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Hidden harms: the economic and financial consequences of deforestation and its underlying drivers

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Summary

Deforestation and land-use change driven by environmentally-damaging extractive activities have far-reaching implications for economies and financial systems. By outlining potential transmission channels from deforestation and land-use change to economic and financial risks, we can elucidate the complex mechanisms through which forest loss can destabilise the economy and financial system, deepening the understanding needed by policymakers tasked with helping to safeguard forest ecosystems and ensure economic stability in the face of environmental and governance challenges. There is a need for urgent engaged and ambitious public action by financial supervisors, central banks and policymakers on this matter, particularly as forest loss has increased in recent decades and efforts to prevent it have proved insufficient.

The critical role of forest ecosystems

- Forest ecosystems are an essential component of the biosphere, covering 31% of the Earth's total land area and containing 80% of terrestrial biodiversity. But forests are under significant pressure from human activities and natural disasters. Each year an additional 3.5 million hectares of primary forest are lost, contributing to the global decrease in land forest cover that started to gather pace in the 20th century. This is threatening the delivery of forests' critical functions for human societies, termed 'ecosystem services'.

- There is a close relationship between forest loss and climate change. In addition to forests' key role in carbon storage, some of the ecosystem services provided by forests can either mitigate or exacerbate the impacts of climate change, such as by regulating floods and temperatures. Climate change often limits the ability of previously forested areas to sustain forest ecosystems in the future.

Economic pressures on forests

- The rate of deforestation has increased markedly since the 1970s. This is closely tied to economic trends that place significant pressure on forests: international consumption and production patterns have boosted an extractive global economy with an increase in practices that threaten forests such as agricultural expansion, urbanisation, mineral extraction and energy generation.

- Economic pressure on forests often materialises through large-scale land acquisitions, in which foreign actors acquire forested land for economic activity, or through 'embodied deforestation' in imported products, where the economic activity directly responsible for deforestation is domestic but is induced and destined for external consumption.

- The international financial system actively reinforces this dynamic as forest-rich developing economies face constraints in attracting financing. This favours the adoption of short-term, export-driven growth strategies that are preferred by foreign investors and that result in forest loss, rather than environmentally and economically sustainable policies.

- Deforestation can also be caused by domestic economic pressures. Countries seeking economic growth, particularly emerging and developing economies where poverty alleviation is a key concern, may choose to invest in economic activities that harm forests, even if this jeopardises long-term prospects.

- Economic growth often requires the expansion of agriculture and infrastructure. Often, forested areas are cleared to make space for farmland or pastures, while road infrastructure directly and indirectly leads to deforestation.

Governance systems that amplify the risks from deforestation

- Global biodiversity conservation targets have been in existence for decades, including the Aichi target to at least halve the rate of forest loss by 2020. However, broadly, they have not been achieved, casting doubt over the effectiveness of quantitative target-setting in achieving transformative change in land-use governance.

- Coupled with growing economic pressure on forests, three factors are particularly important in explaining the pervasiveness of deforestation despite international policy efforts to reduce it:

    i. The absence of enforcement mechanisms due to the non-legally binding nature of existing agreements: voluntary initiatives are rarely translated into domestic legislation, regulations or enforcement.

    ii. The lack of a consist definition of 'forest' (and what counts as deforestation) across different jurisdictions and regulatory frameworks, resulting in loopholes and poor execution of target-setting measures to halt deforestation.

    iii. The lack of accountability and coordinated legal safeguards in international market-based instruments and voluntary declarations. These measures do not address economic pressures of large-scale land acquisitions, nor do they adequately hold international financial actors accountable for their impacts on forests.

- Given the prevalence of embodied deforestation in commodities and consumer products, the governance of trade and supply chains has become an important way to minimise deforestation risk. Countries importing forest-risk products tend to mitigate this risk by ensuring legality, promoting certification and regulating forest-risk commodities. However, these measures have often fallen short of preventing deforestation and fail to address the underlying economic and governance issues that perpetuate forest loss.

- Domestic governance pressures further contribute to deforestation. Countries often have complex, ambiguous and decentralised legal regimes for governing land-use change that focus on economic growth rather than conservation and are largely driven by global demand for resources. This enables deforestation, particularly when states grant concessions for the expansion of agriculture or infrastructure in forested areas. Pressures on forests are further exacerbated by political issues such as weak tenure rights, lack of transparency over management of forest resources, poor enforcement of regulations and 'elite capture', in which resource benefits are held by a small group of powerful actors rather than shared with the wider population; these factors often negatively impact local communities and Indigenous groups.

- The interaction of poor governance and economic pressure leads to an increase in forest loss. It is necessary to address these two underlying drivers with a focus on equity, justice and inclusion.

Economic and financial impacts of deforestation and land-use change

- Due to the loss of ecosystem services, the well-documented degradation of forest ecosystems in recent decades has significant implications for economic and financial systems, affecting households, firms, financial institutions and the broader macroeconomy, through physical risks and risks related to the process of transitioning to a more sustainable economy ('transition risks').

- Forest loss facilitates disease outbreaks, decreases regional air quality, and weakens resilience to temperature fluctuations and natural disasters.

- Agricultural production and hydropower generation are particularly vulnerable to the loss of forest ecosystem services due to the increase in soil erosion and altered rainfall patterns that result from forest loss. The increased likelihood of forest fires due to deforestation is another channel through which households and firms are adversely impacted by forest loss.

- As awareness of the magnitude of the threat of forest loss rises, transition risks become a key source of concern for companies. Firms linked with deforestation face further policy constraints and are at enhanced risk of litigation whereby they are held accountable for their role in forest loss. Companies are also managing market and reputational risks as they come under pressure to demonstrate that their operations do not harm forests.

- These impacts on economic agents reverberate across the economic system, resulting in aggregate impacts on output and prices. Due to their unique role in economic systems, financial institutions are vulnerable to the transmission of these effects, which materialise in credit, operational, market and liquidity risks.

Policy implications

Financial supervisors need to coordinate on:

- Enhancing microprudential frameworks through promoting and enforcing risk management processes that adequately account for nature-related risks, particularly deforestation-related risks.
- Enhancing macroprudential frameworks to integrate the information in the implementation of stress-tests to improve the assessment of financial risks.
- Supporting the collection, use and sharing of information related to nature-related risks, to enable their monitoring.
- Aligning the actions taken by institutions supervising the financial sector, both domestically (e.g. in the banking sector, securities and exchange, insurance, pension funds) and internationally.

Regarding monetary policy, central banks can:

- Lead on the implementation of measures to mitigate deforestation risk, including by defining transition plans and actively monitoring and reporting on their portfolio exposure to deforestation risk, which is often underpriced by markets.
- Recognise the impact of deforestation on their price stability mandates, including its direct impact on the price level and the monetary policy transmission channels upon which central banks rely.
- Engage in ongoing debates about the scope of their mandate and their strategy on nature loss, focusing on whether their mission calls for more active efforts to prevent forest degradation, including forest loss.

Economic policy actors can:

- Consider the negative impact of deforestation within their growth strategies, where large-scale forest destruction was previously commonplace. Cost–benefit analysis, even if approximate, can demonstrate that such projects do not always have a clear economic case. Future economic policy decisions must explicitly account for the costs for forest loss, finding a balance between addressing economic pressure and ensuring the long-term sustainability of investments.
- Recognise the specific characteristics of deforestation risks. While they may materialise differently across regions, they are closely tied to global dynamics in both cause and effect – because of their implications for climate change, for example.
- Policy strategies to address deforestation risk must be informed by the interconnectivity of different ecosystem services, including the key nexus of nature and the climate, and the non-linear behaviour and possible irreversibility of some changes to the environment.

1. Introduction

Deforestation and land-use change driven by environmentally-damaging extractive activities have far-reaching implications for economies and financial systems. This report furthers exploration of the role of deforestation as a driver of nature loss and source of potential economic and financial destabilisation.

Awareness of the implications of deforestation has been growing among economic and financial policymakers, shaped by the work of the Network for Greening the Financial System (NGFS) and the International Network for Sustainable Financial Policy Insights, Research, and Exchange (INSPIRE) Study Group on Biodiversity Loss and Financial Stability. Their research conceptually highlights the macroeconomic and financial stability risks posed by environmental degradation, particularly the loss of biodiversity (NGFS and INSPIRE, 2022), including risks associated with widespread deforestation.

Building on the work of the NGFS and INSPIRE, this report examines the intricate connections between forest ecosystems and their economic and social dimensions by providing evidence on the links between forest loss and a host of economic and social factors such as impacts to health, productivity and livelihoods. By outlining potential transmission channels from deforestation and land-use change to economic and financial risks, the report aims to elucidate the complex mechanisms through which forest loss can destabilise the economy and financial system.

Deforestation persists despite global efforts spanning decades to curb it, driven by various economic and governance pressures. A further objective of this report is to explore the reasons behind the continuation of deforestation, considering factors such as agricultural expansion, illegal logging and inadequate enforcement of environmental regulations. Grasping the economic pressures and governance amplifiers[1] facilitating deforestation is crucial for understanding future trends and developing effective strategies to mitigate deforestation and its associated risks.

By contributing to the growing evidence base on the economic and financial ramifications of deforestation and land-use change, this report seeks to inform and influence policy decisions that will help safeguard forest ecosystems and ensure economic stability in the face of environmental challenges.

[1] In this report, governance amplifiers refer to governance systems that add to the economic risks from deforestation. These decision-making structures or institutions, which operate at the global to local scale, are underlying factors that shape how people relate to forests, and determine access to and control of forests and their benefits. Some examples of these governance systems are land-use classification systems, land-use and access rights, legislative arrangements, treaties, voluntary agreements and voluntary mechanisms e.g. certification schemes.

Box 1.1. Definitions: deforestation and related terms

Deforestation in its broadest sense is the removal of forests or the conversion of forested land to non-forested land. Some definitions specifically refer to deforestation that is primarily driven by human activities (e.g. WRI, 2024; IPBES, 2018), while others include non-human-induced causes to track the total extent of forest loss (e.g. FAO, 2025). Deforestation caused by human activities can be carried out to harvest timber and wood products. It can also occur for the purpose of changing land use, clearing forests for another purpose such as agriculture, mining, infrastructure, urban development, or the construction of hydropower plants or water reservoirs.

In this report, 'deforestation' and 'forest loss' are used interchangeably.

Land-use change is a term sometimes used to imply a legal change in the land's status, while **forest conversion** is often used by non-state actors to describe a visible physical change in the structure and use of the land, whether or not there is a legal change.

Forest degradation refers broadly to a decline in the health of a forest ecosystem, and its intactness, quality and ability to support local biodiversity and human populations through ecosystem services, including to sequester and store carbon. It can involve subtle, gradual or incremental changes to the forest structure, caused by human or natural disturbances. Persistent degradation can lead to lower resilience of the forest to storms, fires and droughts, which increases the vulnerability of local populations to more frequent extreme weather events. Forest degradation is often a precursor to forest conversion or deforestation (WRI, 2024).

Deforestation risk refers to the economic risks stemming from forest loss, which includes the removal of forests or conversion of forested land to non-forested land as well as forest degradation. In the context of this report, it is not used to refer to the risk that an economic activity may lead to deforestation.

Further definitions used by organisations active in this field are provided in the Appendix.

2. The critical role of forest ecosystems for society and the economy

Forest ecosystems, covering 31% of the Earth's land surface and home to 80% of terrestrial biodiversity, are crucial for the health of the natural environment, human society and the economy. Forests face significant threats from human activities; forest loss continues at an alarming pace and a complex interplay between deforestation and climate change affects the ability of forests to provide essential ecosystem services.

Forests are complex ecosystems that comprise various biotic (living) and abiotic (non-living) components including plants, animals and microbes that interact in intricate ways with one another and with the physical and chemical attributes of tree-dominated environments.[2] Typically, forest ecosystems fall into one of three broad categories: tropical, temperate and boreal. From an ecological perspective, forests contain 80% of terrestrial biodiversity and provide habitats and resources for numerous species. Tropical forests in particular are central to Earth's biodiversity, being home to more than half of terrestrial vertebrates (Pillay et al., 2022; Wilson, 1988).

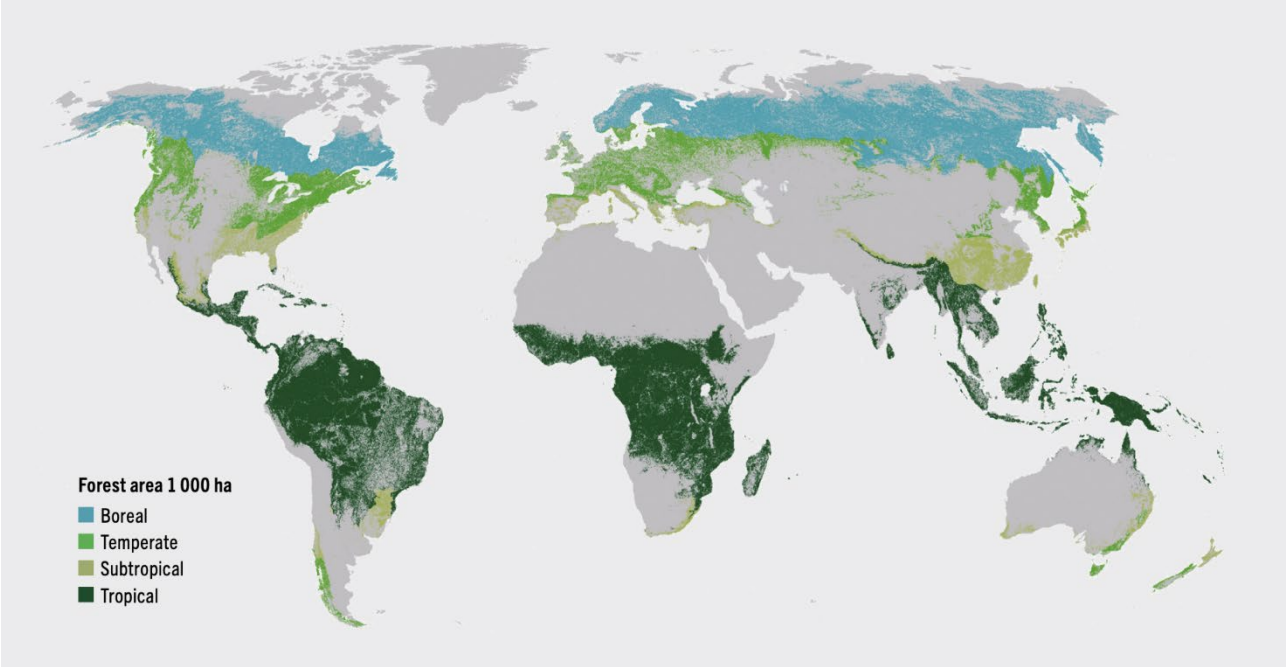
Currently, forests cover approximately four billion hectares or 31% of the Earth's total land area (FAO, 2020). Looking at the distribution of forests around the world (see Figure 2.1), 25% are situated in Europe (including the Russian Federation, which is home to 20% of the world's forests), 21% in South America, 19% in North and Central America, 16% in Africa, 15% in Asia, and 5% in Oceania. More than half of the world's forests are located in just five countries (Russia, Brazil, Canada, the US and China) (ibid.). Globally, 5% of forests are plantations that are generally used for commercial purposes (Pan et al., 2011).

In 2020, only 34% of Earth's forests qualified as primary forests, i.e. those that have no visible indication of human activity and whose ecological processes are not significantly disturbed (FAO, 2020). Over the past 20 years, global primary forest loss has been 3.5 million hectares per year on average (WRI, 2024). The percentage of the world's area covered by forest decreased from 48% of habitable land in 1900 to 44% in 1950 and 38% in 2018 (see Figure 2.2).

Deforestation leads to the loss of valuable resources and important ecosystem services provided by forests that encompass a range of regulating, provisioning and supporting functions that sustain life and promote economic and social stability. Forests play vital roles in filtering water, providing buffers against natural hazards like storms and floods, regulating the hydrological cycle and global temperatures, and sequestering carbon dioxide (CO_2), thereby mitigating climate change. Forests also regulate air quality. The biodiversity within forests ensures the resilience of ecosystems, supports species diversity and prevents the spread of diseases. These ecosystem services and their contributions to a functioning society and economy are outlined further following Figures 2.1 and 2.2.

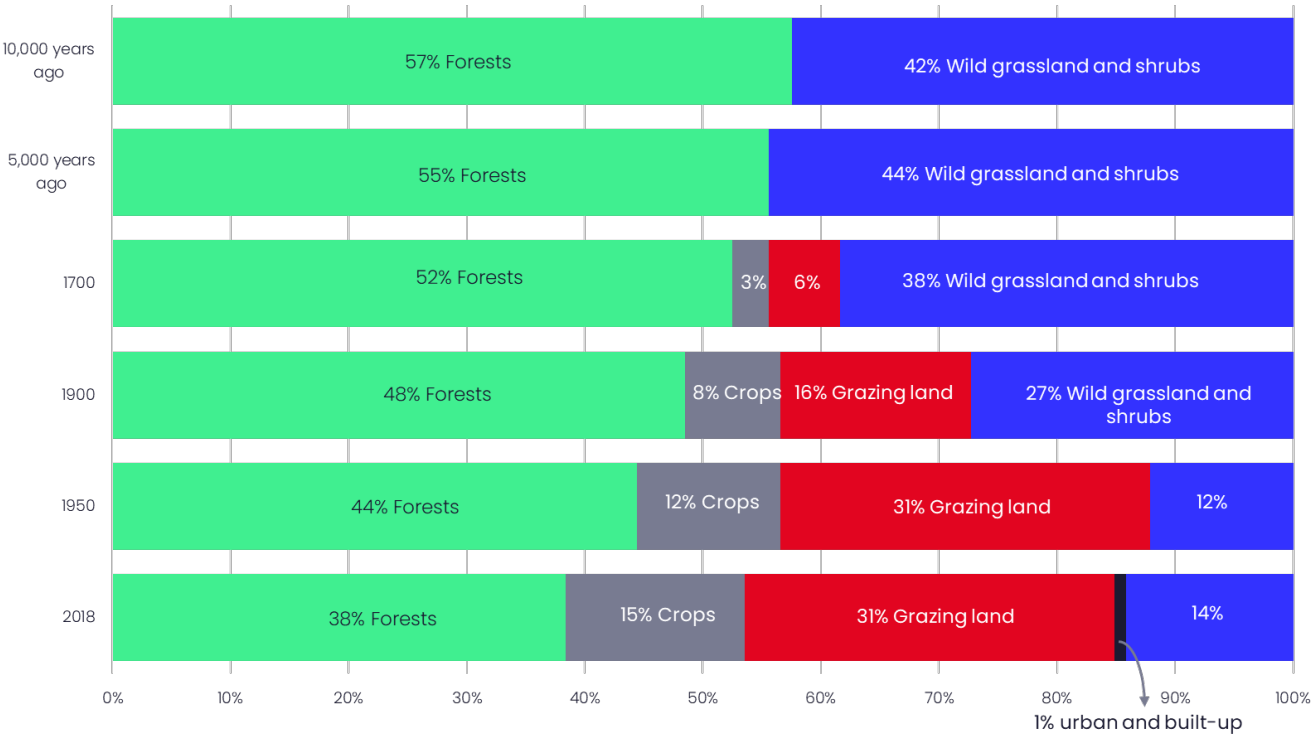
[2]The UN Food and Agricultural Organization (FAO) defines forests in its ongoing 2025 Forest Resource Assessment (FAO, 2023) as land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10%, or with trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. See the Appendix for further details.

Figure 2.1. Distribution of forests globally by climactic domain, 2020



Source: FAO (2020)

Figure 2.2. Forest coverage and land-use change over time



Source: Ritchie (2021)

Ecosystem services: regulating services

Water capture and filtration

Forests have an important role in water conservation and supply, purifying water and maintaining water quality (Sun et al., 2023; Qin et al., 2016). Forests act as natural filters, trapping sediments and pollutants, thereby protecting downstream bodies of water from contamination. When rainwater falls on forested landscapes, it passes through the vegetation to the forest floor. Here, the roots of trees and plants absorb excess nutrients and pollutants that would otherwise enter the water cycle. Because of this, tree cover is associated with a lower prevalence of diarrhoeal disease in children that live downstream (e.g. as shown in Malawi [Johnson et al., 2013]) and has been shown to improve the effectiveness of water quality treatment (e.g. in Haiti and Honduras [Rasolofoson et al., 2021]). Even in urban environments, the presence of forest buffers is beneficial as it is associated with higher groundwater recharge and decreased sediment and nutrient loading (Brett et al., 2005), forest buffers are associated with higher groundwater recharge and decreased sediment loading (Matteo et al., 2006). Deforested areas have been shown to affect water supply though decreased water retention due to an increase in surface run-offand lower soil infiltration (Zhang and Wei, 2021). Additionally, forests play an important role in regulating water temperature, preventing excessive heating and maintaining suitable conditions for aquatic life.

Hazard protection from storms, floods and landslides

Forests help regions to respond to storms and extreme rainfall: they moderate variations in discharge by allowing soil to absorb water. A study of the physical properties of ecological catchments finds that forested areas have the most buffered storm response (Nainar et al., 2018). The presence of fallen leaves on the ground, slope stabilisation, nutrient cycling and water absorption further contribute to soil stability and erosion prevention, and, in turn, flood prevention. When forests are cleared, soil erosion happens on a large scale, which can dramatically increase the pace of sediment moving into river systems, exceeding natural levels of sedimentation (Reusser et al., 2015). Floods in the northern Andes of Colombia, for example, have been linked to severe soil erosion and high sedimentation of the Magdalena river catchment resulting from decades of forest clearance (Restrepo et al., 2015). The majority of Colombia's population live in this region, and it generates more than 80% of the country's GDP. Scenarios of extreme riverine flooding have been explored in a climate stress-test of the Colombian banking system, showing potentially substantial impacts on the macroeconomy and financial sector (Reinders et al., 2021).

The strong relationship between deforestation or land-use change and flooding and landslide events is well-documented (e.g. Tan-Soo et al., 2016; Bradshaw et al., 2007; Agarwal et al., 2023; Bhattacharjee and Behera, 2018; Robalino et al., 2023). Looking specifically at deforestation for urbanisation purposes, Nirupama and Simonovic (2007) show how previously forested areas face an elevated risk of flooding. Chauhan et al. (2023) review environmental change in the Himalayas, which are home to around 50,000 glaciers and face extreme threats from shrinking glaciers and land-use change, leading to cascading hazards such as glacier outburst floods and frequent droughts and floods. These far-reaching risks should not be understated, as the Himalayan region is the source of the 10 largest rivers in Asia and provides ecosystem services to at least 1.9 billion people (Sharma et al., 2019).

Regulating temperatures

Forests are also important regulators of local and global temperatures. At the local level, tropical and temperate forests in particular reduce the Earth's surface and air temperature,

by casting shade and causing evapotranspiration.[3] Temperatures in ecosystems with non-functional or no vegetation are higher (absorbing heat, similarly to a concrete surface), whereas those in ecosystems with dense, bushy or tree vegetation are lower (Hesslerová et al., 2013). Similar effects can be observed at regional and global scales, beyond the purely redistributive surface air effects of local cooling. Due to emissions from organic compounds, forests contribute to the low-level formation of clouds which increases the reflection of sunlight into space, resulting in global cooling effects (Ban-Weiss et al., 2011, Seymour et al., 2022). In addition to local temperature effects, deforestation of the Amazon Rainforest has caused regional warming within a range of up to 100km (Butt et al., 2023).

Regulating the carbon cycle

Forests play an important role in removing CO_2 from the atmosphere: an important link in the climate–nature nexus. Globally, forests absorb one-third of anthropogenic carbon emissions, making them the second-largest source of carbon sink (the ocean being the largest). However, forests are both a sink and source of carbon emissions. Trees absorb CO_2 when growing or standing; and release stored carbon when they decay or are cleared or degraded (Baccini et al., 2012; Seymour et al., 2022).

As a result of deforestation, some tropical forests now emit more carbon than they capture, turning them from a carbon *sink* into a carbon *source* (Palmer et al., 2023). There is also evidence that structurally intact old growth tropical forests in the Amazon, Africa and Southeast Asia are losing their capacity to absorb carbon due to factors including reduced water availability and higher temperatures during extreme droughts, which are reinforced by deforestation and land degradation (Ometto et al., 2022). For example, carbon mapping research applied to Peru found that a significant amount of carbon stocks were at imminent risk of emitting carbon as a result of deforestation activities (Asner et al., 2014); this is a risk that is relevant to all tropical developing nations.

Global deforestation therefore constitutes a significant and persistent net source of carbon emissions (Pan et al., 2011): it contributed an estimated 4 gigatonnes (Gt) of net CO_2 emissions in 2022, equivalent to 10.4% of that year's total anthropogenic CO_2 emissions (Crippa et al., 2023). Considering other forms of forest disturbance alongside deforestation, Harris et al. (2021) estimate yearly greenhouse gas emissions from these sources as 8.1 Gt of carbon dioxide equivalent (CO_2e). In addition to deforestation, forest degradation is a significant and underestimated source of greenhouse gas emissions, exceeding deforestation emissions in 28 of 74 developing countries examined in one study (Pearson et al., 2017). Accordingly, existing climate scenarios to meet global climate goals depend on halting deforestation and supporting afforestation or reforestation, even in one of the least ambitious scenarios, the Moderate Action[4] scenario (Nabuurs et al., 2022).

Carbon emissions from deforestation are likely underestimated as organic soil carbon stocks have not been considered in estimations to date. This has been demonstrated in Mexico, where the value of temperate forests has been underappreciated (Santini et al., 2019). Furthermore, the boreal forests that form a ring around the North Pole store one-third of global carbon stocks on land and are already at risk from increasing frequency and severity of wildfires; they could reach a tipping point[5] sooner than anticipated under continued global

[3] Evapotranspiration is the biophysical process through which water moves from land to the atmosphere, comprising evaporation which occurs when water turns into vapour and rises from surfaces like soil and water bodies, and transpiration when plants release water vapour from their leaves.
[4] The *Sixth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC) outlines five pathways to meet the Paris Agreement goals, plus two additional scenarios: 'Current Policies' and 'Moderate Action'. The *Moderate Action* scenario represents a future where current climate policies are implemented and Nationally Determined Contributions (NDCs) set for 2023 are achieved, with some policy strengthening after 2030. However, it still falls short of the below-2°C temperature target.
[5] Ecological tipping points are thresholds within ecosystems where a small change or disturbance can lead to a significant and often irreversible shift in the system's structure and function, whereby the ecosystem enters a new state, likely with less biodiversity and reduced ecosystem services.

warming, with a partial dieback in the south of the region. This could release more carbon into the atmosphere (Rao et al., 2023).

Regulating diseases

Deforestation is often accompanied by increased human contact with the natural ecosystem. When degraded, these ecosystems may not regulate disease organisms or their vectors, facilitating zoonotic transmission of diseases (IPBES, 2018). This has important implications for human health: in Central and West Africa, outbreaks of the Ebola virus have been preceded by forest loss in the previous two years, with zoonotic transmission being more likely due to human incursions and the increased density of potential reservoirs of the virus in fragmented forests (Olivero et al., 2017). This is substantiated in research that shows how land intensively used by humans has a much higher proportion of known wildlife hosts of human-shared pathogens and parasites compared with undisturbed habitats (Gibb et al., 2020). A strong feedback loop has been found in Brazil between malaria and deforestation (MacDonald and Mordecai, 2019). Deforestation can worsen the incidence of malaria by increasing forest edge habitats, which promote mosquito breeding and survival. These effects are strongest during the early stages of deforestation.

Ecosystems that are in equilibrium regulate non-human diseases in addition to human ones. Forest loss increases the risk of new emerging diseases in plants and animals in peripheral human-dominated areas. For example, where agriculture meets forests, there can be plant disease epidemics caused by spillovers from wild to domesticated plants (Guégan et al., 2023). Research also finds a negative relationship between the richness and diversity of plant species and the prevalence of viral infection, suggesting natural populations with higher levels of biodiversity are better able to regulate viruses (Susi and Laine, 2021).

Air quality

Forest ecosystems improve air quality through direct and indirect mechanisms. Firstly, trees in forests directly filter pollutants from the air, similar to how they purify water. They reduce gaseous air pollutants and remove particulate matter, which helps prevent human mortality and acute respiratory illness (Nowak et al., 2014). In Mexico, research shows that peri-urban forests, such as the Iztaccíhuatl–Popocatépetl National Park, significantly reduce the annual concentration of air pollutants (Baumgardner et al., 2012).

Secondly, protecting forests has the indirect effect of reducing the risk of wildfires, which also benefits air quality. Land-use change increases wildfire risk by altering forest structures, making fragmented landscapes more susceptible to frequent and larger fires (Alencar et al., 2015). This is particularly significant in tropical regions, where fires are not part of the natural cycle. Both wildfires and conversion fires produce substantial particulate matter, adversely impacting air quality and public health, at a cost to public finances. The 1997 forest fires in Southeast Asia were estimated to have cost US$4.5 billion, with short-term healthcare expenses contributing to this amount (Glover and Jessup, 2006). Deforestation in Brazil's Amazon Rainforest since 2012 has increased the occurrence of fires in the dry season by 39%, potentially resulting in 3,400 additional deaths in 2019 alone (Butt et al., 2021). In Equatorial Asia, the 2015 forest fires exposed 69 million people to poor air quality, possibly leading to 11,880 excess deaths (Crippa et al., 2016). And the 2018 California wildfires are estimated to have directly claimed 104 lives, with a further 3,652 lives lost from the resulting air pollution (Wang et al., 2021).

Ecosystem services: provisioning services

Provisions (timber, biomass, food, non-timber forest products)

Degradation of ecosystems impacts their ability to directly provide valuable resources and materials such as timber and food (Lee et al., 2022; Aziz et al., 2017). Forests are home to a diversity of insects including bees, plus birds and bats which pollinate fruit and nut trees and

plants that are cultivated in adjacent agroecosystems such as coffee, cocoa and melons (Halinski et al., 2020; Krishnan et al., 2020; Tremlett et al., 2019;). Pollinators depend on the floral and non-floral resources provided by forests, and are significantly affected by deforestation (Ulyshen et al., 2023).

The loss of provisioning services provided by ecosystems, including pollination and provision of timber, is projected to negatively impact global GDP by 2030 (Johnson et al., 2021). As natural resources play a fundamental part in the forestry (timber) and agricultural sectors, a natural trade-off arises where the very exploitation of these resources results in forest loss and impairs the provision of the materials in the first place. This dynamic is also exhibited in the production of bioenergy, an important output provided by forest ecosystems that several countries rely on to meet basic energy needs (Yu et al., 2021).

Beyond timber and biomass, forests are also important sources of food (e.g. fruit, seeds, nuts, mushrooms, truffles, wild leaves, spices, roots, medicinal plants, honey and wild meat) and other non-timber forest products (e.g. rattan, bamboo, firewood, charcoal, fragrant woods, resins and gum). These products are used by at least 3.5 billion people, more than 50% of whom are located in urban areas and in high-income countries (Shackleton and de Vos, 2022). This shows that these products are not just the basis of remote economies, providing food, shelter, income and energy for Indigenous and rural communities, but are also consumed by urban dwellers in larger economies.

Ecosystem services: supporting services

Soil quality conservation

Forests prevent soil erosion through their dense root systems and canopy cover, which intercept precipitation, stabilising soil and reducing the impact of rainfall on the earth. Healthy soil makes water available for uptake by plants, reduces erosion and enhances biological activity, as well as being a vital component of agricultural productivity. This has been well documented over time: for example, in western Kenya the conversion of forests to permanent agricultural land has resulted in progressive soil degradation (deterioration in structure and loss of soil organic carbon) and loss of land productivity, threatening the long-term sustainability of agricultural practices (Nyberg et al., 2012). In Nigeria, deforestation has affected the soil's ability to receive and transmit water, and increased the bulk density of soil, which limits microbial activity and root penetration (Lal, 1996), negatively impacting plant growth. Similarly, in Bangladesh, deforestation has been shown to have significantly impaired the biological, physical and chemical properties of the soil (Sirajul Haque et al., 2014). In the Himalayan region, soil degradation has been caused by the destruction of forests and shrubland to produce fuel wood, commercial timber and mining opportunities.

In addition to erosion effects, the soil's decreased capacity for water storage and the increased concentration of polluting fertilisers within it cause devastating impacts not just on local people but also on those living in downstream river basins who depend on freshwater resources (Chauhan et al., 2023; IPCC, 2021; Wester et al., 2019).

Precipitation and the hydrological cycle

Forests are important drivers of rainfall. Trees absorb water from the soil through their roots and release it into the atmosphere through evapotranspiration, which contributes to the formation of clouds and precipitation, thereby influencing regional rainfall patterns and water availability. Evapotranspiration is responsible for 41% of average rainfall in the Amazon basin, and up to 50% in the Congo basin (Baker et al., 2022; Smith et al., 2023). This process in tropical forests of trees absorbing rainwater and releasing it, recycling moisture and maintaining rainfall, is known as 'flying rivers' (Araujo and Mourao, 2023). In the Amazon, about half of rainfall is recycled this way.

When trees are lost, less water is transpired, reducing atmospheric moisture and rainfall, which further degrades the forest and impacts water availability downwind (ibid.). As a result, precipitation patterns change as forest cover is changed, significantly disrupting the water cycle (Malhi et al., 2008; Grosset-Touba et al., 2024). In the Amazon basin there could be an annual reduction in rainfall of 8.1% by 2050 if deforestation continues there at current levels (Spracklen and Garcia-Carreras, 2015).

Changes to precipitation patterns associated with changed forest cover are highly dependent on geographical location. For example, deforestation of Mexico's cloud forests has led to more rainfall, more volatile fluctuations of water reserves, drier dry seasons and higher propensity to flooding (Muñoz-Villers et al., 2015; Lozano Trejo et al., 2020). Forests are important regulators of drought risk, buffering against their effects (Staal et al., 2018) through maintaining the ability of soils to absorb and store water. Forest disturbance such as logging and severe fires are associated with soil compaction, erosion and water repellency, which reduce the flow of water during dry weather, exacerbating drought effects (Zhang and Wei, 2021). The relationship between forests and droughts implies a feedback loop dynamic in which deforestation contributes to future droughts, which increases the pressures on forests. This is particularly worrying in the context of the Amazon ecosystem, which is not resilient to drought as these conditions are not part of the normal seasonal cycle. Overall, forests play a critical role in preventing large-scale ecosystem change, or a 'tipping point transformation', e.g. from rainforest to a savannah-like landscape (Nepstad et al., 2008; Marsden et al., 2024a).

The role of forest ecosystems in the hydrological cycle has an important global dimension in addition to its local effects, which relates to atmospheric circulation. Amazon deforestation has been found to lead to a reduction in precipitation in remote locations such as Central America, the Gulf of Mexico and the Indian Ocean (Werth and Avissar, 2002). Devaraju et al. (2015) also examine the remote effects of deforestation on precipitation patterns, linking global deforestation to an increase in precipitation in Southern Hemisphere monsoon regions, and a reduction in precipitation in Northern Hemisphere monsoon regions.

Habitat, species and biodiversity intactness

Forests provide habitats for 90% of amphibian species, 75% of bird species and 68% of mammal species (FAO, 2022). Intact ecosystems such as primary forests play a fundamental role in maintaining equilibrium among a diversity of species. The greater the diversity of species, the higher the resilience of an ecosystem to withstand and recover from shocks such as invasive species or elevated temperatures.

Table 2.1. Overview of the role of forest ecosystems and ecological impacts of their loss

Example ecosystem services	Example impacts of forest loss
Water capture and filtration	Decline in water quality
Hazard protection from storms, floods and landslides	Rising hazards e.g. floods, storms, landslides
Regulating temperatures	Rising temperatures
Regulating the carbon cycle	Rising carbon emissions
Regulating diseases	Disease outbreaks
Air quality	Rise in air pollution
Provisions (timber, biomass, food, non-timber forest products)	Decline in provision of valuable resources and materials, including pollination services
Soil quality conservation	Decline in soil quality
Precipitation and the hydrological cycle	Changes in precipitation patterns
Habitat, species and biodiversity intactness	Loss of biodiversity

Nature–climate nexus

The ecosystem services provided by forests, as described above, demonstrate the complex interdependence between forest ecosystems and the climate. Climate-related events such as floods, droughts, storms and landslides that lead to loss of labour productivity and asset destruction do not occur in a vacuum: the degradation of nature, for example through forest loss or ocean heating, precedes these events. Forest loss impairs the functioning of ecosystem services such as carbon storage, water and temperature regulation, and soil maintenance. The loss of these services exacerbates the impacts of climate change (Rizzi, 2022), increasing the frequency and severity of climate-related risks. Climate change can also act as a trigger that leads to devastating impacts where nature has been degraded, such as in the case of the Dust Bowl in the US (Almeida et al., forthcoming).

Meanwhile, climate change mitigation efforts, such as constructing renewable energy infrastructure or mining for transition minerals, can result in nature loss by clearing forests and disrupting ecosystems. Nature-based solutions such as preserving healthy forests to absorb excess rainfall and protecting mangroves to buffer against storms can mitigate the impacts of climate change while maintaining ecosystem resilience.

Figure 2.3. Interaction of nature loss and climate and environmental risks

Nature loss precedes climate (physical) risks...

Nature loss	Ecosystem service affected	Climate impact	Economic impact
Forest loss	Carbon regulation	Greenhouse effect	Capital and output losses
	Soil erosion	Landslides, floods	Capital destruction
	Water cycle	Water scarcity	Disruption in production processes
	Temperature regulation	Excess heat	Labour productivity decline

...and creates environmental risks beyond climate

Nature loss	Ecosystem service affected	Nature impact	Economic impact
Forest loss	Pollination	Loss of plant species	Disruption in production process
	Disease regulation	Spread of disease	Labour productivity decline

Source: Authors

The role of forests in regulating the carbon cycle is a good example of the interconnectedness of climate and nature, and shows the importance of considering both simultaneously rather than in isolation. Deforestation exacerbates the effects of climate change as it is a major source of carbon emissions, deprives territories of climate regulation services, and reduces resilience to natural disasters. Meanwhile, global temperature rise can irreversibly affect ecosystems' natural equilibrium, and the increase in climate-related extreme weather events further contributes to the destruction of forests and biodiversity (Finance for Biodiversity Initiative, 2021).

While there is growing awareness and acknowledgement of the crucial importance of forest ecosystems, there is a lack of critical engagement in policy discussions over the role of our economic and financial systems in driving forest loss. At the same time, it is often not recognised that the governance systems meant to protect forests are failing to do so, thereby adding to the risk of ecological collapse. Decisions taken today, including those made within the time bounds of current economic and financial models, have cascading effects on the Earth's ecosystems into the future.

The next two sections will discuss how our economic and financial systems are implicated in causing the economic and financial risks from forest loss, and how governance failures are amplifying them. This understanding can enable consideration of actions that tackle the root causes of the devastating impacts of forest loss, instead of only addressing its symptoms.

3. Economic pressures on forests

Given the widespread and serious risks stemming from the loss of forest ecosystems, it is critical to understand the reasons behind the marked increase in deforestation in recent decades. This section explores the economic engine of this change.

Modern trends in consumption and production depend on the large-scale exploitation of natural resources, including forests and the land on which they stand. The global increase in consumption has contributed significantly to forest loss, as international actors place pressure on forests either through large-scale land acquisitions to sustain economic activity or through demand for international trade, which implies a level of embodied deforestation. These trends are exacerbated by the international financial architecture, which requires forest-rich developing countries to prioritise policies favoured by international investors, often to the detriment of the objectives of forest conservation.

Domestic economic pressures have also played a key role in driving deforestation. The pursuit of domestic economic growth leads countries to invest in critical sectors such as agriculture and infrastructure for transport and energy, which represent large threats to forests. In recent decades, this trade-off has been particularly relevant to tropical forest-rich countries, which are often developing or emerging economies facing acute internal pressures for economic growth and poverty alleviation.

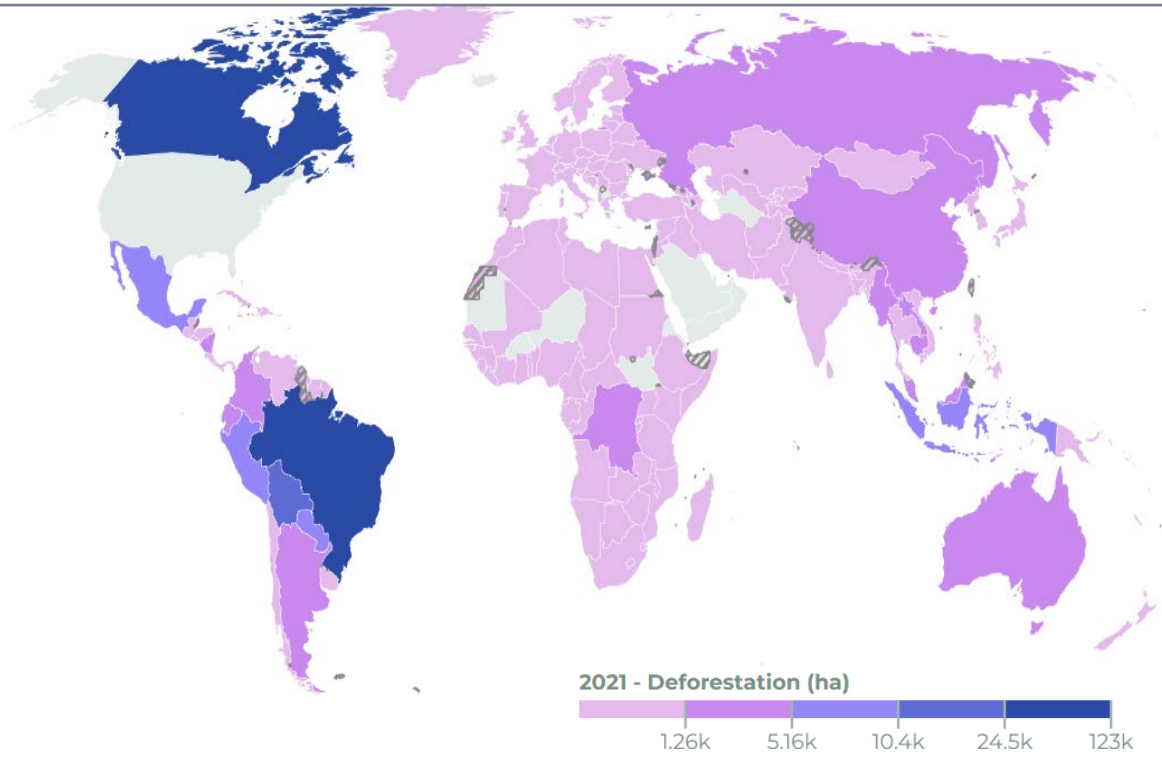
International demand for resources

Growing global demand for resources and the dependence of economies on extractive industries are fundamental drivers of deforestation and land-use change. Demand for food, fuel and consumer products is fuelling unsustainable levels of agricultural expansion, urbanisation and natural resource and mineral extraction. This growing demand is tied to high and rising consumption patterns (IPBES, 2018). For example, the global forestry product industry, valued at US$250 billion annually, is heavily influenced by the consumption patterns of wealthy nations, which can lead to significant forest loss, particularly in regions where enforcement of logging regulations is weak (Antonarakis et al., 2022).

Between 2005 and 2013, 62% of forest loss in the tropics and subtropics was due to the expansion of embodied deforestation in the production of crops, cattle for meat, and forestry products, of which around one-quarter (26%) was attributed to the production of commodities that were exported, particularly crops such as palm oil, soybeans and tree nuts (Pendrill et al., 2019). Seventy-nine per cent of this exported deforestation was attributed to demand from advanced economies (ibid.). The global economic context of international trade and growing commodity markets, which are supported by economic and financial structures and institutions, puts relentless pressure on forests and will continue to be a dominant driver of deforestation in tropical regions unless it is addressed (IPCC, 2021; Dempsey et al., 2024).

Titley and West (2024) show how direct imports of seven forest-risk commodities by the US were linked to 122,800 hectares (ha) of tropical deforestation between October 2021 and November 2023, mainly in Indonesia, Colombia and Brazil. This is likely an underestimation as they only consider direct trade due to the challenge of accounting for complex supply chains and embedded deforestation. In fact, looking more broadly at consumption-linked deforestation, researchers attribute 240,000 ha of foreign deforestation to the US in 2021 (see Figure 3.1). This leverages the input–output analysis of Exiobase, going beyond the seven commodities and tropical regions considered by Titley and West (2024).

Figure 3.1. Foreign deforestation exposure by consumption flows, US, 2021



Source: SEI/JNCC (2023), commodityfootprints.earth

Addressing deforestation and land degradation thus requires systemic change in the macroeconomy (IPBES, 2018), at both the global and national levels.

Large-scale land acquisition is one way through which the economic pressure from rising consumption drives forest loss and land degradation. Such acquisitions have surged in recent decades, particularly in emerging markets and developing economies, driven by the growing global demand for food, fuel and fibre. Three-quarters (76%) of all land acquired in these countries is done so through foreign investment (Davis et al., 2020) and land is often acquired to secure access to high-demand natural resources or agricultural commodities such as palm oil, timber and wood fibre. Foreign firms frequently target areas with high forest cover, leading to elevated rates of deforestation (Ordway et al., 2017; 2019).

Embodied deforestation in imported products also translates into forest loss. Despite obtaining net gains in domestic forested land, many advanced economies have increasing levels of embodied deforestation in their imports that mainly threaten tropical forests. Consumption in G7 countries (Canada, France, Germany, Italy, Japan, the UK and the US) drives an average loss of 3.9 trees or 58 square metres of forest per person per year, which equates to an area equivalent to the size of Denmark; China, India, Russia and the US contribute to the most imported deforestation (Pendrill et al., 2019). The deforestation embodied in international trade originates from locations including biodiversity hotspots such as Southeast Asia, Madagascar, Liberia, Central America and the Amazon Rainforest (Hoang and Kanemoto, 2021).

These findings highlight that countries are offsetting progress made in increasing domestic forest cover through the import of commodities that cause deforestation elsewhere – mainly in tropical regions. Instead of the source of economic pressure being tackled, the countries facing deforestation pressure are expected to manage the issue. These countries are expected to finance and enforce stricter conservation policies, enhance the monitoring of

illegal logging and enforce sanctions against it, and promote sustainable agricultural practices. However, financial constraints, inadequate infrastructure and weak governance systems hinder their ability to implement and sustain effective deforestation control measures – while international support and resources are limited.

International monetary system and financial architecture

Challenges to forest conservation are exacerbated by the international financial system. Svartzman and Althouse (2020) posit that structural imbalances within the global monetary system underscore the ecological and economic challenges faced by emerging market and developing economies (peripheral economies), due to existing monetary hierarchies. They argue that countries with strong currencies (core economies), particularly the US, leverage their highly liquid currencies, such as the US dollar, to dominate the international monetary landscape. This dominance allows them to pursue domestic economic objectives with minimal foreign exchange constraints, thereby reinforcing their position at the centre of the global economy. Conversely, peripheral economies, whose currencies lack liquidity and are seldom used in international trade, face significant risks and higher costs when attracting foreign investment (ibid.). These constraints undermine the ability of peripheral economies to develop sustainable, long-term industrial policies that could enhance their global competitiveness, forcing them to adopt short-term, export-driven strategies focused on low-value-added goods (ibid.). Often, these policies interact with extractivism, resulting in forest loss, to pursue economic activities such as agriculture and mining (Dempsey et al., 2024) that have little benefit to local communities.

Furthermore, peripheral economies remain vulnerable to external financial conditions, such as interest rates set by the US Federal Reserve and the fluctuating confidence of international investors. These exogenous factors can lead to volatile and destabilising exchange rate movements in peripheral economies. This exacerbates the 'survival constraint' that emerging market and developing economies face, which compels them to continuously seek foreign financing to manage their balance-of-payment challenges (Svartzman and Althouse, 2020). Moreover, the need to compete for foreign direct investment results in the adoption of policies in peripheral economies that undermine nature loss, for example dismantling oversight of national forest conservation, enacting preferential exchange rates for commodity exports, degazettement[6] of protected areas, and entering into international treaties that protect ongoing extractive activities (Dempsey et al., 2024). As a result, these economies become trapped in a cycle that prioritises short-term gains over long-term development.

Concerns are increasingly being raised about large global banks financing and brokering deals with companies supplying and trading deforestation-linked products, particularly in the production of beef, soy, palm oil, pulp and paper, rubber and timber. Between 2016 and 2020, 20 major companies were identified as being involved in deforestation, with financiers for these activities headquartered in the EU, UK, US and China earning substantial revenues from these deals (Global Witness, 2021). In addition, 300 of the largest companies operating in forest-risk sectors were found to be primarily financed by banks from Brazil, Indonesia, China, the US and Japan (Forests and Finance, 2023). More recently, Marsden et al. (2024b) identified a cluster of 39 companies – many of which are linked to the financial system – that are heavily involved in land-use change and environmental degradation in the Brazilian Amazon and Indonesian peatlands through their supply chains, corroborating reports from environmental organisations. Marsden et al. find that many of these companies that pose ecological tipping point risks are linked to the global financial system. In particular, there is a concentration of key financial players that parallels the oligopoly in the agricultural sector. For example, financial flows to the Brazilian Amazon are primarily managed by institutions

[6] Degazettement refers to legal changes that ease restrictions on the use of a protected area, shrink a protected area's boundaries or eliminate legal protections entirely (IPBES glossary).

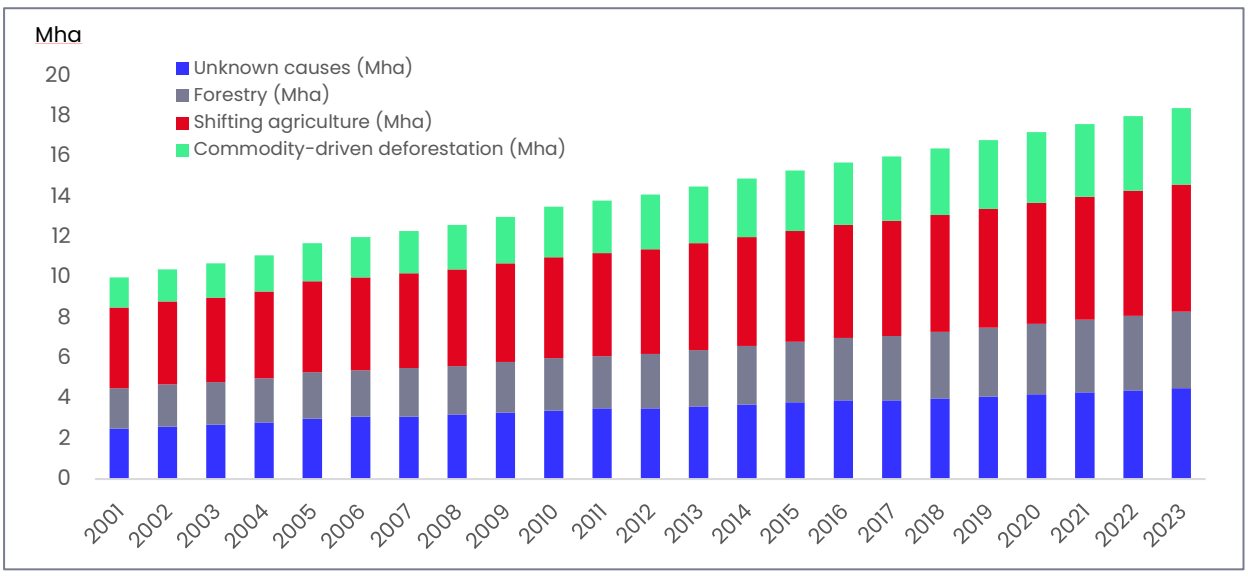
based in North America and Europe, while those affecting Indonesian peatlands are largely controlled by regional institutions, especially in Indonesia, Japan and China.

Domestic pressures: trade-offs between environmental conservation and economic growth

While international trade and external demands on land are increasing, domestic economic pressures are also rising in countries that are home to forest ecosystems. Forests have been cleared to obtain resources (namely, wood) and to create spaces suitable for agriculture, pastures and urbanisation throughout human history. Socioeconomic pressures such as demographic growth, urban expansion and agricultural production have therefore always played a role in human society's relationship with forests. Countries with large forested areas often face difficult choices when balancing the need for economic development and the protection of their natural resources. This tension is especially pronounced in emerging market and developing economies, where poverty alleviation and economic progress are pressing priorities.

Figure 3.2 shows global annual tree cover loss attributed to the main drivers of deforestation. One of the primary domestic pressures that leads to forest loss, particularly of tropical forests, is the expansion of agricultural production (Curtis et al., 2018). Evidence on deforestation trends suggests that in Latin America, commercial agriculture in the form of cattle ranching and soy is the main driver, while in Southeast Asia, the leading drivers are timber and oil palm plantations, and in Africa, small-scale subsistence agriculture, although commercial agriculture and timber plantations are also expanding there (Pacheco et al., 2021). As populations grow and urbanisation increases, demand for arable land and food production rises, prompting the conversion of forested areas into farmland or pastures. Notably, although agriculture drove over 90% of deforestation in countries with tropical forests from 2011–2015, only half of the cleared land became productive agricultural land (Pendrill et al., 2022).

Figure 3.2. Global annual tree cover loss by dominant driver



Source: Global Forest Watch www.globalforestwatch.org/dashboards/global/

Another driver of agricultural expansion is demand for bioenergy, with biofuels such as biodiesel based on soybean oil, palm oil and ethanol made from sugarcane and corn leading to land-use change (Adami et al., 2011). The impact of biofuel crops on forests has led to the creation of several conservation initiatives including the soy moratorium and the 2009

ban on sugarcane expansion in the Amazon (Macedo et al., 2012). While these restrictions prevent direct forest conversion for biofuel crops, they may lead to the conversion of existing cattle farms or plantations for these crops, leading to indirect land -use change (ILUC) in other locations (Bicalho et al., 2016; Jusys, 2017; Nepstad et al., 2008).

The economic incentives provided by global demand for agricultural commodities often outweigh the perceived benefits of forest conservation, undermining long-term environmental sustainability. The same can be said for clearing land to mine metals, which has become even more lucrative in the context of the low-carbon economic transition, with further pressure to mine in emerging market and developing economies due to legislation that limits the creation of new mines in advanced economies (Nobletz et al., 2024).

Understanding forest loss generally requires consideration of multiple interacting processes, rather than a single direct factor. While the most relevant direct cause of deforestation in the tropics is conversion for agriculture, pastures and mining, this often interacts with infrastructure expansion such as road-building to facilitate economic growth and connect remote areas, creating access to previously intact ecosystems. New transport networks expose previously inaccessible forests to logging activities, illegal settlements and further deforestation.

To be effective, policies for managing forest risk must address first and foremost the outsized influence of agriculture, timber (including biomass), mining and energy generation. The operational model of these industries depends on the large-scale destruction of forest ecosystems, which significantly exposes them to transition risks from future initiatives seeking to protect forests. However, the scale of impact from these industries is also linked to the supply chains of a wide range of products, including the automobile, textile, chemical and personal care sectors, and, most challengingly, low-carbon technologies. A fair share of the pressure on forests must also be attributed to these activities.

4. Governance amplifiers

Despite decades of international targets being set to curb deforestation, little has been achieved to arrest the continued increase in forest loss. This section looks at how the governance systems at the national and global levels that underlie how forests are managed and used are failing to protect forests in the face of increasing economic pressure. Current approaches to governance continue to enable the exploitation of forests, therefore adding to the risk of ecological collapse.

Deforestation rarely occurs in a governance vacuum: there are often legal and political processes by which deforestation is enabled or deterred. The prevailing policy approach, which employs quantitative target-setting, has been questioned as an effective way to bring about meaningful and transformative change in land-use governance (McDermott, 2023). The economic pressures described in Section 3 act on multiple scales and form complex interactions with other drivers of deforestation and forest ecosystem degradation such as poverty, insecure land tenure, weak forest sector governance and institutions, poor cross-sectoral coordination and illegal activity (IPCC, 2021). Unless these underlying drivers are addressed with a focus on equity, justice and inclusion, forest and land-use governance will continue to be fraught with issues that enable and amplify the extraction of resources and forest loss.

Global governance

Absence of enforceable global mechanisms on forests

Unlike approaches taken for issues such as climate change, desertification and biological diversity, there is a notable absence of an overarching global convention on forests. The concept of a Global Forest Convention was proposed at the 1992 Rio Earth Summit but was strongly opposed on the basis that forests are a natural resource belonging to a sovereign state that has the right to use forests in line with development objectives (Humphreys, 2005).

The first initiative to resemble a global framework for forest protection was established in 2010 with the Aichi Biodiversity Targets, 20 ambitious goals adopted under the Convention on Biological Diversity (CBD). These targets were designed to address the ongoing loss of biodiversity and set a strategic framework for global efforts to conserve biodiversity. Building on the Aichi Targets, the New York Declaration on Forests constituted a voluntary and non-legally binding international declaration introduced during the UN Climate Summit held in New York in September 2014. Among the goals set by the New York Declaration was the goal to halt global deforestation by 2030 and restore 350 million hectares of degraded forests and land by 2030.

The Kunming-Montreal Global Biodiversity Framework was adopted in December 2022, further expanding on the Aichi Biodiversity Targets of the CBD. One of its objectives is to commit at least 30% of the planet's land and oceans to protected status by 2030, which would imply substantial efforts to combat deforestation. The Glasgow Declaration on Forests and Land Use, introduced in November 2021 at the UN climate conference COP26 made a similar attempt at convening global action on forests by creating a voluntary commitment to end and reverse deforestation and land degradation by 2030. The Declaration has been signed by nearly 150 nations, representing 75% of the global trade in forest-risk commodities and 85% of global forest cover. Alongside the Declaration, 12 countries pledged US$12 billion as part of the Global Forest Finance Pledge, channelling public finance to support the protection, restoration and sustainable management of forests. However, current investments in forest conservation are vastly inadequate compared with the scale of the problem. Furthermore, private sector investment in sectors contributing to deforestation

continue to outpace conservation efforts, with financial institutions being very active in financing deforestation-risk sectors (Forest Declaration Assessment Partners, 2023).

Several issues persist in the global context of forest governance. Most important is the absence of enforcement mechanisms due to the non-legally binding nature of existing agreements. Voluntary initiatives are rarely translated into domestic legislation, regulations or enforcement. Without a basis in law, there are no standardised definitions, nor an alignment of monitoring processes, tracking mechanisms, accountability measures and implementation strategies. Furthermore, there is a lack of clarity around the information that companies are required to disclose on their forest-related activities, which adds to the challenge of assessing their impacts.

Inconsistencies in defining and classifying forests and associated concepts

A range of terms and proxies are used to depict diverse conditions and changes within forests. In the absence of a global convention on forests, efforts to standardise these terms and definitions are chiefly led by the Food and Agriculture Organization (FAO) of the UN, through initiatives such as the Global Forest Resources Assessment (FRA). However, there remain discrepancies in the definitions adopted by different initiatives on land-use governance at the global and local levels (see Appendix), and therefore also in their execution (Mackey et al., 2021).

Even the term 'forest' itself is differently defined across two major international environmental agreements: the UNFCCC and the CBD. In the Marrakesh Accords of 2001, the UNFCCC defined forests as having a minimum land area of 0.05–1 hectare (UNFCCC, 2001; definition adopted to guide land use, land-use change and forestry activities under the Kyoto Protocol). In the CBD of 2006, forests are defined as having a minimum land area of 0.5 hectares (CBD, 2006). The UNFCCC's definition also sets a lower threshold for tree height, at 2–5 metres, in comparison to the CBD's 5 metres. The UNFCCC also includes areas of forest that have been "temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest", and "all plantations which have yet to reach a crown density of 10–30% or a tree height of 2–5 metres" (UNFCCC, 2001). Under this definition, both natural forests that are converted or degraded for timber harvesting and industrial timber plantations would count as forests. This definition does not reflect the ecological conditions of forests, with an intact primary forest having far greater biodiversity and ecosystem integrity and higher carbon stock and sequestration potential than a degraded forest or timber plantation (Rogers et al., 2022; Keith et al., 2024). The FAO has attempted to reflect these differences in its updated FRA, clarifying, for example, the differences between primary forests and plantation forests (see Table 4.1 and the appendix).

Terms that reflect different ecological states and changes to a forest are not necessarily used in national forest governance frameworks, which adopt classification systems inherited from colonial land-use systems, or best suit current administrative processes. Some countries do not distinguish between primary forests, which have a broad diversity of species, and plantation forests that are managed and typically have one or two tree species (Agarwal et al., 2023; FAO, 2018). States may also permit concessions for managed logging within areas of intact forest landscapes, which over time may be further degraded and encroached upon, and may lead to deforestation outside of the concession areas, but may not be reflected as such in statistical accounts.

Table 4.1. Overview of forest-related terms and definitions used in forest governance frameworks

Term	Definition	Source
Forest	"Forest is a minimum area of land of 0.05–1.0 hectares (ha) with tree crown cover (or equivalent stocking level) of more than 10–30% with trees with the potential to reach a minimum height of 2–5 metres (m) at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30% or tree height of 2–5ms are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest."	United Nations Framework Convention on Climate Change, [UNFCCC] (2001)
Forest	"Forest is a land area of more than 0.5 ha, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use. In the case of young forests or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5m in situ, and of meeting the canopy cover requirement."	Convention on Biological Diversity [CBD], (2006)
Plantation forest	Planted forest that is intensively managed and meets all the following criteria at planting and seed maturity: one or two species; even age class; and regular spacing.	FAO Forest Resources Assessment 2025 (FAO, 2023)
Primary forest	Naturally regenerated forest of native species, where there are no clearly visible indicators of human activities and the ecological processes are not significantly disturbed.	FAO (2023)
Primary forest	A primary forest is a forest that has never been logged and has developed following natural disturbances and under natural processes, regardless of its age.	CBD (2006)
Secondary forests	"A secondary forest is a forest that has been logged and has recovered naturally or artificially. Not all secondary forests provide the same value to sustaining biological diversity, or goods and services, as did primary forest in the same location."	CBD (2006)

Note: See the Appendix for fuller and further descriptions.

In practice, national categories of land use differ, and countries use a variety of sources with inconsistent definitions to report and communicate land-use, land-use change and forestry (LULUCF) activities to the UNFCCC, including agricultural census data, forest inventories and remote sensing data (IPCC, 2003). Even under UNFCCC methodologies, states are not compelled to harmonise their domestic definitions or categorisations of forest management with international environmental agreements. This results in a multitude of operational definitions of forests and deforestation across jurisdictions and policy frameworks, posing challenges to global initiatives aimed at tracking and halting deforestation (de Oca et al., 2021). For example, part of the reason none of the 20 Aichi Biodiversity Targets were fully met was due to a lack of common mechanisms for monitoring and reporting of the targets of

reducing biodiversity loss by the end of 2020 (CBD, 2020; Maxwell et al., 2020), a factor in which was the absence of agreed definitions.

Lack of accountability in international market-based instruments

In the absence of enforceable global mechanisms, international market-based instruments have been developed to tackle forest loss. Payments for Ecosystem Services (PES) programmes define frameworks for voluntary transfers of incentives for land management practices providing ecosystem services. In the context of forest loss, the 'Reducing emissions from deforestation and forest degradation in developing countries' (REDD+) framework allows developing countries to receive payments when reducing deforestation to reduce emissions. REDD+ gained enough traction to generate US$1.3 billion in traded carbon offsets in 2021. However, rather than substituting for the lack of coordinated efforts in curtailing deforestation, REDD+ is similarly constrained by that precise challenge (Brown et al., 2011). Emission reductions from voluntary REDD+ projects are independently claimed and currently difficult to scale-up or integrate into broader climate management frameworks such as NDCs. Moreover, their effectiveness in reducing deforestation is contested, as estimations are based on ex-ante established baselines and projections. When compared to more realistic counterfactuals, REDD+ estimations are shown to reduce forest loss on a much smaller scale than officially reported. Ultimately, this uncoordinated approach does not prevent offset emissions from being calculated according to a contested methodology that often overestimates the levels of deforestation avoided, thereby enabling unmitigated additional emissions for holders of offsets (West et al., 2020; 2023).

While there is an absence of coordination among states, there has been an increase in private sector pledges and initiatives to align with the voluntary forest declarations and the Kunming-Montreal Global Biodiversity Framework. Firms have made individual organisation-level zero-deforestation pledges, primarily through No Deforestation, Peat and Exploitation (NDPE) commitments, and have signed up to initiatives like the Task Force on Nature-related Financial Disclosures (TNFD) to fund conservation, many of which combine private sector and state intentions through private–public partnerships. Nonetheless, there remain challenges regarding the scope and effectiveness of financial pledges. Notably, pledged funds for forest conservation and nature-based solutions have gone unaccounted for, with financial disclosure under the TNFD being the primary method of governance (Irvine-Broque and Dempsey, 2023). Additionally, economic pressures, such as foreign countries or investments engaging in land grabs for securing food or extracting fossil fuels, remain unaddressed and lack coordinated legal safeguards. Crucially, the issue of equity is also overlooked, which underscores the failure of target-setting to adequately address key concerns (McDermott 2023).

Trade and supply-chain governance

Countries importing forest-risk products tend to mitigate the associated risks by ensuring legality, promoting certification and regulating the trade of commodities linked to deforestation. However, these measures often fall short of preventing deforestation and fail to address its root causes. Ensuring legality typically focuses on compliance with local laws, which can vary significantly in their effectiveness and enforcement. Promoting certification aims to encourage sustainable practices but often suffers from inconsistent standards and limited market coverage. Moreover, it places a disproportionate burden on small-scale farmers to meet certification standards due to high compliance costs, complex requirements and limited access to resources. Although farmers frequently receive a small share of the financial benefits from certified products, it is the large companies that capture most of the added value.

Regulating the trade of commodities linked to deforestation can act as a financial disincentive, but regulation does not directly target the practices driving deforestation. Consequently, these solutions, although valuable, primarily serve to manage the symptoms

of deforestation rather than tackling the underlying economic and governance issues that perpetuate forest loss.

Ensuring legality

Given the predominance of international trade in driving deforestation, countries have sought to enact policies or legislation that aim to avoid importing products linked to deforestation abroad. Historically, these trade-based policies have focused on the issue of legality, with the aim to curb illegal deforestation. Purchasing countries (or blocs, in the context of the EU) legislate to prohibit the import of products that violate the laws of the country of origin and require declarations of legality and proof of due diligence in ensuring their legal origin. This is also premised on respecting state sovereignty and ensuring that imported products are legal by host country definitions.

Since they place no constraints on legal deforestation, these approaches are ineffective in preventing forest loss, as the legislation framework on deforestation in origin countries is often nascent or fragile. Moreover, even if a strong legal regime does exist, countries do not always have the means to ensure enforcement. On the other hand, the emphasis on legal forest production significantly empowers pre-existing institutional and power structures to define access to and use of resources. Therefore, it inadvertently strengthens state actors (at federal and local levels) and creates incentives for political patronage and elite capture.

Some approaches attempt to go even further. For example, the EU Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan introduced in 2003 sought to enforce the EU's Timber Regulations and establish voluntary partnership agreements (VPAs) for trade with supplier countries, as a way to address the lack of governance capacity in origin countries. VPAs explicitly target how countries define legality in the context of deforestation, and include EU support for legal and governance reforms such as capacity-building for policymakers and civil society engagement. However, this approach presents new challenges. First, rather than addressing environmental equity and structural challenges, VPAs are powerful instruments for the EU to influence policymaking in other regions, pursuing domestically-determined environmental protection goals. Moreover, it is not clear that VPAs are able to deliver on their objective of reforming forest governance. For example, Ghana and Cameroon have not been able to approve legality verification frameworks, a critical objective of FLEGT, despite having VPAs in place (Carodenuto et al., 2024). Indeed, only one country – Indonesia – has managed to issue FLEGT licences to date. The FLEGT initiative has contributed to establishing processes and accountability mechanisms in Indonesia, but has not been successful in holding all actors in the supply chain accountable (Villanueva et al., 2023), with reports of corrupt practices and loopholes enabling illegal logs to enter the supply chain through large certified companies (Setyowati and McDermott, 2017; Neupane et al., 2019). Villanueva et al. also find that VPAs have been found to weaken the rights of access and forest tenure of local communities by prioritising international actors. In terms of the effects of VPAs on the international timber market, they conclude that exporting companies have diverted the volume of timber previously destined for the EU to less restrictive markets, and importing companies in the EU have substituted their supply of timber volume to non-partner countries; as a result, the overall supply of illegal timber has not been reduced.

Promoting certification

Market-led initiatives have emerged to track and verify the source of commodities and determine whether they are produced sustainably. One key example of a certification scheme is the Forest Stewardship Council (FSC), which was launched in 1993 to spur demand for wood-based products that meet standards of sustainable forest management. Standards were set at global and national levels and audited by third-party verifiers. A standardised system of tracking and auditing was set up to facilitate global transparency for consumers and buyers. Similar standards and certification schemes now exist for products including palm oil (e.g. the Roundtable on Sustainable Palm Oil [RSPO]), cocoa (e.g. Rainforest Alliance) and rubber.

While certification schemes have contributed to raising awareness and improving practices in some areas, they pose several challenges, particularly for smallholders. Small-scale producers often face significant barriers to market access due to the high costs associated with obtaining and maintaining certifications. These costs can include fees for the certification itself, the expense of adapting to required practices, and the ongoing costs of compliance and audits. For smallholders with limited resources, these costs can be prohibitive, effectively excluding them from certified markets (Ndoumbe and Ongolo, 2019).

Certification standards like the Clean Development Mechanism (CDM), Verified Carbon Standard (VCS), and the Climate, Community and Biodiversity Alliance (CCBA) all require documentation of land tenure and property rights. However, tenure issues further complicate the certification process. For example, in many regions, land ownership and usage rights are unclear or contested, making it difficult for producers to meet certification requirements. A lack of clear tenure can lead to conflict and undermine the credibility of certification schemes.

The quality of audits conducted by third-party verifiers also varies, raising concerns about the reliability and integrity of certification. Inconsistent auditing practices and the potential for conflicts of interest can result in certified products that do not truly meet sustainability standards, thereby eroding consumer trust. Major scandals involving prominent certification schemes, including the FSC, RSPO and Program for Endorsement of Forest Certification (PEFC), have further highlighted these issues. Lengthy reports from non-governmental watchdog organisations like the Environmental Investigation Agency (EIA) and The Borneo Project have exposed how these schemes often fail to protect forests. For example, one report details questionable auditing practices for the RSPO (EIA and Grassroots, 2015), and another exposes how certified FSC and PEFC timber are sometimes sourced from illegal logging or unsustainable sources, where fraudulent land transactions and human rights violations have occurred, undermining the very goals of environmental protection and conservation (EIA, 2015; The Borneo Project and Bruno Mansor Fonds, 2023).

Certification schemes do not always address deeper equity and structural issues within supply chains. They may not adequately consider the socioeconomic conditions of smallholders or the power imbalances between large corporations and local producers. Without addressing these fundamental issues, certification alone cannot drive the systemic change needed for truly sustainable and equitable commodity production.

'Leakage' issues present another significant challenge. Certified and non-certified products can become mixed together during transportation and processing, diluting the effectiveness of certification schemes. This mixing, or leakage, undermines efforts to ensure that only sustainably produced commodities reach the market.

Regulating forest-risk commodities

Going a step further than ensuring legality, states have sought to regulate the trade of forest-risk commodities by prohibiting both legal and illegal deforestation in products entering their market. The only example to date is the EU Deforestation Regulation (EUDR), which is innovative in this respect. The EUDR aims to guarantee that the products that EU citizens consume do not contribute to deforestation or forest degradation anywhere in the world. The regulation covers seven commodities (cattle, cocoa, coffee, palm oil, rubber, soya and wood), and many derived products;[7] mineral resources are a notable omission. Coming into force for most products (excluding timber) in June 2023, the regulation has significant implications for emerging and developing economies which rely on EU imports of their products.

[7] These include meat products, leather, chocolate, coffee, palm nuts, palm oil derivatives, glycerol, natural rubber products, soybeans, soy-bean flour and oil, fuel wood, wood products, pulp and paper and printed books.

The EUDR defines deforestation relatively narrowly as the conversion of forests for agricultural purposes, owing to the scope and purpose of the regulation to tackle deforestation driven by the EU's demand for agricultural commodities. It does also acknowledge other dynamic processes that have destructive impacts on forest cover in its definition of forest degradation[8] and states the intention to review and update this definition based on scientific evidence and developing global perspectives around the scope of the term.

Implementation of the EUDR is yet to play out, but policy roll-out and review should pay attention to the following issues:

- Leakage
- Loopholes in due diligence, disadvantaging small-scale farmers
- Uncertainties about sources of data needed from suppliers to prove whether concessions are legitimate
- Countries lobbying against being put on the 'high risk' list
- Reorienting status quo agricultural policies towards other kinds of commodities that could have the same demand on land, e.g. mining for minerals
- A lack of similar legislation being passed by other big importers, thus shifting the destination of products linked to deforestation to jurisdictions with fewer legislative barriers.

Domestic governance

Just as domestic economic issues put pressure on forests, domestic governance issues amplify forest loss. As many impacts from biodiversity and nature loss are intrinsically local, so too are the risks. Forest ecosystem services, such as soil conservation and hazard protection, derive from the material influence of trees in their immediate surroundings. The localised effects of forest loss mean that megadiverse countries[9] face a stronger imperative to protect their forests if they want to protect the ecosystem services that they provide to their economy. The local specificity of deforestation effects also has implications within nations: forest loss directly denies forested regions the benefits that they offer, hurting their economy and exposing them to disproportionate risks. Even if the economic impact may seem manageable at the national scale, the materialisation of these risks often results in severe, concentrated impacts to specific regions and economic sectors, which further complicates the national economy's ability to absorb them.

Governments predominantly view forested lands, except for protected area designations, as resources or sources of alternative land use for revenue generation. Countries therefore have complex legal regimes (which are also often ambiguous) for governing land-use change, using policy instruments and legal structures that are fit for developmental purposes, not for conservation and regeneration. They may have decentralised systems of land governance that devolve authority to subnational governments to grant permits or approve development projects in forested lands. In this context, there are often disputes over the control of forests and erratic policy coordination within the domestic governance landscape. Powerful actors at the top echelons of national and subnational government institutions exploit this fragmentation through so-called 'cunning governance', where strategic and often manipulative approaches in the management of natural resources are used to achieve other, often economic, goals (Ongolo et al., 2015).

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[8] This definition includes "the conversion of primary forests or naturally regenerating forests into plantation forests into other wooded land; or primary forests into planted forests".

[9] Conservation International identifies 17 'megadiverse' countries which exhibit particularly high levels of biodiversity: Australia, Brazil, China, Colombia, Democratic Republic of the Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, the United States and Venezuela.

Countries in which subnational governments have significant authority in land matters include India, Brazil, Indonesia and Malaysia (Busch and Amarjagal, 2020). Subnational governments also tend to view forests as a source of income, particularly when there are budgetary or capacity constraints, sometimes due to insufficient allocation or mismanagement of funds for other public goods. This has spurred the use of Ecological Fiscal Transfers, an intergovernmental revenue transfer mechanism that compensates subnational governments for the costs and opportunity costs of conservation (Busch et al., 2021).

The effective functioning of multi-level land governance systems tends to face issues such as ambiguous lines of authority, grey areas in land tenure or concession-granting processes, and coordination problems among different government actors, enabling land contestation and encroachment of public forest lands (Pacheco et al., 2021). These create opportunities for elite capture, political patronage and rent-seeking that enable deforestation despite existing environmental laws and regulations.

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) summarises key factors that contribute to increasing forest loss in tropical regions in the context of environmental law enforcement:

- Weak forest sector governance and institutions, conflicting policies beyond the forest sector, corruption and illegality
- Poor implementation and enforcement of environmental laws owing primarily to a lack of political will
- Conflicting legal instruments, lack of clarity in implementation, monitoring and evaluation, poorly defined and fragmented responsibilities across multiple agencies
- Lack of sanctions, transparency and accountability
- Open-ended decision-making, exacerbating political asymmetries.

For example, pressure on forests often arises from transport-system expansion projects. In Brazil, the 4,260km BR-230 Trans-Amazonian Highway was one of the most significant government-led projects to have facilitated deforestation. In the Brazilian Amazon, 94.9% of deforestation takes place in an 'accessible zone' near to roadways or navigable rivers (although a region's protection status may mitigate this effect) (Barber et al., 2014). Deforestation governance challenges similarly arise in association with policies intended to strengthen the agricultural sector, such as subsidies or tax breaks. In Mexico, the PROGAN subsidy for livestock was shown to increase municipal deforestation by 7%. This subsidy is particularly inefficient as a simultaneous payment for ecosystem services (PES) scheme is also in place, which mitigates the effects of PROGAN, demonstrating a lack of appropriate targeting in these measures (Moffette and Alix-Garcia, 2024).

Forest loss is also significantly affected by administrative approaches to exploiting natural resources such as timber and plantation concessions. Even the implementation of Sustainable Forest Management (SFM) principles in timber concessions can lead to increased deforestation rates, as they are associated with higher international investment flows and timber demand. For example, SFM-based concessions in the Republic of the Congo exhibited up to double the amount of deforestation and increased rates of legal timber production (Brandt et al., 2016).

These domestic governance issues therefore remain largely tied to increasing global demand for commodities and rising consumption levels, often from outside the areas where forests exist. Public policies that intend to increase economic output, such as through building roads and infrastructure and converting forests into agricultural land, are often rolled out with a lack of transparency and accountability and minimal human rights protection for Indigenous groups and local communities that live in and close to the forests. The implications of forest loss are felt most by those who lose their homes and livelihoods to such projects. Not only are they disproportionately exposed to physical risks from forest loss:

they also bear the cost of defending the forests, often against multinational companies and powerful government actors. Despite a long history of violations of Indigenous Peoples' rights which continues today, these peoples have been recognised as the best stewards of remaining forestland, with growing evidence documenting that deforestation is lower in Indigenous and community lands than outside of them (Busch and Ferreti Gallon, 2023; WRI, 2024).

5. Economic and financial impacts of deforestation

Deforestation and land-use change bring about material economic and financial impacts that affect households, firms, financial institutions and the wider economy. This section explores the various ways in which forest loss affects households, the production processes of firms, financial institutions and the broader macroeconomy to understand the ways in which deforestation risk is transmitted to the financial system. Collectively, these factors contribute to a cycle of economic vulnerability, reduced productivity and increased financial instability, underscoring the critical need for sustainable land-use policies.

Table 5.1 summarises examples of ecological and economic impacts of forest lost before we take a more detailed look at the impacts on households, firms and the macroeconomy.

Table 5.1. Example impacts from the loss of forest ecosystem services

Example ecosystem services	Ecological impacts from their loss	Economic impacts from their loss
Water capture and filtration	Decline in water quality	Increased mortality; healthcare costs
Protection from hazards – storms, floods and landslides	Rising impacts from hazards	Human fatalities; capital destruction
Regulating temperatures	Rising temperatures	Increased mortality; healthcare costs; lost production
Regulating the carbon cycle	Rising carbon emissions	Capital destruction; reduced agricultural output; lost production
Regulating diseases	Disease outbreaks	Increased mortality; healthcare costs; lost production; school absenteeism
Air quality	Rise in air pollution	Increased mortality; healthcare costs; lost production
Provisions – timber, biomass, food, non-timber forest products	Decline in provision of valuable resources and materials, including pollination services	Loss of livelihoods; reduced output for timber, agriculture and forest product industries
Soil quality conservation	Decline in soil quality	Reduced output for agriculture and hydropower generation
Precipitation and hydrological cycle	Changes in precipitation patterns	Reduced output for agriculture and hydropower generation; reduced tourism
Habitat, species and biodiversity intactness	Loss of biodiversity	Weakened forest resilience and exacerbated risk of ecosystem service losses

Source: Authors

Impacts on households

Deforestation can significantly impact the economic wellbeing of households at the individual level, manifesting through various channels such as disease outbreaks and compromised air quality, which directly affect health. These effects can directly jeopardise the livelihoods of marginalised rural populations, particularly in relation to the impacts of logging on non-timber forest resources that are essential for livelihoods (Rist et al., 2012).

Disease outbreaks: By disrupting ecosystem equilibrium and increasing human exposure to wildlife, deforestation can lead to more frequent disease outbreaks. Forest loss in the Brazilian Amazon has increased malaria incidence, particularly in interior regions where forest cover is higher (MacDonald and Mordecai, 2019). The economic and social impacts of increased malaria incidence include premature mortality, medical costs, school absenteeism and disproportionately high fertility rates and population growth, due to behavioural responses to expected childhood mortality (Sachs and Malaney, 2002).

Air quality: Deforestation directly and indirectly increases the risk of forest fires, which are significant sources of air pollution. The removal of air pollution by trees and forests in the US in 2010 was estimated to be worth US$6.8 billion to human health (Nowak et al., 2014). There is also a massive impact on mortality from the particulate matter emitted by forest fires. The early-life mortality caused by Indonesia's 1997 wildfires consisted of 15,600 child, infant and fetal inferred deaths, estimated to have cost above US$15 billion (Jayachandran, 2009). This excludes the health costs among survivors. The healthcare cost of the 2018 California wildfires were estimated at US$32.2 billion due to increased mortality, medical expenses and work time lost (Wang et al., 2020).

Temperature regulation: Deforestation impacts labour productivity through the loss of temperature regulation, in particular reducing resilience to heatwaves; this affects households as well as at the firm level (see below). An exploration of how large-scale deforestation increases the risk of exposure to extreme heat caused by climate change found that vulnerable regions will particularly suffer from physiologically intolerable heat levels, which affect workability, mortality associated with cardiovascular disease, psychological outcomes and kidney disease (Alves de Oliveira et al., 2021). A field experiment in rural communities in Indonesia demonstrated that subsistence agriculture worker productivity was 8.22% lower in deforested areas, where temperatures were higher (Masuda et al., 2021). This productivity gap is explained by behavioural adaptations such as having to take more frequent breaks. Tropical deforestation is associated with local warming, which significantly affects outdoor working conditions and productivity; between 2003 and 2018 tropical deforestation may have resulted in a total loss of 0.5 billion potential safe work hours per year (0.5 hours per day for 2.8 million workers) (Parsons et al., 2021), and as climate change intensifies, this will likely worsen.

Natural disasters: Due to their importance in the Earth system, forests (and forest loss) affect resilience to natural disasters and extreme weather events, which cause human fatalities and damage physical capital. In particular, land-use change exposes deforested regions to damage by floods. Forest cover reduces loss of life and damage to property (Bhattacharjee and Behera, 2018; Agarwal et al., 2023). In the case of Trinidad, the annual monetary benefit of forests' flood risk regulation services was estimated to be between US$16 and $218 per hectare, depending on catchment characteristics (Brookhuis and Hein, 2016). For a region in Georgia, Brander et al. (2018) calculate that forest degradation could cause the annual costs from landslides to more than quadruple from US$196,000 to $852,000 by 2035.

Forest fires: Damage caused by forest fires can be sizable. For example, the 2018 California wildfires were estimated to have caused US$4.5 billion in damages to household property, in addition to the 104 direct victims and 3,652 deaths due to air pollution (Wang et al., 2021).

Impacts on firms and production processes

Deforestation poses significant challenges to firms' production processes, impacting both physical ecosystem services and introducing transition risks that can disrupt supply chains and operational sustainability. We describe the impact channels through which these risks impact firms below.

Physical risks

Hydrological services: Aylward (2005) provides a comprehensive overview of how deforestation diminishes economic welfare due to changes in water quality and quantity:

- Deforestation leads to increased sediment levels, including through soil erosion, resulting in clogged irrigation systems and reduced efficiency of hydropower facilities.
- Runoff from deforested areas can carry nutrients and chemicals into water bodies, affecting water quality and increasing treatment costs for industries dependent on clean water.
- Deforestation can decrease the water storage capacity of a region, particularly due to decreased infiltration capacity of eroded soil, impacting both irrigation and hydropower generation.

These changes affect agricultural production, disrupt downstream hydropower and irrigation facilities, reduce benefits from fisheries, tourism and flood regulation, and elevate water treatment costs. For example, deforestation in the Brazilian Amazon has been shown to impact agricultural production downstream (Wu et al., 2021). Crops are sensitive to changes in precipitation and temperature, with repercussions for agricultural productivity (Arellano Gonzales, 2023). Reduced water availability significantly impacts hydroelectricity generation in the US and Europe, underlining the global implications for energy-dependent industries (Colesanti Senni and Jagow, 2024). Moreover, Pérez-Rubio et al. (2021) show that landholders recognise the economic value of water availability and soil erosion control. Their willingness to accept restoration projects underscores the economic importance of these ecosystem services for maintaining and enhancing productivity.

Forest fires: Although deforestation is not directly responsible for forest fires, it contributes to their frequency and intensity. In the US, wildfires, the incidence of which is exacerbated by climate change'have been shown to reduce the economic value of land used for the production of timber by 8.78%, with most of the effect coming from changes in expectations, rather than direct burning on specific properties (Wang and Lewis, 2024). The total costs from the 2018 California wildfires are estimated at US$148.5 billion, with damages to productive capital including commercial, industrial or public assets amounting to US$27.7 billion (Wang et al., 2020). The impact of wildfire smoke on labour markets in the US from 2007-19 led to decreased quarterly earnings through reduced air quality, in turn diminishing worker health and productivity (Borgschulte et al., 2022). Consequently, businesses face heightened operational costs and reduced output, exacerbating the financial strain caused by direct fire damage.

Temperature regulation: The impacts on labour at the household level discussed above combine to affect firms' productivity and profitability.

Invasive species: Land-use change, particularly deforestation and land clearing through fire, creates conditions that accelerate the spread of invasive species, undermining productivity and increasing management expenses across agriculture, forestry and fisheries. In agriculture, invasive plants reduce yields and increase weed management costs, while invasive insects damage crops, directly lowering productivity (Susi and Laine, 2020). Similarly, forestry operations face rising operational costs and declining profitability due to pests and diseases that harm valuable tree species (ibid.). Additional revenue losses are incurred as invasive species reduce product quality and marketability, with damaged crops failing to

meet market standards and the loss of valuable tree species limiting access to high-quality timber (Chort and Öktem, 2023).

Transition and litigation risks

In addition to physical risks, deforestation exposes economic actors to transition risks: namely, a misalignment between their economic activity and actions related to the restoration or conservation of nature. Growing awareness of the impacts of climate change and forest loss on the economy in the past decade has created a global policy paradigm that recognises the importance of preserving forests and biodiversity. For example, Brazil's government is already committed to zero deforestation by 2030 (Rodrigues, 2023). As a result, economic activities that significantly contribute to forest loss are expected to face increasing limitations. Transition risks may also materialise in the form of evolving market and investor sentiment, consumer preferences or technological advances that render certain activities obsolete. Litigation risks are also covered in this section, as corporate and financial law duties may stem from companies that depend on and negatively impact forest ecosystems.

Policy risks: In a context of worsening biodiversity decline and climate change, the expected policy response is to address deforestation. Some jurisdictions have explicitly attributed legal personhood to the environment, for example making national parks and rivers in New Zealand juridical entities endowed with rights, and establishing the rights of nature in Ecuador and Bolivia (Gordon, 2019). In addition, sustainability due diligence laws such as the EU's Corporate Sustainability Due Diligence Directive (CSDDD) could oblige companies to prevent environmental degradation, including deforestation. These policy changes can exacerbate litigation risks faced by firms and the financial institutions funding their activities (see also Section 3).

A more established way for governments to tackle deforestation is by upholding deforestation-free value chains. For example, as described in Section 4, the EU Deforestation Regulation (EUDR) was recently enacted to ensure deforestation-free products enter the EU marketplace. The EUDR will be reviewed by June 2025 on "the role of financial institutions in preventing financial flows that contribute directly or indirectly to deforestation and forest degradation and assess the need to provide for any specific obligations for financial institutions in Union legal acts in that regard, taking into account any relevant existing horizontal and sectoral legislation" (EU Directive 2023/1115: Article 34(4)). Similar measures are being considered in the UK through the Forest Risk Commodities regulations, and the US through the FOREST Act.

The 2023 EU Renewable Energy Directive (RED III), which updates the renewable energy framework across the EU, also creates transition risk. The agreement includes several new provisions for the use of forest biomass, eliminating the eligibility of energy generated by certain wood categories (namely, primary and old growth forests) to receive subsidies or count towards renewables targets. It also lowers the reporting threshold for biomass plants and enhances monitoring of how the cascading principle for wood use is applied. EU policymakers to phase out the use of palm oil as a biofuel feedstock, given its high probability of causing indirect land-use change (ILUC) and the role of European countries in driving embodied deforestation elsewhere around the world (Bausano et al., 2023). The European Parliament has also voted for a lower threshold in ILUC risk, which effectively bans soy use for biofuel, although the exact enforcement of this decision depends on the European Commission (Goulding Carroll, 2022).

Legal risks: Firms may face more targeted restrictions due to their specific impacts on forests. Upholding stronger regulations to conserve or protect forests can be realised through litigation initiatives, which can result in material financial consequences in the form of fines, stranded assets or impacts on firm valuations. Policy pressure may also originate from domestic institutions, particularly financial system supervisors (as described later in this

section). As deforestation becomes a more salient issue, these newly created policies are rapidly being upheld in court, often supported by technological developments in satellites and traceability. Following an initial wave of climate justice initiatives targeting governments' climate change commitments, civil society has turned its attention to corporate actors responsible for sizable greenhouse gas emissions. For example, following the decision in 2018 against the Dutch Government in the case of *Urgenda Foundation v. State of the Netherlands*, a group of non-governmental organisations (NGOs) filed a complaint against Royal Dutch Shell in 2019, alleging hazardous negligence in failing to reduce its contributions to climate change (*Milieudefensie et al. v. Royal Dutch Shell plc.*). The initial 2021 ruling determined that Shell should take action to limit the volume of its emissions by 45% relative to 2019 levels, both from its own operations and from the use of the fossil fuels it produces (though Shell has appealed). Legal cases have also been brought by public entities, such as the city of New York, the state of California, and certain municipalities in California which have sued oil and gas giants (Exxon, Shell, Chevron and others) for misleading the public regarding the role of fossil fuels in warming the planet.

Establishing the causal link between activities and damage can be more straightforward in court cases about forest loss than in cases about climate change. A collective of political parties presented a case in 2020 to the Brazilian Supreme Court based on the failure of the Federal Union to adopt measures concerning both the Climate Fund and the Amazon Fund (*PSB et al. v. Brazil [on Amazon Fund]*). The Supreme Court ruled that the federal government had failed its duty to activate and fulfil these funds, ultimately exacerbating trends of deforestation and climate change, causing significant political repercussions. In the *Lhaka Honhat Association v. Argentina* case, the Inter-American Court of Human Rights ruled that Argentina had breached its obligation to respect Indigenous groups' property rights, including the right to a healthy environment, food, water and cultural identity, with reparation measures including the recovery of forest resources (Tigre, 2021). In 2018, members of Pakistan's civil society filed a petition against government departments for failing to implement policies to protect forests in Punjab (*Sheikh Asim Farooq v. Federation of Pakistan etc.*). In court, the Government was found to have neglected its duties to apply existing laws and was consequently ordered to reforest recent urban settlements, improve reporting on forested areas, and better enforce national forestry legislation.

In addition to public authorities, private entities have been targeted by litigation connected with forest loss. For example, in 2021 a group of Brazilian and Colombian Indigenous People and environmental NGOs brought a case against the French supermarket chain Casino concerning the alleged sale of Amazon deforestation-linked beef (*Envol Vert et al. v. Casino*). According to the litigants, this constitutes a failure of due diligence obligation under France's duty of vigilance law. In addition to NGO-led cases, evolving legislative toolboxes have enabled national authorities to file environmental class-actions against companies and private persons. In Brazil, in 2019 the Federal Environmental Agency (IBAMA) sued a steel company and its managing partner for the firm's longstanding use of illegally sourced coal, which promoted an illegal deforestation scheme (*Federal Environmental Agency [IBAMA] v. Siderúrgica São Luiz Ltd. and Martins*). Similarly, the Amazon taskforce within the Public Prosecutor's office sued a Brazilian farmer in 2021 for causing the deforestation of 2,500 hectares of forest, ordering the removal of cattle from farms and seeking compensation for monetary damages (*Ministério Público Federal v. de Rezende*). In 2017, the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) fined JBS, the largest meat processing enterprise in the world, US$7.7 million for purchasing cattle raised on deforestation-linked pastures (BloombergNEF, 2023). As early as 2009, the Indonesian Government sued two mining firms for damages linked to illegal mining, including the clearing of protected forests (*Minister of Environment v. PT Selatnasik Indokwarsa and PT Simpang Pesak Indokwarsa*). In 2014, the defendants were found liable by the Supreme Court and were ordered to compensate for the greenhouse emissions from destroyed forests, as well as restoration costs.

Risks from shifting preferences: Changes in consumer and investor perceptions are significant sources of financial risk for companies. As the impact of deforestation becomes more salient, firms may face challenges related to decreased demand by consumers and lower appetite from investors. These risks may apply to companies contributing to deforestation and to the financial institutions financing them. Van Gelder et al. (2017) document how eight million Indonesian consumers are willing to shift to sustainable palm oil products based on sustainability concerns. At a global level, European consumers have been important drivers of the uptake of certified sustainable palm oil (CSPO), which represents 93% of total European imports of palm oil and 45% of the total market (EPOA et al., 2022). NGOs often play a role in these decisions, with organisations such as Forests & Finance and Responsibank enabling cross-bank comparisons based on sustainability impacts. In the Amazon, NGOs uncovered the link between the soybean and cattle industries and deforestation (Greenpeace International, 2006; 2009). Since then, these companies have had to adapt their practices to maintain or improve their reputation, for example by designing Brazil's Soy Moratorium (Gibbs et al., 2015).

Risks from changing preferences can manifest at different stages along the value chain, resulting in operational difficulties for firms. For example, the implementation of stricter procurement policies by palm oil buyers has forced non-sustainable growers out of the market. To meet commitments such as No Deforestation, No Peat, No Exploitation (NDPE), firms often demand certifications such as the International Sustainability and Carbon Certification or the Roundtable on Sustainable Palm Oil Certification, which has significantly reshaped the palm oil market and constrains the action of deforestation-inducing firms (Yeong Sheng et al., 2021). More broadly, voluntary sustainability standards have become relevant conditions for market access, affecting in particular the cocoa, palm oil, soybean, and timber industries (Larrea et al., 2021), notably the 2006 Soy Moratorium and 2009 Beef Conduct Adjustment Agreement (TAC) in the Amazon. Similarly, the adoption of the Principles for Responsible Investment (PRI) by investment institutions worldwide signals growing awareness by investors and financial institutions to reduce their exposure to deforestation-inducing practices. For example, following concerns regarding its connections with deforestation-linked pastures, meat processor JBS had its shares sold by Norway's Government Pension Fund Global and by Nordea Asset Management due to unacceptable risk (BloombergNEF, 2023). Ultimately, this may result in an increase in the financing costs of non-compliant firms, which will face higher interest rates in order to cover the additional risks (van Gelder et al., 2017).

Technology risks: Recognising the criticality of reducing human impacts on forests has motivated serious efforts to develop enabling technologies. Successful technological developments could enable economies to satisfy their needs without resorting to operational models that cause deforestation. For example, the known impact of cattle-raising on forests is fuelling innovation in the food industry to advance plant-based protein offerings and lab-grown meat. While clearly beneficial for the environment, these breakthroughs could negatively impact the bottom line of companies that rely on environmentally harmful practices.

Second-order risks: A set of second-order risks directly stem from the deforestation risks outlined above. The materialisation of deforestation risk in sectors such as energy generation that have high-risk exposure transmits to other companies and sectors in the supply chain, who face either increased and more volatile input prices or lower demand for their output. For example, hydropower plants in the Amazon are heavily dependent on the forest's hydrological cycle. Deforestation, which reduces rainfall, disrupts this cycle, directly affecting energy output. Stickler et al. (2013) focused research on an energy complex in the eastern Amazon and predicted that in the future electricity generation will be 40% lower than industry estimates, achieving only a quarter of the plant's maximum potential, as energy companies fail to account for deforestation's impact on rainfall.

Wang et al. (2020) determined that indirect impacts, estimated through aggregate value-added losses related to value chain disturbances, accounted for 59% (US$88.6 billion) of the total estimated damages from California wildfires in 2018. Due to the interruption of transport, labour supply impacts and the destruction of productive capital, these large indirect losses affected economic activity beyond the immediate location of the wildfire.

Macroeconomic impacts

The economic repercussions of deforestation and the corresponding loss of ecosystem services are often material enough to manifest in aggregate production and price-level impacts. For example, significant declines in **pollinators** associated with habitat destruction and deforestation directly affect crops; over the period 1991–2012 these shocks caused a negative impact on global output valued at US$235-577 billion (Breeze et al., 2016).

The impact of land-use change on **wildfire** regimes can have macroeconomic impacts: for example, southern European economies are estimated to lose €1.3–2.1 billion per average wildfire season (Meier et al., 2023). These costs are likely to recur year after year as wildfire become more common with climate change. While the effect on employment is heterogeneous across sectors, with tourism-related activities being the most affected, the aggregate negative effect on regional GDP growth rate has been calculated as 0.11%–0.18% (ibid.).

The macroeconomic impacts of vulnerability to more frequent and severe **floods** are connected with forest loss. A lack of forest cover has been correlated with the economic damage caused by floods across a sample of 56 developing countries (Bradshaw et al., 2007). Destruction from hurricanes was estimated to have had an average negative impact of 0.8 percentage points on the annual economic output of Central American and Caribbean countries (Strobl, 2012), which is relevant to deforestation given the role of forests in protecting against storm damage.[10]

Unavailability of **clean water,** which can be exacerbated by forest loss, has significant economic implications. Degraded water quality through river pollution has been found to reduce economic growth in downstream regions by 1.4% (moderate levels of pollution) and 2.5% (high levels), with even stronger effects in low- and middle-income countries (Desbureaux et al., 2019). A study on the relationship between economic growth and water scarcity and quality in 177 countries concluded that while water pollution is associated with positive impacts on GDP per capita in the short term, it negatively affects the five-year growth rate, and there seems to be a clear limit to the extent to which economies can benefit from pollution-generating activities (El Khanji et al., 2016). Moreover, water scarcity and economic growth are found to have a U-curve relationship, with water utilisation initially benefitting growth but eventually becoming a constraining factor.

Macroeconomic implications also derive from the disruption to essential **ecosystem services** caused by forest loss, which affect long-term economic stability. These ecosystem services are often undervalued in the economy, even when there are efforts to place a value on them. A cost-benefit analysis comparing the value of intact Amazonian forests with agricultural land considered ecosystem services such as timber production, water recycling and fire control, estimated that the total economic value of forested land amounted to approximately US$18,000 per hectare (Andersen, 2015). The analysis suggested that, in the short term, agricultural land yields higher economic returns, but did not take into account that as forests diminish, the cumulative value of standing rainforests surpasses that of converted agricultural land. Another study assessed the trade-off between forest conservation and logging, quantifying the benefits of carbon sequestration and tourism activity, and logging

[10] The link between natural disasters and macroeconomic losses more generally is very well documented (e.g. Cavallo et al., 2021; Noy, 2009), including through decreases in exports and, therefore, in GDP (Mohan, 2017; Spencer and Polachek, 2015).

revenues in Australia's Central Highlands (Cross et al., 2022). The researchers concluded that ending deforestation between 2022 and 2030 would generate a net benefit of US$59 million in present value terms. See Box 5.1 for more on Cost–Benefit Analysis.

Economic effects from the loss of ecosystem services are most likely to stem from several impact channels, which may result in significant **aggregate shocks**. In the UK, degradation of the natural environment has been conservatively estimated to result in a fall in GDP of between 6% and 12% by the 2030s, depending on the scenarios considered, and even before accounting for the impacts of climate change (GFI, 2024).[11] In Nicaragua, a preliminary report by the World Bank (2018) analysed the cost of environmental degradation to society, including of deforestation. Here, estimations of different ecosystem services provided by forests (including carbon removal and storage, watershed protection and non-timber forest products) were combined to place the annual cost of deforestation in the country at US$162 million, or 1.2% of GDP in 2016.

Beyond direct effects on output, impacts of forest loss can manifest in price-level changes and affect international economic relations – e.g. through disease incidence and natural disasters. Deforestation contributes to malaria incidence, as well as other disease outbreaks, which can lead to reduced savings and investment rates and limits to economic relations (such as migration, trade and foreign direct investment flows) with regions and counterparts not affected by malaria (Sachs and Malaney, 2002). Natural disasters (including floods, storms and droughts) can lead to changes in price levels (Parker, 2018): in general, developing countries normally see inflation rise following a natural event. This effect is broken down in short-term increases in food prices and negative impact (deflation) in housing and other sub-indices, with further implications for exchange rates and capital accounts. The inflationary effect of droughts is generally longer lasting than that of storms and floods.

Box 5.1. Cost–benefit analysis in the deforestation context

Cost–benefit analysis (CBA) is an economic decision-making tool used to assess the value of a project or policy by comparing its costs and benefits to help determine whether the benefits justify the investment. It attempts to assign a monetary value to all impacts, including both direct financial costs (e.g. expenses, resources) and indirect or non-market effects (e.g. environmental or social change).

When applied to valuing forest ecosystems, CBA captures both the tangible and intangible benefits that forests provide. These can include:

- Timber production: Forests generate income through the sale of wood and related products
- Recreation: Forests provide spaces for tourism, hiking, camping and other outdoor activities, which can be a source of revenue
- Ecosystem services: These include carbon sequestration, water filtration and soil stabilisation which contribute to climate regulation, biodiversity and human health
- Biodiversity preservation: Forests serve as habitats for countless species, preserving ecological balance and supporting genetic diversity, which is difficult to monetise but invaluable

The costs can include:

- Management expenses
- The opportunity cost of not converting forest land to other uses (like agriculture or real estate)
- Potential financial losses arising from physical and transition risks

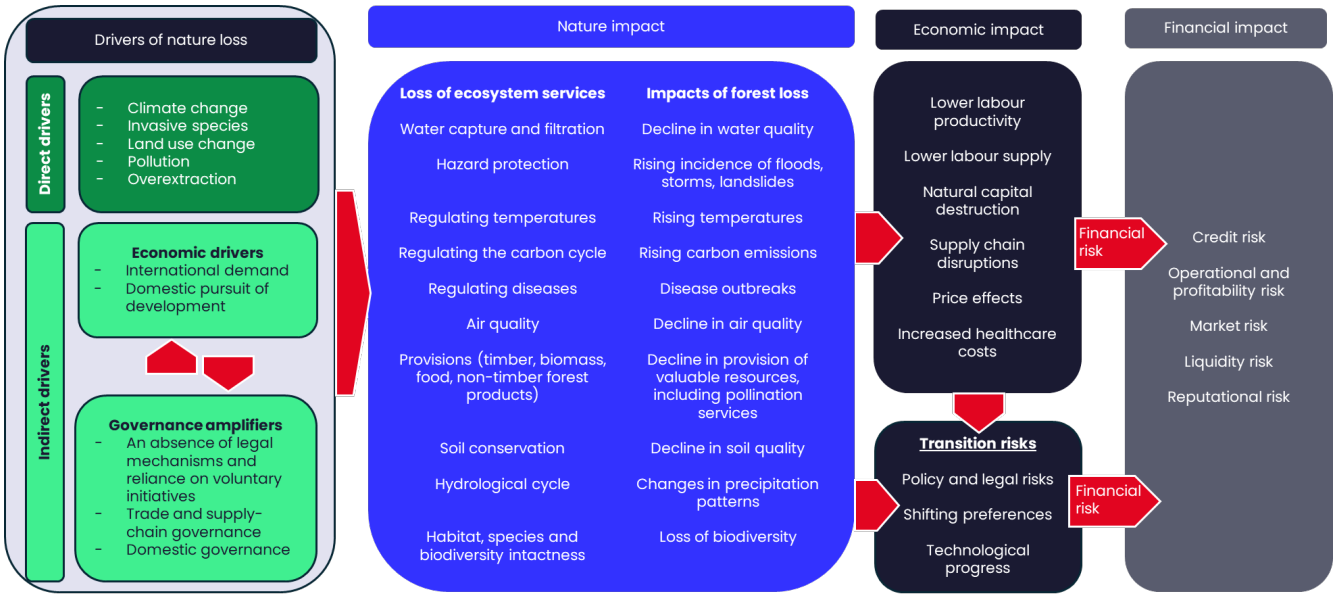
[11] The scenarios differ, but impacts include effects on agriculture due to soil health degradation and pollinator decline, on energy production due to lower water quality and scarcity, overexploitation of fisheries, or antimicrobial resistance incidence, and secondary effects on health expenditure, productivity due to pollution, and geopolitical instability.

Highlighting the relevance of deforestation in Mexico in this context, Arellano Gonzalez et al. (2023) show how heatwaves create pressures on price indices, mainly on fruit and vegetables, and with geographical heterogeneity across the country.

Risk transmission to the financial system

The financial risks from deforestation to firms and households described above translate into risk for financial institutions and the financial system as a whole. All these impacts ultimately transmit into financial institutions, manifesting in asset devaluations and credit market instability – in addition to the other credit, market, liquidity and operational risks examined below. Although individual financial institutions are affected, the cumulative impact heightens systemic risks that threaten financial stability and economic resilience – see Figure 5.1.

Figure 5.1. Transmission channels from direct and indirect drivers of nature loss to natural, economic and financial impacts



Source: Authors

Credit risk

One of the most significant deforestation-related risk exposures for banks is that the impact of such risk on corporate or retail entities may result in their decreased ability to repay their loans and a higher incidence of non-performing loans (NPL). The physical and transition risks highlighted in the previous section could financially impact firms and households to the extent that they cannot honour their commitments or are even put out of business: this is a particular source of concern for financial institutions exhibiting a concentration of at-risk counterparties.

A recent flood risk assessment revealed that 6.5% of the total loan exposures of Colombian banks are in municipalities at high risk of flooding (Reinders et al., 2021). Severe flood scenarios could lead to declines in capital adequacy, with impacts on the capital adequacy ratio further influenced by exacerbating factors such as the flood's severity (ibid.), which is directly affected by deforestation trends causing increased sedimentation in rivers (Restrepo et al., 2015). Moreover, banks with high exposures in rural areas or to sovereign debt are substantially more vulnerable to flood hazards, with severe natural disasters leading to possible downgrades of sovereign debt, which has significant implications for the financial system. In Mexico, extreme heat events have been shown to affect credit default and credit use, with a particularly strong effect on small and medium-sized enterprises and the

agriculture sector (Aguilar-Gomez et al., 2022). Here, indirect effects are also highlighted: in regions with a sufficiently large proportion of agricultural workers, extreme heat also affects non-agricultural sectors that depend on the productivity and spending of agricultural workers, such as retail and services. These labour productivity impacts further showcase the relevance of the temperature regulation provided by intact forests. Brazil's central bank conducted a stress-test considering the RCP 8.5 scenario[12] with drought frequency accentuated for 2030 and 2050, and concluded that the number of financial institutions exposed to drought-risk sectors and locations through their credit books is set to increase over time. The Southeast region (mainly Cerrado and Mata Atlántica) is the most exposed due to the credit volumes allocated to the region and number of municipalities with high risk of drought.

Financial regulators are increasingly aware of these concerns and often take a system-level approach to assessing the nature-related vulnerabilities of the financial sector. A preliminary analysis of the impact of the loss of ecosystem services on loan quality in Brazil shows that 46% of Brazilian banks' total corporate loan portfolio (20% of their total credit portfolio) is to companies operating in sectors highly or very highly dependent on ecosystem services, particularly climate regulation, groundwater and surface water (World Bank, 2021). The authors estimate a long-term increase in corporate NPLs of between 4.5% and 9% due to physical risks and highlight that specific sectors, such as agriculture and livestock, may be particularly affected. Similarly, GFI (2024) examined the potential impact of nature shocks on the domestic loan portfolio of UK banks through a nature risk stress-test and estimated a potential devaluation of 4–5% from nature risks alone, with certain banks facing particularly serious risks. A critical country for global biodiversity, Mexico has assessed its banking sector's exposure to and impact on ecosystem services (Martinez-Jaramillo et al., 2023), finding that more than one-third (36.5%) of banking sector lending is to sub-industries that are highly or very highly dependent on one or more ecosystem service, exposing financial institutions to physical risks. The study also found that 64.9% of bank lending is to sectors that have a high or very high impact on one or more ecosystem services, exposing financial institutions to transition risks. Equivalent analyses have been conducted for the Dutch financial sector (Toor et al., 2020) and Malaysia (World Bank and Bank Negara Malaysia, 2022), with similar findings.

Banks rely on collateral assets as stable and reliable safeguards against credit risks. However, the valuation of these assets may not adequately account for future nature-related impacts, meaning that banks could be under-protected. In case of client default, banks may find themselves holding assets with a market value that is significantly inferior to their accounting value (such as in the case of stranded assets).

Operational and profitability risk

In response to heightened exposure to credit risks of NPLs and insufficient collateral, banks may need to adjust their current operations to properly account for biodiversity risk and minimise their losses. This could result in higher collateral requirements, interest margins and enhanced monitoring systems, with lower revenues and higher costs for banks. The negative effect on bank profitability may impact provision levels, making banks more vulnerable to future crises and raising concerns around the level of financial system preparedness.

Due to increasing awareness of the financial system's responsibility in driving forest loss, there is growing regulatory pressure on the financial sector to actively support sustainable development goals and adequately manage physical and transition risks linked to environmental degradation. This includes, for example, the adoption of sustainable strategies or ensuring that financed entities comply with environmental regulation. This has implications for the current business model of banks, forcing them to change existing

[12] RCP 8.5 is the highest baseline emissions scenario in which emissions continue to rise throughout the 21st century.

operational procedures, exposing them to legal costs and penalties for non-compliance, and potentially preventing them from working with some of their existing customer base.

Brazil's central bank has already implemented regulations that require financial institutions to report on environmental risks and incorporate them into risk management frameworks. The central bank has also introduced regulation with restrictions to the provision of rural credit, requiring due diligence processes to ensure that financing does not contribute to deforestation (Banco Central do Brasil, 2024). In Indonesia, a permanent moratorium on land conversion for palm plantation and logging activities was issued in 2019, which has severely impacted the performance of these sectors (Diela, 2019). Governments have also imposed stricter management practices to control the spread of invasive species – another source of increased regulatory scrutiny and compliance costs (Guégan et al., 2020). Increased regulatory pressure can also result in legal risks, exemplified by the lawsuit filed in 2023 targeting French bank BNP Paribas, which is accused of conducting insufficient due diligence before providing services to firms allegedly responsible for deforestation, land-grabbing and forced labour (*Comissão Pastoral da Terra and Notre Affaire à Tous v. BNP Paribas*).

Insurance companies in particular face underwriting risks. As the main entity responsible for safeguarding customers against physical risks, the insurance and reinsurance industries are exposed to the consequences of forest loss on the frequency and intensity of natural disasters, and their financial repercussions. Insurers face increasing liabilities, with unexpected shocks resulting in higher insurance claim pay-outs, which could lead to a refusal to accept or renew policies in areas with high nature-related risks. This is already playing out: State Farm Insurance, for example, will no longer accept new applications for home insurance in California due to wildfire and financial risk. This is particularly worrying in a context of limited data availability and insufficient supervisory guidance on nature-related risks. These heightened risks are also driving insurance firms to adjust their risk selection and risk pricing strategies, ultimately impacting the ability of certain economic activities to rely on insurance services to hedge against risks (Schelske et al., 2020).

Market risk

The loss of ecosystem services also affects the financial system through the market value of assets. Physical and transition risks force economic actors to reassess the valuation of exposed assets, which may result in added volatility and significant value reductions in the balance sheets of financial institutions, for example through fire sales. While climate-related risks are increasingly priced in, understanding of forest loss risk is still limited, exposing financial institutions to volatility in significant portions of their portfolios. For example, 42% of the securities portfolio (by market value) held by French financial institutions is highly dependent on ecosystem services (Svartzman et al., 2021), exposing portfolios to potential losses. In the Netherlands, 36% of the investment portfolio of listed shares held by financial institutions, equivalent to €510 billion, is 'highly' or 'very' dependent on ecosystem services (Toor et al., 2020).

The impact of deforestation risk has macroeconomic implications beyond individual entities. As a result, the value of government bonds is also significantly exposed to natural impacts, which constitutes another channel through which financial institutions must account for forest risks in the value of their holdings.

Liquidity risk

The credit, operational and market risks reviewed in this report all complicate the financial standing of banks and other financial sector institutions, and could jeopardise their ability to access financing with favourable terms. This would create serious feedback loops for financial stability, as liquidity difficulties provoked by the materialisation of these risks may prevent banks from adequately managing payment obligations, at least without incurring losses, and further weaken their position.

Nature-related risk also directly affects banks' liquidity through counterparty borrowing behaviour, potentially impacting their ability to source necessary funding for their operations. In particular, natural shocks severely affect customer behaviour, as households and companies increasingly demand liquidity to weather these events. Koetter et al. (2020), examining the phenomenon of recovery lending at a regional scale, found that companies affected by floods in Germany increased their borrowing, which then led exposed local banks that are not geographically diversified to incur higher credit risk and exhibit weaker capital positions.

Simultaneously, households' greater need for liquidity may lead them to withdraw deposits, adding pressure to banks by limiting their fundraising ability. The materialisation of deforestation risk in specific shock moments (for example, natural disasters) can trigger liquidity crises, whereby market funding conditions contract, for example due to changes in risk appetite, and relevant assets, such as affected infrastructure, may suddenly become illiquid or significantly less valuable.

Reputational risk

Financial institutions are also increasingly exposed to reputational risks linked to their financing of forest-degrading activities due to shifting market or consumer preferences (see Section 3 for a discussion of impacts on firms). Retail customers may prefer to deal with banks that take deforestation concerns seriously, similar to how some customers avoid products that are directly linked to deforestation. This may affect financial institutions' ability to provide services and raise funds through deposits. Reputational risk also extends to other sources of funding, as most institutional investors are committed to decreasing their impact on nature, whether for business concerns or reasons of principle.

To provide an idea of the scale of this risk, analysis of the vulnerability of Dutch financial institutions to companies with high reputational risk identified a €97 billion exposure to firms not reporting or publishing information on deforestation risks (Toor et al., 2020). This is supported by findings from Thompson (2023) which reveal significant gaps in addressing deforestation risks: 75% of more than 700 climate-committed financial institutions lack a public deforestation policy, with only 21% recognising deforestation as a business risk. None are on track to eliminate commodity-driven deforestation by 2025. While 25% have a deforestation policy for at least one high-risk commodity, only 10% cover all key commodities. Additionally, just 26% have policies on labour rights, 18% on free, prior and informed consent, and only 1% enforce zero tolerance for violence against forest defenders.

6. Policy implications

The significant implications of deforestation for existing economic and financial systems call for engaged and ambitious public action by financial supervisors, central banks and policymakers. This is particularly urgent given insufficiency of efforts to prevent deforestation, which, left unchecked, can lead to risks affecting the environment, human societies, the economy and the financial system.

Economic and financial systems are intrinsically connected with the natural world. As such, the large-scale environmental degradation taking place across the world poses an existential risk to global economies. Meanwhile, environmentally destructive practices, such as forest degradation, are often provoked precisely by economic pressures and amplified by governance challenges. Growing demand for food and minerals in the coming decades is expected to continue to build pressure on forests. Adequately navigating the interlinkages between economic activity and the natural world is one of the fundamental challenges facing economic and financial policymakers today.

Policymakers' responsibilities mostly involve coordinating the activities of market agents to maintain economic and financial stability while ensuring adequate levels of environmental protection. For this effort to be effective, a broad range of authorities must coordinate their initiatives to address deforestation risks. The financial sector enables deforestation, therefore there is a clear need for coordination between government, central banks and financial supervisors to address this.

Key challenges for policy development on deforestation risks

To effectively tackle the threat of deforestation risk, governments, central banks and financial supervisors must recognise and address the specific challenges of this policy area.

Coordination on local and global scales

While deforestation necessarily has a global element to it, through its interaction with climate change and global trade, it affects first and foremost the locality in which it takes place. This means that megadiverse countries, mostly located in the Southern hemisphere, stand to lose the most from further forest loss. This dynamic has important consequences for the way policymakers regard deforestation, or nature-related risk more broadly, particularly when there is already a tendency to treat them identically to climate risk, or worse, to take a 'climate-first then nature' approach. Many forest-rich territories are low- or middle-income countries where developmental trade-offs are more acute, and the economic activities contributing to deforestation are often key for raising incomes and improving wellbeing. In addition to domestic pressures on growth, structural imbalances in the international financial system effectively coerce poorer countries to prioritise environment-damaging activities, such as resource extraction (Dempsey et al., 2024). In this sense, megadiverse developing economies have to grapple not only with domestic developmental trade-offs, but also with severe social and environmental impacts from the loss of forests, while contending in the arena of global trade.

While responsible forest management must happen locally, advanced economies play a critical role in contributing to forest conservation globally through their economic influence, consumption demand, and international financial systems that promote deforestation and nature loss. Advanced economies are also still impacted by the negative global effects of deforestation such as through worsened climate impacts, reduced resilience to global pandemics and supply chain bottlenecks, all of which could affect price and financial stability. Governments of advanced economies are increasingly focusing on mitigating their

impact on forest loss through consumption and production and imposing stricter requirements on supply chain due diligence (e.g. through the EU Deforestation Regulation and the US FOREST Act), but these tend to omit future drivers of forest loss such as mining for critical minerals required for the net zero transition.

The local and global dimensions necessitate countries to have a 'commons' approach, which places responsibility to act not only with the countries that host forests, but also on countries that rely on resources, goods and financial accumulation from extractive activities that pressurise those forested lands. Furthermore, the large variation in countries' sovereignty over their forest resources, and the different degrees of freedom they have to define economic policy, affect nations' ability to contribute to forest protection. These dynamics clarify the need for international agreements to foster tailored policy solutions, rather than universal approaches, which would be unfair and unrealistic. This calls for locally adaptive solutions to effectively balance the need for local action with a level of global integration that sufficiently recognises the aggregate repercussions of local deforestation.

Nature complexity: interconnections, synergies and trade-offs

The extreme complexity of the Earth system complicates both conservation efforts and the management of financial risks stemming from nature and forest loss. To effectively act on environmental degradation, public authorities need to improve their understanding of how natural processes occur. Although research is bridging existing gaps, there are several areas in which scenarios remain approximative, due to the sheer complexity of the underlying physical dynamics they seek to model.

The interdependence of ecosystem services highlights the need for integrated policy approaches that consider multiple environmental dimensions simultaneously. Policymakers must recognise how changes in one area affect others, to effectively manage environmental risks and curb nature loss. For example, forests play a critical role in regulating the carbon cycle, requiring climate and nature to be addressed together, rather than in isolation or sequentially. However, central banks and financial supervisors in advanced economies have been slow to adopt this integrated approach, often focusing solely on climate change while overlooking the broader risks of biodiversity loss, despite its recognised impact on financial stability (NGFS, 2022).

Ecological processes often behave in a non-linear way, which introduces an important degree of uncertainty into decision-making. While it is relatively clear when certain actions are detrimental to the environment, it is often challenging to comprehensively account for the full extent of these effects. Often, natural equilibria exhibit tipping points, meaning that changes may initially be marginal, but severe impacts take place in abrupt and irreversible ways. To avoid these, a broader perspective on the consequences of natural degradation is needed, incorporating medium- and long-term impacts to the economic and financial system.

The complexity of measuring nature risk poses a significant challenge for decision-makers when setting objectives and tracking progress. Unlike carbon emissions, which provide a clear metric for climate change, nature risk involves multiple variables, leading to varying methodologies and goals across countries and over time. This complicates national policy design and international coordination to address biodiversity threats. However, focusing on specific drivers of nature loss such as deforestation offers a clearer path forward. Sectors like agriculture, infrastructure and mining are well-known contributors to deforestation, and advances in data and technology now enable better monitoring of forest loss. As a result, deforestation risk *can* be addressed – as it must be.

Economic assessment and government policy

Government stakeholders and their decision-making practices must play a critical role in preventing further forest loss. As current approaches to governance favour economic development at the expense of forest protection and regeneration, a fundamental shift is required in how governments view and account for the importance of keeping remaining forests standing.

Valuing ecosystem services from forests, while approximate, is useful to understand the benefits of forest conservation, and the opportunity costs associated with forest loss. To adequately account for the benefits of forest conservation, a significant body of work has evolved around the valuation of ecosystem services, enabling the benefits of forest ecosystem services, such as regulating air quality, climate and water, maintaining habitats, and providing products such as food, timber and non-timber forest products to be calculated, even if estimates differ due to the variety of methods used.

Addressing the trade-off between environmental conservation and economic growth requires finding a delicate balance between the two and adopting a long-term perspective. Governments must recognise the value of ecosystem services provided by forests, such as carbon sequestration, biodiversity preservation and climate regulation, and incorporate these considerations into their economic policies.

The disproportionate impact of specific economic activities on forests, including agriculture, mining, timber harvesting and renewable energy generation, calls for additional diligence by economic policymakers related to these sectors. The high concentration of deforestation impacts in these economic activities must be accounted for when assessing their contribution to the economy and the feasibility of additional investments. Policies for managing deforestation risk must first and foremost address the outsized influence of these industries, which depends on an operational model involving large-scale destruction of forest ecosystems and significantly exposes them to transition risks from future initiatives seeking to protect forests.

Governments must reassess their pursuance of growth-oriented development strategies that prioritise increasing aggregate consumption. The scale of impact from the industries listed above is also linked to the supply chains of a wide range of products, including the automobile, textile, chemical and personal care sectors. Beyond improving supply chain traceability, policies that manage the production of and demand for these products should also be in place, with requirements for producers to comply with stronger environmental standards and shifting consumption patterns to more local and less harmful sources. Equity concerns regarding land ownership and market access rights between small local producers and large companies also need to be addressed. Beyond that, auditing practices for voluntary certification schemes need to be regulated and governments can already improve monitoring mechanisms to locate and penalise companies engaging in deforestation with the aid of satellite imagery.

Finance and economic ministries also need to be vigilant of forests being the target of large-scale land acquisitions by foreign governments and companies, and recognise that the potential foreign direct investment benefits from these projects may not necessarily serve their long-term best interests if critical ecosystem services in the host country are destroyed. Economic policies need to be reoriented towards undoing structural inequalities and moving away from fossil fuels and extractive industries as the engine of growth.

A critical trade-off between limiting deforestation and addressing climate change exists in the development of renewable energy generation (namely hydropower dams and biomass) and mining for critical materials required for net zero transition technologies. In these cases, climate change concerns must be considered alongside the risks brought by deforestation and the associated climate impacts. To that end, laws such as the EUDR and

the US FOREST Act should be extended to include the regulation of mining and trading critical minerals as these are expected to pose substantial pressures on forests in the future.

To address the failures of governance systems and institutions to halt deforestation, stronger legal frameworks are necessary to hold governments and private sector actors accountable for their impacts on forests. Should governments remain defiant against initiating a legally binding global convention on forests, any implementation of the 30x30 Global Biodiversity Framework and Declaration on Forests and Land Use Change should at the very least update, refine and standardise the definitions of forests, to reflect their ecological importance and prevent loopholes in accounting for deforestation. At the bare minimum, governments that have pledged to halt and reverse deforestation must uphold the following: not permit any conversion or degradation of intact forest landscapes and naturally regenerating forests (including small forests) for infrastructure expansion, mining, agricultural development, or industrial timber plantations; not revert or decrease their gazettement of protected areas; and strengthen land rights protection for Indigenous Peoples.

Prudential policy

Financial regulators have a key role to play through prudential policy to ensure that the financial sector does not continue to put pressure on forests through the activities they facilitate or finance.

Financial supervisors should enhance microprudential frameworks by promoting and enforcing risk management frameworks that adequately and comprehensively account for nature-related risks. To achieve this, policy design should be informed by a good understanding of the channels through which deforestation transmits financial risk to individual financial institutions. This understanding can be gained through undertaking microprudential assessments for financial institutions that explicitly target deforestation-inducing economic activities, including through supply chains; incorporating nature-related risks in existing risk-based supervision mechanisms, such as Internal Capital Adequacy and Assessment exercises; and creating specific mitigation mechanisms for the materialisation of deforestation risks (disaster risk insurance).

In addition to managing risks to individual financial institutions, financial supervisors should recognise the systemic risks that the loss of forest-based ecosystem services could pose to the financial system as a whole. To this end, it is necessary to enhance macroprudential frameworks to integrate information on forest risk into stress-tests; and incorporate an understanding of ecological tipping points or implications of the loss of forest ecosystems in nature (and climate) scenarios.

Monetary policy

Central banks should lead by example in the implementation of deforestation risk management measures, focusing on active risk management and upholding information reporting standards. In addition to planning their transition from deforestation-linked activities and reviewing taxonomy alignment, central banks should actively monitor and report on the exposure of their balance sheets to deforestation risks, which are often underpriced by the market (OECD, 2021; ECB, 2024). The manifestation of these risks results in decreases in the value of assets purchased in the context of quantitative easing or pledged as collateral.

As public institutions, central banks have a duty to protect their balance sheet from significant financial risks, including deforestation risks, for example by implementing risk-management frameworks that adequately account for risks; making liquidity pricing to financial institutions dependent on the degree of exposure to deforestation risks of the assets pledged as collateral; calibrating haircuts applied to pledged collateral based on the assets'

exposure to nature risks; incorporating deforestation risk in scenario analyses and forecasts of price level developments, including the likelihood of several risks being triggered simultaneously and defining counterparty eligibility for central bank facilities based on their disclosure of and compliance with ceiling for deforestation impacts; and defining the eligibility of assets for purchase or acceptance as collateral based on the same criteria that is applied to their issuer.

Central banks should actively engage in ongoing debates about their role in preventing environmental degradation, and clearly define their strategies on deforestation. Central banks often have multiple mandates beyond price stability, including broader public policy goals. These goals can either be defined as of equal importance or hierarchised. It is vital for central banks to assess the relative importance of their goals and how they interact to subsequently define their policy stance. This could be done by assessing how monetary policy operations directly contribute to pressures on deforestation, such as through the incentive provided by central bank purchase, or acceptance as collateral, of assets linked to nature loss, or the creation of favourable financing conditions for prejudicial activities (such as through targeted credit operations). Central banks could interpret their role as requiring a simple 'do no harm' approach or take an active role in undoing biodiversity damage. In the context of severe nature loss and, particularly, unsustainable levels of deforestation, adopting the traditional 'market neutrality' approach is taking a decision to 'do harm'.

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Appendix.
Definitions of forest-related terms

Term	Definitions	Source
Forest	"Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use. "Explanatory notes 1. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters *in situ*. 2. Includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of 10 percent and tree height of 5 meters. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years. Local conditions may, in exceptional cases, justify that a longer time frame is used. 3. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest. 4. Includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 meters. 5. Includes abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of 10 percent and tree height of 5 meters. 6. Includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not. 7. Includes rubber-wood, cork oak and Christmas tree plantations. 8. Includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met. 9. Includes areas outside the legally designated forest land which meet the definition of "forest". 10. Excludes tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations, olive orchards and agroforestry systems when crops are grown under tree cover. Note: Some agroforestry	*Forest Resources Assessment Working Paper 194 – Terms and Definitions|FRA 2025* (FAO, 2023)

	systems such as the 'Taungya' system where crops are grown only during the first years of the forest rotation should be classified as forest."	
Forest	"'Forest' is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 metres at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest; …"	*Decision 11/CP.7. Land use, land-use change and forestry* (UNFCCC, 2001)
Forest	"…a forest is a land area of more than 0.5 ha, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use. In the case of young forests or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5 m *in situ*, and of meeting the canopy cover requirement."	Convention on Biological Diversity www.cbd.int/forest/definitions.shtml
Naturally regenerating forest	"Forest predominantly composed of trees established through natural regeneration. "Explanatory notes 1. Includes forests for which it is not possible to distinguish whether planted or naturally regenerated. 2. Includes forests with a mix of naturally regenerated native tree species and planted/seeded trees, and where the naturally regenerated trees are expected to constitute the major part of the growing stock at stand maturity. 3. Includes coppice from trees originally established through natural regeneration. 4. Includes naturally regenerated trees of introduced species."	*Forest Resources Assessment Working Paper 194 – Terms and Definitions/FRA 2025* (FAO, 2023)
High Conservation Value Forest (HCVF)	A high conservation value approach to forests places emphasis on biological, ecological, social or cultural values of outstanding significance or critical importance. HCVFs possess one or more of the following: HCV1: Forest areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refugia). HCV2: Forest areas containing globally, regionally or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally	Paraphrased from: *Common Guidance for the Management & Monitoring of High Conservation Values* (FSC and HCV Network, 2014)

	occurring species exist in natural patterns of distribution and abundance. HCV3: Forest areas that are in or contain rare, threatened or endangered ecosystems. HCV4: Forest areas that provide basic services of nature in critical situations (e.g. watershed protection, erosion control). HCV5: Forest areas fundamental to meeting basic needs of local communities (e.g. subsistence, health). HCV6: Forest areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).	
Planted forest	"Forest predominantly composed of trees established through planting and/or deliberate seeding. "Explanatory notes 1. In this context, predominantly means that the planted/seeded trees are expected to constitute more than 50 percent of the growing stock at maturity. 2. Includes coppice from trees that were originally planted or seeded."	*Forest Resources Assessment Working Paper 194 – Terms and Definitions/FRA 2025* (FAO, 2023)
Plantation forest	"Planted Forest that is intensively managed and meet ALL the following criteria at planting and seed maturity: one or two species, even age class, and regular spacing. "Explanatory notes 1. Specifically includes: short rotation plantation for wood, fibre and energy. 2. Specifically excludes: forest planted for protection or ecosystem restoration. 3. Specifically excludes: forest established through planting or seeding which at stand maturity resembles or will resemble naturally regenerating forest."	*Forest Resources Assessment Working Paper 194 – Terms and Definitions/FRA 2025* (FAO, 2023)

Primary forest	"Naturally regenerating forest of native tree species, where there are no clearly visible indicators of human activities and the ecological processes are not significantly disturbed. "Explanatory notes 1. Includes both pristine and managed forests that meet the definition. Management practices in primary forests should imply minimum human intervention and aim for the long-term conservation of native vegetation and wildlife habitat. 2. Includes forests where Indigenous Peoples and local communities engage in traditional forest stewardship and management/use activities that meet the definition. 3. Includes forests with visible impacts of natural disturbances (such as storms, snow, drought, wildfire or insects, pests and diseases outbreaks) 4. Excludes forests where hunting, poaching, trapping, or gathering have caused significant native species loss or disturbance to ecological processes. 5. Some key characteristics of primary forests: i. they show natural forest dynamics, such as natural tree species composition, occurrence of dead wood, natural age structure, and natural regeneration processes; ii. the area is large enough and retains a degree of connectivity such that its natural ecological processes are maintained; and iii. there has been no known significant human intervention, or the last significant human intervention was long enough ago to have allowed natural ecosystem elements (including species diversity) and functions to have become re-established."	*Forest Resources Assessment Working Paper 194 – Terms and Definitions/FRA 2025* (FAO, 2023)
Primary forest	"A primary forest is a forest that has never been logged and has developed following natural disturbances and under natural processes, regardless of its age. It is referred to 'direct human disturbance' [sic] as the intentional clearing of forest by any means (including fire) to manage or alter them for human use. Also included as primary, are forests that are used inconsequentially by indigenous and local communities living traditional lifestyles relevant for the conservation and sustainable use of biological diversity."	Convention on Biological Diversity www.cbd.int/forest/definitions.shtml

Primary forest	"Primary forests are naturally regenerated forests of native tree species, including mangroves and peat forests, whose structure and dynamics are dominated by ecological and evolutionary processes, including natural disturbance regimes, and where if there has been significant prior human intervention it was long enough ago to have enabled an ecologically mature forest ecosystem to be naturally re-established. Many primary forests are also home to Indigenous Peoples and local communities and are the basis of their identity, culture, belief system, traditional knowledge, and livelihoods; a forest that meets the definition above would not be excluded due to the presence of these communities. "As used here, primary forest is a broad term which encompasses related terms including: stable forest, intact forest, old-growth, frontier, long-untouched and virgin forest and is consistent with the ways 'primary forests' are defined by other authorities such as the CBD and the United Nations Food and Agriculture Organization (FAO)."	*IUCN Policy on Primary Forests and Intact Forests Landscapes – January 2020* (IUCN, 2020)
Secondary forest	"A secondary forest is a forest that has been logged and has recovered naturally or artificially. Not all secondary forests provide the same value to sustaining biological diversity, or goods and services, as did primary forest in the same location."	Convention on Biological Diversity www.cbd.int/forest/definitions.shtml
Intact forest landscapes	"…a seamless mosaic of forests and associated natural treeless ecosystems that exhibit no remotely detected signs of human activity or habitat fragmentation and are large enough to maintain all native biological diversity, including viable populations of wide-ranging species. … IFLs include large fragments of primary forests with a minimum extent of 500 km^2…."	*The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013* (Potapov et al., 2017)
Old growth forest	"Old growth forest stands are stands in primary or secondary forests that have developed the structures and species normally associated with old primary forest of that type [and] have sufficiently accumulated to act as a forest ecosystem distinct from any younger age class."	Convention on Biological Diversity www.cbd.int/forest/definitions.shtml

Deforestation	"The conversion of forest to other land use independently whether human-induced or not. "Explanatory notes 1. Includes permanent reduction of the tree canopy cover below the minimum 10 percent threshold. 2. It includes areas of forest converted to agriculture, pasture, water reservoirs, mining and urban areas. 3. The term specifically excludes areas where the trees have been removed as a result of harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures. 4. The term also includes areas where, for example, the impact of disturbance, over-utilization or changing environmental conditions affects the forest to an extent that it cannot sustain a canopy cover above the 10 percent threshold."	*Forest Resources Assessment Working Paper 194 – Terms and Definitions|FRA 2025* (FAO, 2023)