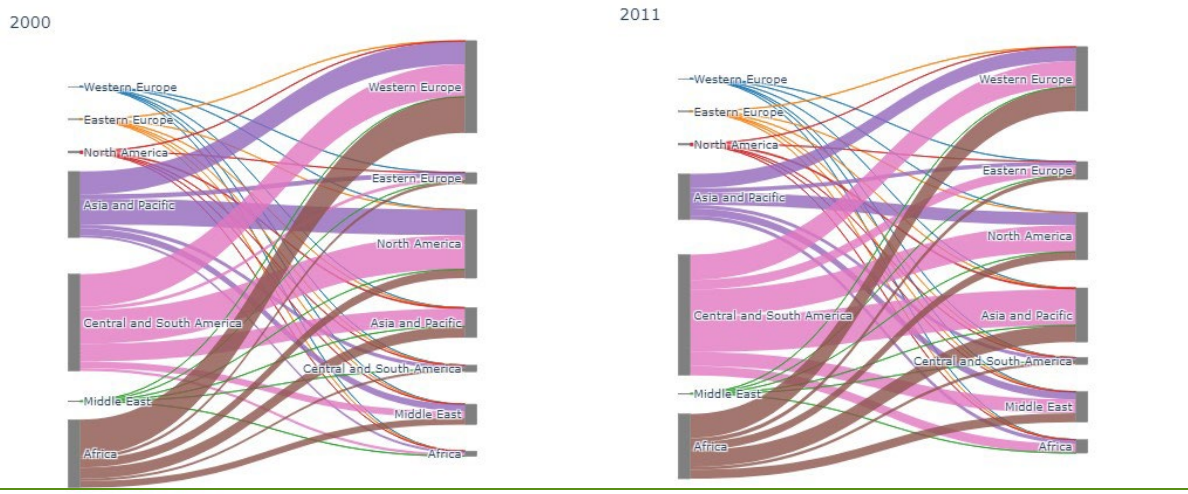
Source: IMF staff.

Nature Loss and International Trade

This section presents stylized facts from the literature on the relationship between nature loss and international Trade. Annex Figure 1.7 (panel 1) shows that consumption based on internationally traded goods drove 25 percent of the global impacts on biodiversity in 2011, a 3-percent increase relative to 2000. Annex Figure 1.7 (panel 2) shows the top importers and exporters of deforestation, with the top three importers being the US, China, and Japan, and the top three importers being the Democratic Republic of the Congo, Tanzania, and Myanmar.

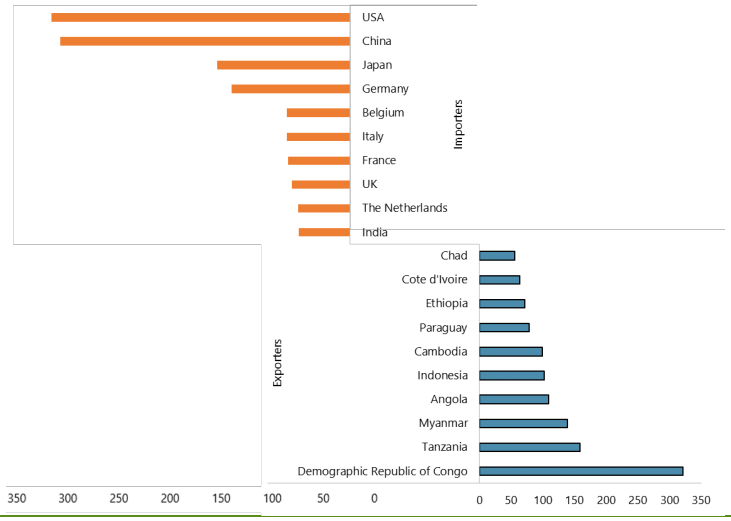
Annex Figure 1.7. Nature Loss and International Trade

1. Biodiversity Impacts Embodied in International Trade (Billions of US Dollars)



Source: Data reproduced from Marques and others (2019), with authors' authorization.
Note: The left-hand and right-hand sides show regions where the impacts occur and whose consumption drives the impacts, respectively. Flow width shows the size of impacts. Impacts from domestic production and consumption are not included.

2. Top 10 Net Importers and Exporters of Deforestation between 2010 and 2015 (Thousand Hectares per Year)



Source: Data reproduced from Mittempergher, Vergez, and Puydarrieux (2023), with authors' authorization.
Note: A given country can be a "net exporter" of deforestation (it exports more deforestation, through the products it exports, than it imports deforestation through the products it imports) or a "net importer" (it exports less "deforestation," through the products it exports, than it imports deforestation through the products it imports).

Annex Box 1. Macroeconomic Shocks, External Financing Constraints, and Nature Degradation

Since the 2000s, many developing economies have been experiencing a prolonged slowdown—and in some cases a reversal—in income convergence with advanced economies (World Bank 2024). Furthermore, since 2020, the global economy has been buffeted by a series of shocks that have disproportionately affected developing economies. As a result, foreign exchange needs have surged in many developing economies. The decline in growth prospects relative to historical levels is particularly large in developing economies, hindering their economic convergence and in many cases their efforts to address climate change, reduce poverty, and ensure food security (IMF 2024). Historically low growth prospects, acute liquidity pressures, and high debt service crowding out vital investment and social spending, represent significant financing constraints for many countries. In 2023, 54 developing economies allocated at least 10 percent of government revenues to debt servicing (UNCTAD 2024). In many developing economies, large foreign exchange needs (notably US dollars) generate short-term pressures to obtain foreign exchange to pay for imports, by issuing sovereign debt (in some cases against expected revenues from natural resources), obtaining official development assistance, attracting foreign direct investment inflows, increasing tourism receipts, exporting commodities, and through direct or indirect foreign takeover of natural resources (for instance, through carbon credits or securitized “green” assets).

Large foreign exchange needs occur in the context of "premature deindustrialization” and “re-primarization” in many developing economies with significant implications for trade-related pressures on nature (Rodrik 2016; Alami and Dixon 2024). Indeed, the economic specialization of many developing economies is oriented toward exporting commodities. Advanced economies tend to be net importers and developing economies tend to be net exporters of primary products (Malik and others 2024). Further, nature loss can be embodied in trade. The top ten net importers of deforestation through trade are large advanced economies and China, whereas the top ten net exporters of deforestation are low-income countries, Indonesia, and Paraguay (Mittempergher, Vergez, and Puydarrieux 2023).[1] Consumption based on internationally traded goods drove 25 percent of the global impact on biodiversity (Marques and others 2019; Annex Figure 1.6).

The interaction of large foreign exchange needs and nature-degrading exports could lock countries into extractive growth models that entrench nature-degrading investments. Developing economies often rely heavily on nature-degrading exports to obtain foreign exchange, as noted previously. Given the productive structure of these economies and the nature loss embedded in their economic activities and particularly in their exports (Dasgupta and Levin 2023), ultimately one of the consequences of repeated shocks and sovereign and external debt crises will be to increase investments in, and lock infrastructure associated with, nature-loss-inducing (as well as carbon-intensive) activities. For instance, growth in export-oriented soy production and mining—largely aimed at addressing balance of payments needs—has led to deforestation and nature loss in Argentina and the Democratic Republic of the Congo, respectively (Dempsey and others 2024). Although efforts are being made in the global governance on nature and climate to take into account these linkages and domestic constraints tied to the international monetary and financial architecture,[2] more needs to be done.

[1] There is also evidence that advanced economies consume high levels of biodiversity-based services by importing up to 40 percent of pollinator-dependent crops from developing economies, stimulating cropland expansion at the expense of biodiversity (Silva and others 2021). Among net exporters, 35 percent of domestic species threats are associated with exports while, among net importers of primary products, 45 percent of their biodiversity footprint is associated with imports (Lenzen and others 2012).

[2] Notable examples of these efforts include intergovernmental negotiations in the context of the United Nations Convention on Biological Diversity and the United Nations Framework Convention on Climate Change, as well as the work of the Network of Central Banks and Financial Supervisors for Greening the Financial System, the Coalition of Finance Ministers for Climate Action, and the Coalition for Capacity on Climate Action.

Debt Sustainability and Nature

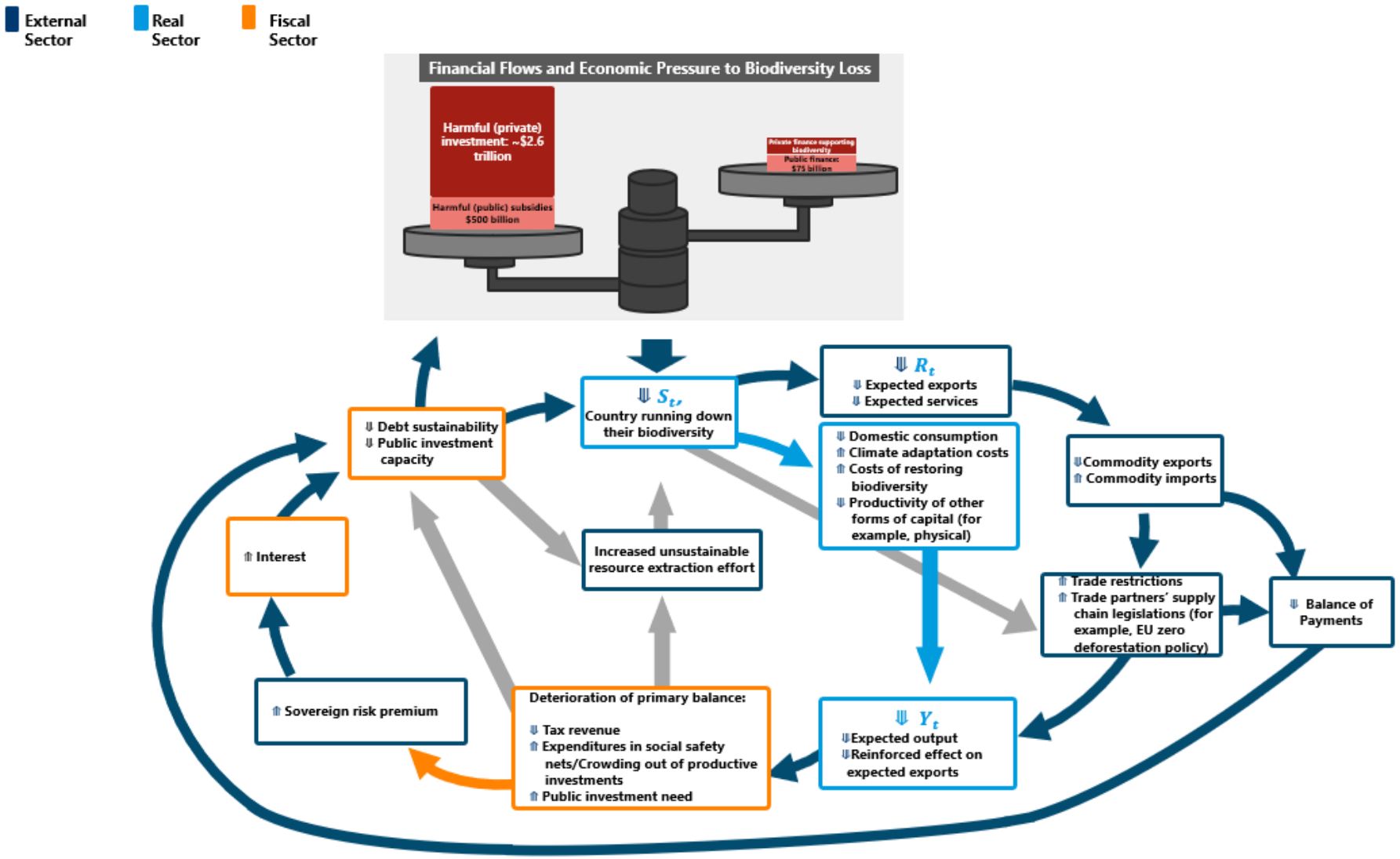
Nature loss and debt sustainability are inextricably linked and influenced by environmental, economic, and social factors. As described in the framework, unsustainable exploitation of natural resources surpasses nature's regeneration capability, resulting in economic effects that could lead to an unsustainable debt trajectory. These are exacerbated by negative feedback loops resulting from the effects of nature loss on social, built, and human capital. As a result, the public finances of advanced economies and emerging market and developing economies, including mega-biodiverse countries, are especially sensitive to natural capital loss, reducing their resilience to climate change and other environmental risks. These risks are exacerbated in countries with existing structural deficits and low debt carrying capacity.

As economies heavily reliant on basic commodity exports continue to deplete natural resources, they approach a tipping point of ecosystem collapse where their potential output significantly decreases, as outlined in the framework. Similarly, as economies heavily reliant on tourism exports continue to unsustainably exploit natural attractions, they near a critical threshold beyond which tourism receipts could markedly decline. The macroeconomic impact of ecosystem collapse, in turn, affects public finances and therefore the government's debt sustainability. Natural resource depletion may entail greater commodity imports, putting a strain on the balance of payments and the sustainability of external debt. The rising costs of nature-related adaptation and mitigation measures may have additional fiscal repercussions (Kraemer and Volz 2022), particularly when climate-related hazards rise and adaption capacity declines owing to loss of ecosystem services. In addition, the transition to a nature-positive economy elsewhere may also result in trade limitations when importing nations implement sustainable supply chain regulations.

In this scenario, investors are likely to demand a risk premium on debt issued by sovereign issuers that are depleting their natural capital and their potential output growth, resulting in higher interest rates and increased borrowing costs. External shocks and sluggish economic development prospects may also heighten vulnerabilities, reducing a country's ability to generate sufficient income for debt servicing and repayment.

This is why nature loss is an important indicator of a country's long-term growth potential and hence significant for sovereign credit assessment (NGFS 2023a). It follows that sovereign credit risk assessments should consider the long-term impacts of nature loss on growth, and the projected need for increased investment to reduce reliance on natural capital depletion. In addition, discussions about bridging the nature financing gap should also include the impact of greater debt sustainability risks, increasing debt servicing costs, and impacts of foreign currency debt repayments on public investment needed for the transition to a nature-positive economy (Dempsey and others 2024) (Annex Figure 1.8).

Annex Figure 1.8. Feedback Loops: Debt Sustainability and Nature



Source: IMF staff.

Annex 2. Data and Methodology

Data Gaps

Data Constraints

The Staff Climate Note can provide a general indication of banks' exposure to possible nature-related transition risks across the 100 largest global banks. However, given prevailing data gaps, estimates in this note should be treated as a starting point for more in-depth analysis that would rely on additional data, as explained in the note. Existing proprietary vendor databases may have had little third-party verification or assessment, potentially leading to dependability concerns. These are exacerbated by a lack of agreed-upon reporting standards and accounting rules, complicating comparisons across enterprises, sectors, and locations. Furthermore, some of the data given might be relatively diluted (for example, giving binary yes/no replies) and have minimal granularity, which may limit in-depth research. In addition, the voluntary nature of data reporting, often by a self-selected group of companies, introduces biases (for example, they may have the resources or incentives to disclose a greater focus on nature-related risks than in reality) and potentially entails greenwashing risks. The lack of regulatory focus on nature-related risks means that the available data may not fully represent the broader industry landscape (as underlined in the note).

Data constraints on the geographical, subindustry, and company size breakdown of harmful subsidies as well as the variety of factors to harmful impacts on nature have challenged the identification of causal links between subsidies and harmful effects. While the global estimate of harmful subsidies amounts to approximately $800 billion per year (OECD 2021), based on OECD and IEA data (self-reported by countries), there is limited literature on the sectoral (and sub-sectoral) breakdown of these subsidies (especially in the mining, manufacturing, and infrastructure sectors, and in emerging market and developing economies). Furthermore, as mentioned in the note, the monetary amount of a subsidy does not necessarily correspond to the extent of its harmful effect: even relatively small subsidies can have major negative impacts, and vice versa (UNDP 2024). Given the location-specific nature of subsidies, and the lack of precise data on species and spatial patterns of biodiversity across regions, further data collection and research are needed in this area.

Impacts of Data Gaps on Comparability, Consistency, and Relevance

As explained in the note, the lack of systematic reporting, particularly in emerging market and developing economies and low-income countries, presents another major obstacle. Without consistent and comprehensive data across geographies, a global assessment of both physical and transition risks is currently unrealizable. In addition, the distinction between input data on the state of nature and output data on companies' dependencies, risks, impacts, and opportunities is often overlooked because of data limitations, making it difficult to conduct a holistic analysis.

Compounding these issues is the scarcity of data on key ecosystem services, which are vital to many business processes (UNEP 2021). This deficiency hampers our understanding of the dependencies and impacts on these services. Moreover, the absence of detailed sector-specific data, such as banks' bilateral loan data, sectoral credit portfolio statistics, temporal perspectives, and disaggregated subsidy data, restricts our ability to provide precise assessments of nature-related risks. The lack of asset location data further complicates our understanding of the direct impacts of companies' activities and supply chains on natural ecosystems.

Significant knowledge gaps, such as the limited availability of cross-border data, make it challenging to assess transnational nature-related risks and their impact on global supply chains. In addition, there is inadequate data on the interdependencies between different ecosystems, which complicates our understanding of cascading effects when one ecosystem service is disrupted. Conceptual challenges to understand the substitutability of

different ecosystem services across various economic sectors remains a complex issue with significant knowledge gaps, as highlighted by Calice and others (2023).

As argues in NGFS 2023, nature-related data is essential for scenario analysis and effective risk management. Data disaggregation is crucial (for example, time-series data on geospatial patterns of biodiversity and ecosystems) given the complexity and interactions between ecosystems, biodiversity, water systems, and oceans (Hochkirch and others 2020). Greater data coverage across species (Oliver and others 2021) and geographies (Daru and Rodriguez 2023) are also needed. This is why the G20 Sustainable Finance Working Group included nature data into its priorities for 2023, recommending improvements in nature and biodiversity data collection, standardization, and assessment (for example, increasing the use of existing data tools and developing data collection infrastructure across ecosystems, species, and geographies). Furthermore, the Task Force on Nature-Related Financial Disclosures (TNFD) is working on setting up a public nature data facility comprised of a nature data catalog, a centralized database, and a distributed access public data, to address challenges of credibility, collection, consistency, and connection in nature-related data (TNFD 2023).

Methodologies

Transition Risks

Our analysis on transition risks focuses on the sample of the 100 largest global banks, as ranked by S&P Global, with total assets amounting to $112 trillion as of 2023. The sample includes banks from dominantly advanced economies as well as emerging markets (among those, 28 banks are represented, with 20 of those being from China). These banks are predominantly ranked based on their total assets, making them a representative sample for assessing banking exposure to nature. Their significant market presence and extensive asset bases mean they are likely to hold diverse portfolios that reflect broader trends in lending and investment across a wide range of geographies (advanced economies and emerging market and developing economies), providing a comprehensive picture of the banking sector's exposure to nature-related risks.

To analyze companies' exposure to harmful subsidies, we adopted a sectoral approach, based on the estimated size of potentially harmful support to biodiversity across key sectors. We concentrated on the agriculture, fisheries, energy, forestry and water sectors (UNEP and BIOFIN 2024), based on estimated adverse impacts of subsidies on nature. Based on existing—but limited—academic literature, we identify the direct or indirect nature of the subsidy (for example, indirect transfer, such as reduction in the price of inputs, or direct transfer, such as grants or cost-sharing for infrastructure or technologies, or output-based payments on production volumes or yields), the type of subsidy (for example, chemical fertilizer, infrastructure development support), its impact on nature and biodiversity (direct or indirect), its estimated size (if data available), and estimated impact (price and supply elasticity). This literature assessment enabled us to take a more granular approach, identifying the potential for detrimental subsidies on pricing and supply across sectors, rather than using a uniform approach, which would have included calculating that subsidy phaseout would affect all sectors equally. We found that the agriculture, fisheries, mining, and forestry sectors would be most at risk ("highly harmful subsidies" in Figure 5, panel 1) (impacts on variable costs of inputs of water, fuel and electricity subsidies, and impacts of direct production subsidies on price and supply levels), while the manufacturing and the energy[70] (power) sectors would be less at risk ("harmful subsidies" in Figure 5, panel 1).

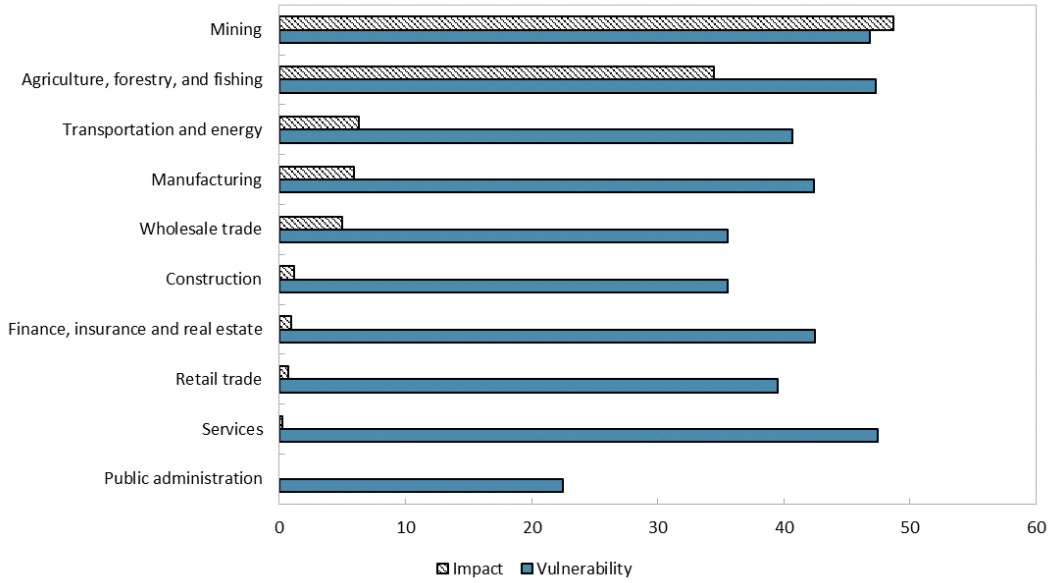
To analyze companies' exposure to nature, we choose the following two indicators from MSCI to proxy separately for the impact and the vulnerability of companies to the ecosystem. As the data indicate, companies in the mining, agriculture, forestry, and fishing sectors are the most vulnerable to highly fragile

[70] The energy sector includes electric services and gas production and distribution, as well as combination of electric, gas, and other utilities. The mining sector includes mining of metal, nonmetallic minerals, and coal in addition to oil and gas extraction.

ecosystems. Although the impact on fragile ecosystems is more evenly spread across different industries, service companies are found to have a more significant adverse effect.

Estimated percentage of operations in business segments with high potential disturbances to land and marine areas (%)	BIODIV_LAND_USE_HIGH_RISK_BUS_PCT	Impact
Estimated percentage of operations located in geographies with highly fragile ecosystems (%)	BIODIV_LAND_USE_HIGH_RISK_GEO_PCT	Vulnerability

Annex Figure 2.1. Company Exposures to Fragile Ecosystem (in Percent of Operations)



Source: MSCI.

Considering that loan defaults by individual companies can impact banks, we use bank loan data from Dealogic to assess bank exposures. Because of data availability constraints, we focus on syndicated loans instead of bilateral loans, which inherently indicates the riskier aspect of lending that necessitates syndication. We also assume, because of data limitations, that the leading banks equally underwrite the tranche amounts. As of July 2024, the total outstanding syndicated loans underwritten by the world's 100 largest banks amount to $18 trillion.

Transition risks resulting from the implementation of Target 3 and protection over fragile ecosystem will disturb companies' operation in those areas, thus affecting company revenue and eventually their ability to pay off bank loans. Since the data do not allow us to directly measure bank loans specifically made to fragile locations, we instead assess the bank loans' indirect exposure to conservation targets through the impact on the companies operating in those ecosystems. In our analysis, we assume that company operations in high fragile ecosystem will be completely discontinued, and the percentage of operations being affected equal to the percentage of bank loans being affected. The equation (1) is used for calculating the bank loans' indirect impact on the ecosystem, with the indirect vulnerability determined using a similar approach.

$$\text{Bank loans' indirect impacts on the ecosystem} = \frac{\sum_{i=1}^{n} \text{averaged company impacts}_{\text{sector}\,i} * \text{bank loans}_{\text{sector}\,i}}{\text{Total bank loans}} \quad (1)$$

In addition, we sought to examine banks' direct exposures specifically in project finance. We used data from Refinitiv, aggregating project finance loans and bonds. To estimate bank exposure to fragile ecosystems, we multiplied the sectoral exposure by the proportion of these sectors associated with fragile ecosystems.

Assessment of Banks and Insurance Firms' Policies

To investigate the ambition of major banks' and insurance companies' nature policies, the Staff Climate Note has applied the methodology described subsequently to assess the criteria adopted by banks and insurance firms in their financing (lending, investment, underwriting) and risk management activities.

Banks

The assessment of banks (Figure 6, panel 1) is based on the disclosed policies (or absence thereof) of the 100 largest global banks (as ranked by S&P Global) across the Asia-Pacific, Western Hemisphere, European, and Middle Eastern and Central Asian regions.

Annex Table 2.1 – Assessment Methodology for Banks

	Criteria for the Assessment of Policies	Methodology
Banks	No policy	Absence of a policy and strategy to incorporate nature into risk management and financing activities or limited steps to include nature in cross-sectoral and sector-specific policy and strategy, usually circumscribed to a single mention in strategy documentation and in sustainability disclosures.
	Weak policy	Initial tangible measures toward incorporating nature into strategy, risk management frameworks, sustainability disclosures, and cross-sectoral (or sector-specific) policies.
	Moderate policy	In addition to the inclusion in the bank's strategy, nature is also included in specific sectoral policies (for example, forestry, agriculture, energy) with limited level of ambition (usually with a limited scope of financing activities and counterparties' range of economic activities), sometimes supported by a dedicated assessment of nature-related risks and the inclusion in the bank's client engagement strategy (for corporates, only).
	Strong policy	In addition to the inclusion in the bank's strategy, nature is also included in cross-sectoral and key sectoral policies (usually limited to due diligence in project finance activities), risk assessment frameworks, and sustainability disclosures.
	Fully fledged policy	Fully fledged inclusion of nature in cross-sectoral and key sectoral policies (spanning across all types of financing activities), risk assessment frameworks, and sustainability disclosures. The bank has adopted a short- to medium-term plan to review its frameworks and methodologies for a robust inclusion of nature into its financing and risk management activities.

Source: IMF staff.

Insurance Firms

The assessment of insurance firms is based on the disclosed policies (or absence thereof) of eight major global insurers (based on the 2016 list of Global Systemically Important Insurers [FSB 2016]).

Annex Table 2.2 – Assessment Methodology for Insurance Firms

	Criteria for the Assessment of Policies	Methodology
Insurance firms	No policy	Absence of a policy and strategy incorporate nature into risk management and investment and underwriting activities (including absence of a mention of nature into the insurance firm's sustainability strategy).
	Weak policy	Initial tangible measures toward incorporating nature into strategy (either a broad sustainability strategy or a dedicated strategy), risk management frameworks (usually limited to risk appetite policies), sustainability disclosures, and cross-sectoral (or sector-specific) policies. In some cases, it may include an early integration in environmental stewardship.
	Strong policy	In addition to the inclusion in the insurance firm's strategy, nature is also included in cross-sectoral and key sectoral policies (usually limited to due diligence in investment activities), risk assessment frameworks (for example, risk and solvency assessment and policy), and sustainability disclosures. It also includes integration in proxy voting and investor engagement, and a broader integration into the firm's governance.
	Fully fledged policy	Fully fledged inclusion of nature in cross-sectoral and key sectoral policies (spanning across all types of financing activities—investment and underwriting), risk assessment frameworks, sustainability disclosures, and governance. The insurance firm has adopted a short- to medium-term plan to review its frameworks and methodologies for a robust inclusion of nature into its financing and risk management activities.

Source: IMF staff.

Physical Risks

To measure raw exposure to nature loss, we use data from the platforms Exploring Natural Capital Opportunities, Risks and Exposure and MSCI to construct an index that describes business dependence on the use of natural capital. Industry-level ENCORE indicators for freshwater ecosystem use, solid waste, terrestrial ecosystem use, biological interference, marine ecosystem use, water use, and other resource use[71] are summed to construct an indicator for total natural capital use.[72] This is combined with company-level MSCI indicators denoting operational exposure to ecosystem degradation, the weight of the biodiversity and land use key issue in the company's ESG ratings assessment, percentage of total revenue derived from activities that involve disturbance to land or marine areas, and percentage of total assets located in fragile ecosystems. All indicators are converted to a min/max measure to facilitate cross-industry comparison and summed to form the total raw exposure score.

[71] All of these indicators are measured on a scale with values from 0 to 10.
[72] The Exploring Natural Capital Opportunities, Risks, and Exposure database examines the interdependence of 86 different production processes and 21 ecosystem services, which in turn are connected to eight types of natural assets (Global Canopy, UNEP FI, and UNEP-WCMC 2024).

To construct a preparedness and mitigation measure, we combine MSCI data on company's ESG ratings. These include the following factors: presence of programs to (1) monitor water risk in operations, (2) reduce operational water usage, and (3) reduce water usage in its supply chain; environmental risk exposure management score relating to lending or underwriting activities; biodiversity risk exposure—management score; operational carbon intensity risk exposure score; climate change physical risk exposure management score; e-waste risk exposure management score; resource consumption in assets management score; ability to manage exposure to its positioning in the transition to renewable energy; ability to manage is reliance on packaging materials and efforts to reduce their environmental impact; management of exposure risk to carbon intensity of its products; environmental contamination or toxic waste risk exposure management; and water stress risk exposure management. We convert each of these to a comparable min/max measure and sum them to obtain the total preparedness score.

Granular analysis of the physical risks from nature loss is hindered by deficits in data availability and quality, emblematic of inadequacies in disclosure requirements and reporting frameworks. Previous studies have attempted to quantify the impact of physical risks from nature loss on growth (Murphy and others 2022, Gallai and others 2008, Waldron and others 2020) or prices (Gallai and others 2008, Kotz and others 2024, OECD 2024). These focus on one type of nature loss (such as pollination services) or are limited by either geography or sector. As described in this note, there is an incomplete scientific understanding of the interlinkages between climate change, nature loss, and the magnitude of economic dependency on natural systems. Further, there is no consensus on how to quantify the economic value added of natural capital, and therefore no concrete way to measure the potential losses across industries on a global level. Therefore, any empirical assessment of the global impact of nature loss on growth or prices is limited by these data constraints.

Data on companies' exposure to physical risks from nature loss and the ability to manage those risks are uneven. Company-level data on risk exposures and mitigation are largely voluntarily self-reported. There are few standards for reporting on risk exposures, or external verification of the strength and credibility of risk management (see the second section of the note). Annex Figure 2.2 shows that while data are more complete for exposure risk, indicators for preparedness to manage risks generally have very low rates of reporting.

Annex Figure 2.2. Rate of Coverage (Percent of Companies Reporting)

Exposure Risk Variables

(i) Land-use exposure	(ii) Land-use weight	(iii) Percent of revenues in high risk areas	(iv) Percent of revenues in medium risk areas	(v) Percent of assets in high fragile areas	(vi) Percent of assets in medium fragile areas
93%	36%	93%	93%	93%	93%

Preparedness Variables

(i) Water risk monitoring	(ii) Water reduction program (operations)	(iii) Water reduction program (supply chain)	(iv) Financing environment impact	(v) Land-use management	(vi) Carbon emissions management
32%	32%	24%	6%	7%	91%

(vii) Climate change risk management	(viii) E-waste management	(ix) Green building management	(x) Renewable energy management	(xi) Packaging waste management	(xii) Carbon footprint management
2%	1%	6%	2%	5%	9%

(xiii) Toxic emissions management	(xiv) Water stress management
22%	32%

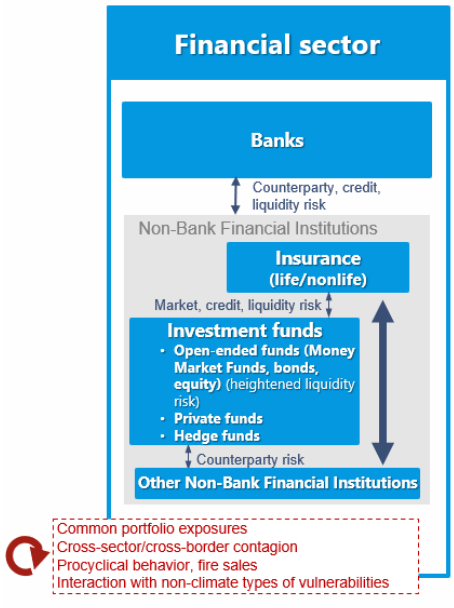
Source: MSCI and ENCORE.

Annex 3. Nature-Related Risks and the Insurance Sector

The Staff Climate Note's conceptual framework (Figure 4) includes the impact of nature-related risks on nonbank financial institutions, including insurance firms. These may face risks from both their investments and their risk coverage operations, which can affect policyholders and the companies in which they invest.

The Global Biodiversity Framework (GBF) is a comprehensive framework that focuses on the role of governments and all stakeholders, including the financial community, in promoting economic, social, and environmental sustainability. The inclusion of a resource mobilization plan and monitoring framework contributes to highlighting the insurance industry's role in achieving these goals. More specifically, the GBF sets forth goals to safeguard and enhance biodiversity, with specific relevance to the insurance industry (UNEP FI 2023).

- Goal A's emphasis is on the importance of ecosystem integrity, connectivity, and resilience translates for the insurance industry into the need to reduce risks from extreme weather events through the preservation and restoration of natural ecosystems. As healthy ecosystems contribute to economic stability, insurers can integrate nature-related considerations into their risk management and develop products addressing biodiversity loss.
- Goal B's focus is on the sustainable use of biodiversity and the valuation of nature's contributions addresses the decline in ecosystem services, which increases the risks related to climate change and natural disasters for the insurance sector. Recognizing and integrating the value of nature into their strategies would enable insurers to better manage and mitigate these risks, promoting sustainable development.
- Goal C (fair and equitable sharing of benefits from the use of genetic resources and traditional knowledge) would impact insurers in that they would need to ensure compliance with international agreements such as the Nagoya Protocol. Collaboration with Indigenous peoples and local communities is emphasized to ensure benefit sharing, relevant to sectors such as pharmaceuticals and health care.
- Goal D—in outlining the need for adequate implementation means to close the biodiversity finance gap—would impact the insurance industry as it needs to manage financial risks related to nature loss and support capacity-building and knowledge transfer, particularly in developing and vulnerable regions, thereby contributing to biodiversity conservation and sustainable development.



The regulatory community has started to recognize the financial materiality of nature-related risks, which can significantly impact the insurance industry, affecting both asset and liability sides of their balance sheets (UNDP SIF 2021; EIOPA 2023; ACPR 2024).

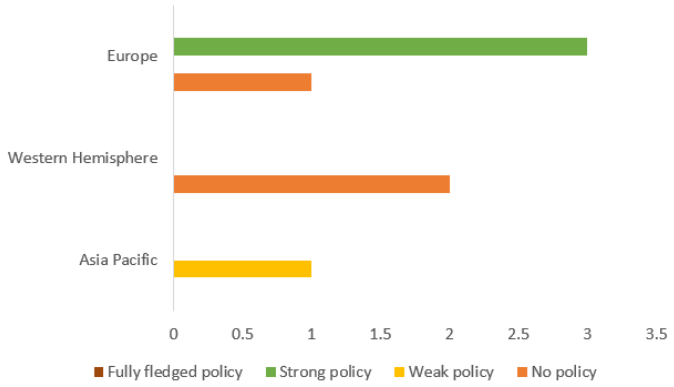
On the assets side, insurance firms may face credit, market, liquidity, and solvency risks. Nature loss can impair the debt repayment capacity of companies in which insurers have invested, because of physical shocks (for example, loss of ecosystem services) or transition shocks (for example, new regulations imposing stricter biodiversity protection measures). Nature loss can also include investment losses, as insurers invest premiums collected from policyholders into various assets (stocks, bonds, real estate, and other financial instruments). Nature-related risks can lead to depreciation in the value of these investments, or even stranded assets, as shown in the conceptual framework. In addition, nature-related risks contribute to increased volatility, thereby disrupting supply chains, affecting commodity prices, and leading to economic losses in affected regions. This volatility can affect the performance of insurers' investment portfolios, especially if they are not diversified enough to mitigate these risks. Furthermore, insurance firms may face liquidity risks, related to the sudden disruption in ecosystem services that could increase liquidity needs,

although insurers are generally less exposed to such disruptions than banks. Finally, losses in asset value and the failure of financed companies could challenge insurers' compliance with solvency requirements.

On the liability side, insurance firms may face underwriting risk as impacts may include a rise in claims considering the physical impacts of nature loss on real assets across a diversity of sectors, as shown in the framework. It can lead to an increase in the number and magnitude of claims insurers must pay out, particularly in property, casualty, and agricultural insurance. The rising costs can strain insurers' financial resources and may lead to higher premiums for policyholders. In addition, liability claims may arise (see Annex Figure 1.4) if firms face lawsuits (for failing to mitigate their environmental impact or for contributing significantly to nature loss) that are included in their liability coverage. Moreover, insurers themselves could face litigation for not adequately disclosing or managing their exposure to nature-related risks, for instance. Insurance firms may also face reputational damage for underwriting policies or investing in projects and companies that are harmful to nature. This could lead to customer attrition and challenges in attracting new clients. In addition, regulatory risks arise as governments implement stricter regulations on environmental protection and climate change mitigation, potentially imposing fines or restrictions on insurers not in compliance. According to ACPR (2024), firms may face an insurance gap risk, given that the decline in nature complicates insurability criteria, making it difficult to measure and increasing the correlation between previously independent risks. This complexity and the nonlinear nature of biodiversity loss could lead to systemic repercussions and unpredictable maximum losses. Other specific liabilities may include claims because of the impact of nature loss on health and on property damage.

Further research needs to be done on major global insurance firms' corporate and government bond, and equity security holdings to sectors-at-risk to understand and identify potentially significant sources of risk. Current policies remain inadequate across most large insurance firms, with the notable exception of those headquartered in Europe (see Annex Figure 3.1). Further work is needed to identify, assess, and prevent financial and nonfinancial risks related to nature loss in the insurance sector (EIOPA 2023).

Annex Figure 3.1. Assessment of Eight Global Insurance Groups' Nature-Related Policies



Sources: IMF staff calculations.
Note: The assessment methodology is included in Annex 2.

The policy discussion is increasingly focusing on the role of the insurance industry (as a group of often large institutional investors) in supporting the transition to a nature positive economy, through product design, investment policies, and the underwriting of activities that contribute to environmental sustainability (UNEP FI 2023; WWF and Deloitte 2023). These include adequate risk assessment and management (for example, due diligence practices), sustainable underwriting (for example, excluding or limiting coverage for activities that significantly harm nature), investment in nature-positive solutions, and the development of cross-sectoral policies aligned with the objectives of the GBF, and the development of insurance products that specifically address nature-related risks (for example, liability product design and claims management).

Annex 4. Scaling up Nature Finance in the Context of the Global Biodiversity Framework

Addressing financial flows' misalignment with nature is a critical priority. In the context of the GBF, it is essential for the financial sector to reallocate capital from activities that are harmful to those that are beneficial to nature. This includes the development of financial products explicitly designed for nature-specific purposes, such as protection, restoration, and sustainable land management.

The dual imperative of halting financing that is harmful to nature while closing the financing gap for nature underscores the broader policy framework outlined in the GBF, which is similar to that of the Paris Agreement. This framework establishes a shared vision of "living in harmony with nature" by 2050 with four main policy goals, supported by 23 policy targets by 2030 to halt and reverse biodiversity loss. These targets collectively provide the policy framework within which the financial sector is called on to act. Specifically, GBF Target 14 emphasizes the concept of "alignment" to nature by underlining the need to align financial flows with the goals and targets of the GBF. Four other key targets relate directly to biodiversity finance: Target 15 (financial institutions and businesses need to reduce negative impacts and increase positive impacts on biodiversity, including through reporting); Target 16 (supply chain transparency and certification programs); Target 18 (incentives for nature-positive choices, including phasing out harmful subsidies by $500 billion by 2030); and Target 19 (mobilizing $200 billion per year from all sources).

Meeting global targets on nature and biodiversity will require large amounts of redirected and new financing. The scale of nature-negative financial flows from both public and private sectors is estimated at $7 trillion per year globally, of which $5 trillion are from the private sector (UNEP 2023). These flows contribute to nature loss and degradation and hinder climate change mitigation and adaptation (financing flows to nature-based solutions were estimated to be merely $200 billion in 2022). Estimates for financial objectives differ but converge on the need for significantly more nature financing. While the GBF estimates that meeting Targets 18 and 19 requires closing a gap of $700 billion per year, other studies imply greater shortfalls of up to $1 trillion by 2030 (Deutz and others 2020). Most estimates are approximations, given large uncertainties and methodological and data issues, and aim to capture the scale of financing needed. Nonetheless, the GBF targets highlight the need for redirecting large amounts of financing from harmful activities.

Although a wide range of nature financing mechanisms have emerged in recent years, scaling up nature finance faces obstacles. Annex Table 4.1 presents the diversity of financial instruments and their characteristics (including sustainable debt issuance, blended finance instruments, and debt-for-nature swaps). More specifically, debt-for-nature swaps have gained traction in the policy discussion and in the market, despite credibility, impact, and scalability issues (detailed in the table). Challenges to scaling up include a lack of policy support for conservation, restoration, and sustainable use of nature (for example, environmentally harmful subsidies and their consequences for prices and market behavior), a lack of bankable project pipelines (characterized by small and localized projects, sectoral fragmentation, inconsistent project assessments, limited technical capacity), uncertainties regarding the integrity of market mechanisms, limited buy-in from industries and communities, insufficient coordination between public and private market participants, and the absence of standardized data and key performance metrics. While there is a need for repeatable and scalable transactions, the current policy frameworks and market initiatives tend to be focused on risk and overlook the opportunity dimension, potentially delaying financial innovation and market interest.

Annex Table 4.1. Overview of Existing Nature Finance Instruments

Instrument	Description	Key Challenges to Achieve Credibility, Impact, and Scalability Common challenges across types of instruments: (1) design, transaction, monitoring, and due-diligence costs; (2) need for a robust pipeline of projects; (3) impact reporting and measurement challenges; (4) replicability limitations; (5) additionality challenges; and (6) limited participation of indigenous peoples and local communities.	Regulatory and Institutional Preconditions for Instruments to Function in the Ways and at the Scale Envisioned
Use-of-proceed debt instruments (thematic debt)	<u>Distinctive characteristics</u> Strict commitment by the issuer to invest proceeds raised by the issuance in predefined nature/biodiversity-oriented projects (for example, ocean conservation and development of marine protected areas, blue infrastructure, reforestation), that is, ringfencing. <u>Issuance documentation</u> The loan or bond framework's use-of-proceeds section must identify the project's qualifying categories, the facility agreement must have pertinent information and covenants, and the issuer must guarantee accurate reporting for the purpose of a project to be labeled. While the issuance is not supported by key performance indicators (KPIs), the instrument's issuance framework includes specific environmental metrics designed to track use of	Costs of monitoring, due diligence, and enforcement. These may be high, depending on the issuance framework's project characteristics and context-specific nature of projects. Issuance requires a robust pipeline of projects that can receive funding using the instrument's revenues. Yet, these instruments may face economic and methodological challenges to channel revenues to biodiversity protection and restoration, including a lack of income-generating projects at scale[1] and technical difficulties in aggregating nature-related projects, the absence of corporate and sovereign issuers' nature protection and restoration plans and targets, a lack of nature-related input and output data, and the slow development of reporting standards and financial sector policies on nature.	An underlying assumption lies in the limited fiscal space and, as a result, public investment (see Annex 1 on debt sustainability and nature loss). The existence of a robust information architecture (nature-related data, reporting standards, taxonomy) and assurance standards (for example, ex-post verification), to ensure the credibility and standardization of these instruments. An institutional setting and regulatory framework that enable permanent, systematic, and systemic engagement with Indigenous Peoples and Local Communities and ecosystem building (Kedward and others 2023; CPI 2024; Power and Seefeld

	proceeds. It contributes to ensuring impact. <u>Financial conditions</u> Repayment takes place though project revenues (usually for corporate debt issuance) or state budget, grants and donor capital (for sovereign or multilateral development bank [MDB]/development finance institution [DFI] debt), or a combination of these.	Capturing and quantifying nature-related impacts may be technically complex. Impact KPIs are often skewed toward nature-based solutions (for example, forestry projects for carbon capture) that are easier to report on.	2024), for project design and leadership, ensuring adequate safeguards, and encouraging tailored pilot projects, such as in the case of bioregional financing facilities (Power and Seefeld 2024; UNEP 2024b). Strong state capacity enabling the systematic provision of high-quality technical assistance and capacity building. More broadly, an institutional setting and state capacity that enable interministerial coordination and a high degree of public accountability, including environmental agencies and financial regulators that are formally integrated into private sector-led initiatives (see third section of the note, and Kedward and others 2023; CPI 2024). A large investor base with appetite for atypical assets characterized by highly uncertain returns that materialize over a long period of time, and in many cases that have a public good or common good nature. There are challenges because of the misalignment between institutional investors' conditions[2] and the financial characteristics of nature-related projects (patient investment, with uncertain returns and materialization of benefits over a long period of time).
Outcome-based debt instrument (sustainability-linked debt)	<u>Distinctive characteristics</u> The objective of the issuance is to achieve specific nature-related targets, with a coupon price structure based on predefined KPIs, that is, no ringfencing and use-of-proceed criteria. Usually, each KPI is supported by a trigger event that can change the instrument's price structure (usually a coupon increase) if not met. <u>Issuance documentation</u> Although there are no restrictions on the use of proceeds, the issuance is supported by a commitment to achieve these predefined targets (for example, decrease in nitrogen secretion levels in the maritime industry, reintroduction of threatened species, increase in native forest coverage). To ensure environmental integrity, a solution based on Harstad and	In addition to those discussed previously, these instruments may suffer from limited scalability potential considering the lack of nature transition planning (at both corporate and sovereign level). Yet, the issuer's sustainability credentials in this space (in addition to the issuer's financial characteristics) depend on their ability to meet KPIs. While KPIs determine potential nature-related impacts, the price structure serves as the incentive mechanism (for example, financial penalties that should be high enough to motivate issuers to achieve targets). Yet, for these instruments to achieve a material impact, the penalties associated with missing the target need to be set such that private issuers have a sufficient incentive to fulfill the targets (IMF 2022).	

	Storesletten (2024) lies in combining a loan with a repayment that will be requested (or an interest rate that will be high) if and only if the KPI is designed relative to a benchmark (for example, native forest coverage). In addition, financial conditions could be contingent on how much a natural resource is conserved rather than extracted, which would commit issuers to a certain amount of natural resources conservation. <u>Financial conditions</u> Repayment takes place through project revenues and the issuer's general revenues (for corporate and sovereign issuance).		
Blended finance	<u>Distinctive characteristics</u> Blended finance refers broadly to the strategic use of a limited number of concessional resources to mobilize financing from public and private financial institutions to achieve climate-related impacts (NGFS 2023c). <u>Financial conditions</u> It includes *pooled investment funds* combining capital from various entities (public and private). For instance, MDBs, DFIs, or a sovereign/sub-sovereign entity make an equity or mezzanine investment or give a guarantee to de-risk and crowd in private investors. This mechanism aims to	The complexity of these arrangements may lead to often limited replicability. The public sector holds a strong role in risk mitigation, concessional, and grant funding, which entails important capacity and technical assistance funding needs. In addition, de-risking may represent an overly expensive use of government investment capacity in some cases. Environmental and financial credibility of underlying debt instruments.	

	provide for the reduction of credit (by elevating to investment-grade finance), currency, and political risks, as well as the resolution of information asymmetry issues. Credibility is enhanced by the selection of underlying debt instruments and their certification process. It may also include *specific facilities* (earmarked allocation of public funding, which can invest in projects with the aim of attracting commercial investment to those same projects) and bonds, such as *conservation bonds* (debt instruments in which proceeds finance development projects that generate a return and interest payments directly financing conservation activities instead of being paid to investors).		
Debt-for-nature swaps (DNS)	<u>Distinctive characteristics</u> Instruments to promote specific investments and policy actions, usually nature conservation-oriented, and provide some debt relief (rather than comprehensive debt relief or restoring debt sustainability) on a country' external public debt (Chamon and others 2022). Recent DNS arrangements have involved bilateral debt (Seychelles) and commercial debt (Belize, Barbados, Ecuador, Gabon). Several DNS have benefited from a political risk guarantee, provided by	Small-scale, bespoke nature of financial arrangements, and limited potential debt reduction (excludes LICs without market access, which contain 22 percent of the world's biodiversity) (Nedopil and others 2023). Mechanisms involved are complex and time consuming. DNS are hard to replicate, limiting the scalability potential. There are also high transaction costs (Standing 2023). Unclear additionality. More generally, DNS do not address root	Exchange rate and price stability. Additionality principle is met (debt relief does not reduce amount of other funds provided by the creditor, and environmental measures implemented by the recipient country would not have occurred without the swap). Data must also be available to assess whether this principle is met. Debtor country must have strong ownership of and sovereignty over its fiscal and natural resources (Paul and others 2023).

	the US Development Finance Corporation, which has allowed them to benefit from a higher credit rating (*ceteris paribus*). Some DNS clauses have been standard across recent DNS (30 × 30 clause), while other conditions (including mandatory conditions related to implementing national plans) are bespoke (Standing 2023). <u>Financial conditions</u> Debt buyback involving the replacement of a eurobond (or of a portion of bond notes across multiple eurobonds) with blue or green bonds (with a haircut), whose proceeds are used for nature-related investments, and with additional clauses related to mandatory environment-related policy measures.	causes of nature loss (Pérez-Beltràn and Landry 2023). Limited impact on fiscal space to date (Carbon Brief 2024). Historically, DNS have not provided comprehensive debt relief or restored debt sustainability (Chamon and others 2022). Concerns over democratic governance of marine or other natural resources, and concerns over debtor country ownership and the relative power of domestic authorities in environment-related policy choices (Standing 2023). Long value chain of industry players and limited involvement of local stakeholders generates or perpetuates political economy challenges over use of natural resources and limits environmental impact potential. Limited participation of indigenous peoples, local communities, and civil society in the definition and implementation of DNS (Standing 2023). Lack of systematic monitoring, accountability, and evaluation of impacts of DNS. Use of “tied aid” approaches favoring creditor country interests in use of freed-up resources. Special purpose vehicles and companies used in DNS	Debtor country must have the institutions and physical and informational resources to conduct high-quality impact assessments regarding conservation measures. Debtor countries should not be vulnerable to the global financial cycle, which can more than offset any improvement in debt sustainability achieved by a DNS (Standing 2023). The correlation between the relative need for ecosystem protection and sovereign debt vulnerability should be sufficiently high (Paul and others 2023).

		mechanisms have in some cases (for example, the Belize DNS) relied on tax havens, raising questions about tax evasion and scalability. Loan arrangements within DNS programs have included large interest margins for participating NGOs, with unclear or unspecified use of funds. Credit guarantees (for example, political risk guarantees) may be required for DNSs to be attractive to debtor countries, generating potential for socialization of losses (domestically or cross-border, depending on how the credit guarantees are paid for). Risk of privatization of profits and socialization of losses if the stated environmental and debt reduction objectives of the DNS are not achieved.	

Source: IMF staff.
Note: The table does not include all nature finance instruments. More specifically, the table does not include biodiversity credits and offsets, payment for ecosystem services and equity investment for nature. Furthermore, the table does not distinguish conservation from restoration goals, which may have an impact on instrument characteristics, challenges, and limitations. This is an area for further research. DNS = Debt-for-nature swaps; LICs = low-income countries.

[1] The minimum bond issuance size typically required by most institutional investors can be a hurdle for issuers (minimum of $200 million in developed debt markets, preferably $1 billion versus $100 million in emerging debt markets).

[2] This includes competitive returns, diversification, standardized investment terms, credit assurances, liquid secondary markets, and scale (large transaction sizes).

Annex 5. Detailed Policy Recommendations

Policy Considerations

Scaling up nature finance requires assessing characteristics of existing financial instruments (including risk-sharing tools and concessional finance) as well as their potential impact and relevance across different contexts, income levels, and ecological and financial needs. An important priority is to develop instruments that incorporate robust conservation incentives for sovereign, quasi-sovereign, and private actors (Harstad and Storesletten 2023). Credibility, impact, and scalability issues related to debt-for-nature swaps also need to be closely considered. Lastly, scaling up requires the development of strategies for nature-based finance in the context of the GBF, countries' national biodiversity strategies and action plans, taxonomies, and integrating nature-oriented transition plans. It also requires building technical capacity, engaging indigenous peoples and local communities, and implementing robust monitoring and evaluation mechanisms.

Scaling up nature finance requires a comprehensive and adaptative approach that considers the diverse financial instruments available, their relative impacts in different contexts, and their linkages to climate. A one-size-fits-all approach should be avoided, given the heterogeneity of relevant instruments for different contexts (ecosystem protection and restoration priorities, availability of international financing and domestic resource mobilization, and so on). Most mega-biodiverse countries are emerging market and developing economies, including low-income countries, with limited borrowing capacity and barriers to scaling up nature finance. Furthermore, solutions should address the nexus between climate change mitigation and adaptation and nature conservation. Hence, policies and financial models that incorporate this nexus—for example, forest conservation, restoration of coastal mangroves—are critical and should be explored by policymakers and market participants, working with communities and scientific experts.

Policy Recommendations: Financial Sector Focus

Global collaboration is essential to develop and ensure access to reliable and comprehensive data on nature, which is subsequently essential for scenario analysis and effective risk management and to address financial flows' misalignment with nature. These could include standardization of nature-oriented transition plans, disclosures, and taxonomies across sectors and regions, and support robust physical and transition risk assessment. The work by international standard setters, including the International Sustainability Standards Board (ISSB) and the International Organization of Securities Commissions (IOSCO), is also critical in leading the work on strengthening nature-related disclosures. The complexity of the climate–nature nexus and the multidimensional nature of nature call for the design and use of metrics on ecosystem state and vulnerability, and interdependencies (with an emphasis on species and ecosystem-level indicators). Policy initiatives should also consider geographical location, dependence and impacts on nature across sectors, and supply chain traceability (refer to Annex 2 on the impacts of data gaps on comparability, consistency, and relevance). In addition, enhanced global and country-level accounting of public[73] and private financial resources employed for nature conservation and restoration will be critical. Robust data in this area would provide baseline knowledge needed to assess biodiversity results from investments and build nature conservation financing strategies and policies. The demand for quality nature data also calls for substantial technological advances in data generation and analysis to improve data credibility, collection, consistency, and connectivity (TNFD 2023).

[73] With the integration of biodiversity valuation into national accounting and reporting systems (for example, expanding the production of System of Environmental Economic Accounting Central Framework accounts) and increasing the production of natural accounting in emerging market and developing economies (OECD 2023).

Financial regulators and supervisors have a role to play to support the alignment of the financial sector with nature-related risks and goals. Authorities can facilitate a constructive feedback loop between national biodiversity strategies and action plans, nationally determined contributions, corporate and financial institution transition plans for nature (IMF 2023; IMF, World Bank Group, and OECD 2023). While financial sector regulators would act as per their core mandates of financial stability, market integrity and investor protection, as an outcome of such initiatives, this could support a shift in capital allocation from harmful to nature-beneficial activities and projects in the economy and thereby affect investment, lending, and underwriting, while managing risks in capital markets. In this way, such transition could support both the implementation of the Paris Agreement and the GBF.

Considering the numerous targets for biodiversity conservation and restoration in the GBF, it will be important that entities, especially those faced with high levels of nature-related risks, identify and mitigate adverse impacts on nature, understand their impacts, and align their activities and assets with global commitments. It is equally important that this policy process involve indigenous people and local communities, considering their key role in a financing ecosystem that also includes policymakers and capital and project holders.

Nonfinancial and financial institutions (banks and non-bank financial institutions) could use biodiversity measurement methodologies that are increasingly used across industries. Nonbank financial institutions, including investment fund managers and insurance firms,[74] starting with those that are most affected by nature-related risk, should consider integrating nature-related risks into their practices, including shareholder and client engagement, risk management, and investment strategy.

Going beyond financial sector policies, governments need to transparently disclose subsidies. The lack of detailed data on geographic and subindustry breakdowns of harmful subsidies, and by company size, poses significant hurdles to the assessment and potential phasing out of harmful subsidies, although empirical analysis remains possible based on available data (as reflected in the empirical analysis in the second section, and in Annex 1). Therefore, introducing a consistent transparency framework that is comparable across countries is essential to aligning economic policies and activities with the international objective of halting and reversing nature loss.

[74] See Annex 3 on the insurance sector and nature-related risks.

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