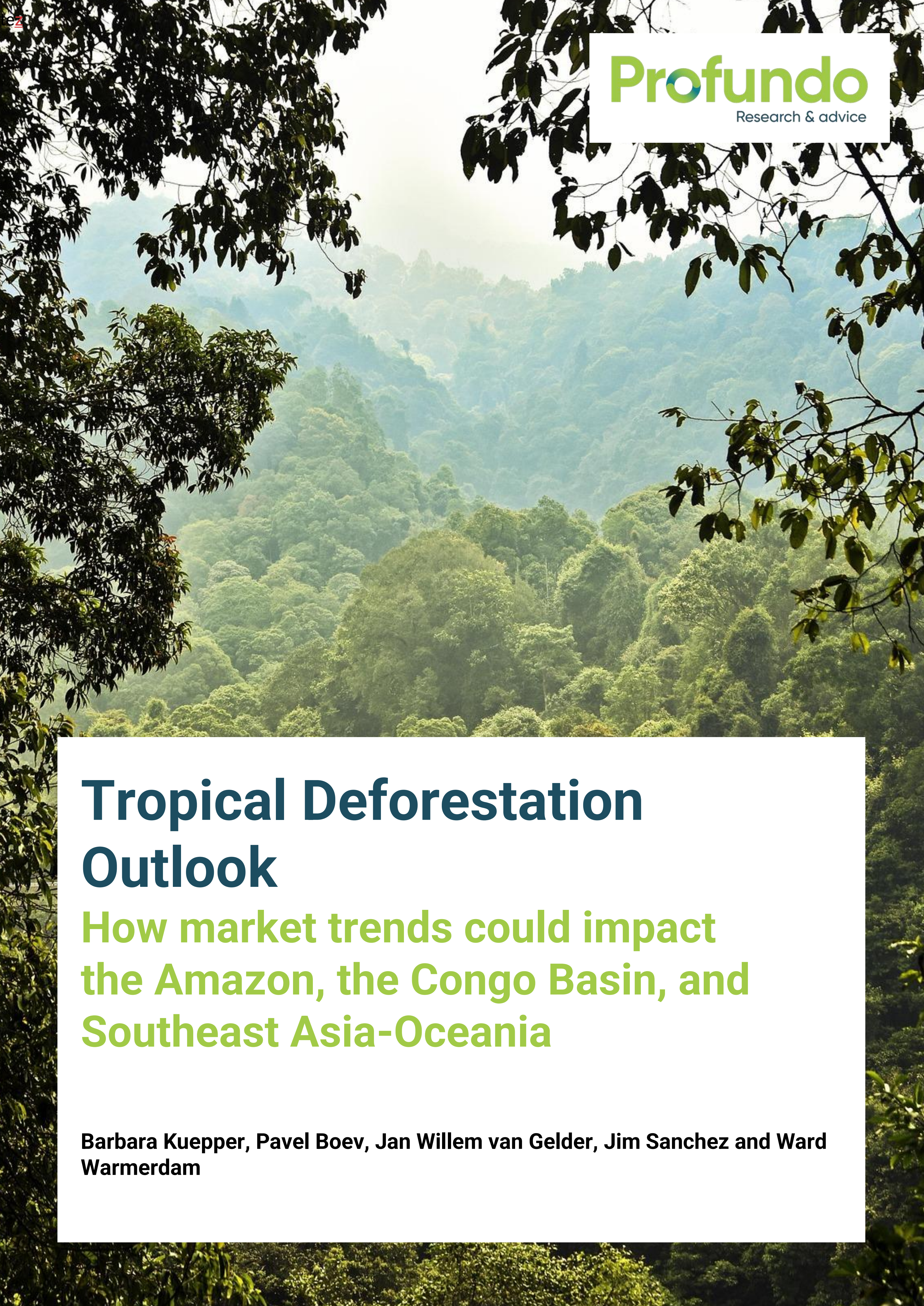

Tropical Deforestation Outlook

How market trends could impact the Amazon, the Congo Basin, and Southeast Asia-Oceania

Barbara Kuepper, Pavel Boev, Jan Willem van Gelder, Jim Sanchez and Ward Warmerdam

About this report

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Summary

Tropical deforestation continues to erode biodiversity, disrupt water cycles, compromise climate stability, and undermine livelihoods. Commodity supply chains linked to agriculture, forestry, mining, and fossil fuels remain the dominant drivers of forest loss and related human rights risks; public policies, zero-deforestation pledges, and certifications have not yet delivered a fundamental transition.

The Amazon, Congo Basin, and Southeast Asia-Oceania contain the largest remaining tropical rainforests. Curbing loss requires limiting commercial activity to uses that prevent conversion and rights violations, halting industrial operations that drive deforestation, and strengthening the rights and capacities of Indigenous Peoples and Local Communities (IP and LC) through robust public policy.

This research assesses how current and emerging drivers of tropical deforestation—commodity expansion, global trade and consumer demand, and shifting socio-economic and policy priorities—interact. We map where, how, and how much key forest-risk commodities are likely to be produced, traded, and consumed in the coming years, and estimate the impacts on tropical rainforests; then, we examine how policy and market trends could accelerate or slow forest loss. We convert findings into scenario-based consequences and cross-cutting recommendations. Sectors of three commercial complexes with future risks are discussed in detail:

- **Energy Systems:** Mineral extraction for the energy transition, bioenergy, and fossil fuels
- **Food Systems:** Future meat consumption, livestock production, and processed food trends
- **Fast-Turnover Products and Emerging Forest-Risk trends:** Wood pulp demand linked to fast-fashion, packaging and e-commerce, logging for tropical timber, and global gold demand

These economic sectors exert direct pressures (mining, fossil fuel extraction, plantations, pastures, and logging) and powerful indirect effects (supply chain infrastructure, official and unofficial transportation infrastructure, energy supply, and settlement expansion).

We outline three forward-looking pathways. In a **Pressured Expansion** pathway, ongoing demand growth and lax or unequal governance push frontiers, while the resource intensity of products remains unaddressed. A **Managed Transition** strengthens producer- and consumer-side policies with controlled or flat land expansion. A **Resource-Light** shift goes further by combining sufficiency and durability norms with circular-economy strategies, lower resource consumption, and strict rules across supply chains. Pressured expansion leads to the worst outcomes for forests, the climate, and communities. Better results can be achieved through a managed transition, and, even better, through a resource-light shift.

Energy Systems. Global energy demand continues to grow while renewables and electrification scale. However, near-term realities point to a 'layering' of systems rather than a full transition. Many pathways are land- and resource-intensive: surging demand for 'critical' minerals, continued expansion of bioenergy (biofuels and biomass), and residual reliance on fossil fuels in hard-to-abate sectors all pose risks to rainforest regions when safeguards are weak. The direct and indirect footprints of mining, especially along access roads, power lines, and settlements, are still often under-estimated, yet they widely overlap with key rainforest geographies in the three basins.

A pressured expansion intensifies mining 'impact halos', sustains first-generation biofuels, and prolongs fossil exploration in and near rainforest areas. Depending on the battery chemistry, a business-as-usual (BAU) scenario for the transport sector may result in cumulative deforestation of ~1,500 km^2 to ~4,700 km^2 for the global electric vehicle fleet by 2050. Improved chemistries and sufficiency measures significantly reduce the forest footprint of the EV industry. 'Critical' mineral mining expansion threatens rainforests across the three basins. In Indonesia, wood pellet co-firing policies and export demand could drive the conversion of tens of thousands of square kilometres of forest. Rising biofuel mandates across Indonesia, Brazil and other markets are reinforcing the expansion of palm oil, soy, and sugarcane in the Amazon and Southeast Asia-Oceania, as truly

sustainable waste feedstocks are limited and prone to fraud or leakage. Greenfield fossil fuel development is still observed across all three rainforest regions.

Under a managed transition, no-go zones, cumulative-impact environmental impact assessments (EIAs), free, prior and informed consent (FPIC), traceability, a halt of new fossil fuel projects, and tightened bioenergy residue rules help mitigate impacts. A resource-light shift accelerates the phase-out of fossil fuels, further reduces greenfield mining through material efficiency, high recycling rates, changes in battery chemistry, and better transport management. Given the current political and market dynamics, as well as weakening and delayed due diligence obligations for supply chain companies, a hybrid trajectory between pressured expansion and managed transition appears most likely in the near term.

Food Systems. Livestock, feed crops, and palm oil remain pivotal linkages with tropical rainforests. Rising incomes, urbanisation, and marketing drive demand in globalised supply chains. Without demand-side changes, trying to meet this appetite by converting new areas keeps forest pressure high.

The Amazon faces continued expansion of its pasture frontier, with soy-related risks driven by global feed demand in light of eroding safeguards. The currently anticipated growth in Brazilian beef production may lead to deforestation of ~57,000 km^2 in the Amazon by 2034. In Southeast Asia-Oceania, palm oil demand, driven by global growth in processed food products and leakage to markets with laxer rules, increases forest risk. In the Congo Basin, narratives of 'suitable land' and investor interest may encourage industrial palm oil unless robust tenure and biodiversity safeguards are implemented.

A managed transition uses tenure enforcement, FPIC, cattle traceability, geolocation screening, moratoria-type instruments, and due diligence legislation consistently applied across markets to bend the curve. A resource-light diet shift, incorporating more plant-based proteins, targeted meat substitutions, and less ultra-processed foods, alongside comprehensive measures to cut food waste, delivers the largest benefits. However, it requires ambitious, coordinated policy and cultural changes, as well as strong political support.

Fast-turnover products and emerging forest-risk trends. Fast-turnover goods, such as fast fashion or flatpack furniture, and investment-sensitive sectors like gold raise forest pressure through pulpwood plantations, timber demand, and mining supply chains. Pulp mill expansion in Indonesia is driven by growing demand for plastic substitution, e-commerce, and the use of man-made cellulosic fibres (viscose) in textiles. This development threatens thousands of square kilometres of tropical rainforests in Southeast Asia-Oceania, risking their conversion into pulpwood plantations. Weak legality systems in forest and processing countries can enable high-risk timber trade worldwide, with persistently high levels of timber illegality observed across all three regions. Driven by investment and jewellery demand, gold mining is expanding, with connected forest footprints and mercury pollution risk in Amazon hotspots. Driven by high gold prices, an additional ~375 km^2 of gold mining area may expand in the Brazilian Amazon by 2028, while the Madre de Dios region in Peru may experience gold mining-driven deforestation on ~530 km^2 until 2029.

A managed transition depends on enforcing zero-deforestation policies, enhancing concession audits, strengthening timber legality systems, ensuring traceability, increasing producer responsibility, and raising recycled content. A resource-light shift layers verified non-conversion sourcing with sufficiency and durability norms, tighter recyclability and circularity rules for consumer products, true-price levies, and robust gold recycling and traceability.

Cross-cutting drivers: Various cross-cutting issues influence risks and opportunities. The rapid expansion of transportation infrastructure, both official and unofficial and often linked to the development of extractive industries, opens up large tracts of tropical rainforest. Climate change intensifies fires, droughts, and feedback loops that degrade tropical rainforests and increase flammability. Civil society efforts have been vital in improving transparency and tenure security, but face funding volatility and political pushback in many countries. No deforestation and due diligence legislation is being developed in some markets, but it is the target of impactful corporate lobbying seeking to dilute or delay the laws. These dynamics underscore the necessity for robust legal frameworks, monitoring, and policy coherence to prevent leakage between ecosystems and markets.

Where current dynamics point. Today's political economy is marked by emerging demand-side shifts, uneven due diligence and traceability implementation, and pressure on moratoria. These factors pose high risks to thousands of square kilometres of tropical rainforest. Therefore, the near-term reality appears to be a hybrid: parts of a managed transition within a broader pressured-expansion context. To shift trajectories, the analysis emphasises the importance of policy convergence across major markets to prevent the leakage of deforestation-linked commodities to less regulated markets, strengthening production-side controls to ensure strict environmental and human rights safeguards, and scaling demand-side measures that reduce overall material and land pressure.

Recommendations

To end deforestation, policymakers must take urgent action to create and implement enabling regulations. Private sector actors must implement deforestation- and conversion-free (DCF) supply chains, and financiers must shift their capital towards sustainable practices. These actions should be taken in tandem, with red lines and legal protections as the top priority.

Governments in producer countries

Establish strong red lines and legal protections

- *Enforce strict protections*: Legally designate 'no-go' zones with buffer areas for commercial extraction for all high-conservation value lands, primary forests, and critical ecosystems. Ban all extractive activities in Indigenous territories where consent has not been granted, particularly for isolated peoples.
- *Secure land rights and free, prior and informed consent (FPIC)*: Formalise land tenure to end speculative clearing, specifically recognising IP and LC rights and women's land titles. Enshrine FPIC in national law, including the 'right to say no', with meaningful participation of all groups.

Strengthen governance and justice

- *Reinforce legal frameworks*: Reinforce legal frameworks to protect forests and ensure robust, long-term funding for law enforcement. Provide public access to near-real-time deforestation alerts to enable immediate embargoes and seizures.
- *Protect defenders*: Mandate protection assessments for environmental and human rights defenders in all project approvals. Establish secure grievance mechanisms for communities and other affected stakeholders.

Provide social and economic safety

- *Create 'Just Transition' frameworks*: Implement the UN's Fairness and Justice Recommendations to ensure equity, benefit-sharing, and safeguards across value chains.
- *Support alternative livelihoods*: Fund and support community-led economic models to help workers transition to alternative, more sustainable livelihoods.

Regulate economic drivers of deforestation

- *Limit and monitor infrastructure expansion*: Minimise new infrastructure development and enforce no-deforestation buffers.
- *Control commodity production*: Halt new concessions until governance is strengthened. Regulate extractive industries to implement cumulative-impact EIAs, community benefit-sharing, and post-production rehabilitation.

- *Phase out fossil fuels and unsustainable bioenergy*: Stop approving new fossil fuel projects and subsidies, and plan to phase out existing fossil fuel production. Limit bioenergy to waste-based alternatives.

Governments in consumer countries

Establish strict market regulation

- *Enact mandatory due diligence*: Implement binding environmental and human rights due diligence laws with full upstream-to-downstream traceability, including for indirect supply chains.
- *Limit corporate lobby influence*: Restrict industry influence and commit to high standards of transparency in public policy engagement.

Create partnerships to protect forests

- *Provide support and share best practices*: Partnerships should be created between importing and exporting countries to provide financial and technical support as well as law enforcement cooperation, and align best practices to protect forests.

Shift economic incentives and consumption patterns

- *Implement a circular economy:* Tackle excessive resource use and waste by setting product-intensity targets to design waste out of products, establishing repairability mandates, and facilitating efficient recycling.
- *Promote lower-impact diets*: Shift public health policies and subsidies toward less resource-intensive and less processed diets, prioritising plant protein over animal protein.

Supply chain companies, public and private financiers

Operationalise deforestation-free supply chains

- *Implement robust DCF policies:* Adopt DCF policies with comprehensive traceability and satellite monitoring. Strictly adhere to the mitigation hierarchy (avoid → mitigate → restore) and enforce contractual no-conversion clauses for suppliers.
- *Support and engage*: Provide technical and financial support to smallholders for the development of collective traceability and compliance systems. Engage meaningfully with non-compliant suppliers/investees, with clear escalation strategies in place that lead to suspension if violations persist.

Ensure circularity

- *Design for durability*: Switch business models to prioritise longevity and repair. Publicly disclose product footprints to empower consumer choice.
- *Prioritise low-impact technology*: Focus research and development on low-resource options and increase the use of recycled content to reduce the reliance on virgin extraction.

Align capital with sustainability goals

- *Enforce strict lending and investment criteria*: Make access to finance contingent on credible due diligence. Implement clear escalation strategies that lead to the suspension of funds for persistent violations.
- *Mobilise 'Just Transition' funds*: Shifting economic incentives toward forest conservation and direct funding for Indigenous-led governance.,

Urgency to take action. Tropical rainforests are exposed to increasing commodity demand, uneven patterns of governance, and escalating climate risk. The report's scenarios clearly show that governance is the decisive lever to halt the further loss of tropical rainforests. Effective governance frameworks must be anchored in rights, hard legal boundaries, and verifiable transparency, combined with demand-side strategies that reduce resource consumption and ensure environmental and human rights due diligence.

A managed transition pathway is already possible with today's instruments, while a resource-light shift should be the ambition for a just transition that ensures a fair distribution of resources within the planetary boundaries. Both require coordinated action **now** to avoid locking the Amazon, Congo Basin, and Southeast Asia-Oceania rainforests into another decade of pressured expansion and irreversible loss of rainforests and livelihoods.

Abbreviations

ANM	National Mining Agency (Brazil and Colombia)
APS	Announced Pledges Scenario (IEA)
ASM	Artisanal and Small-scale Mining
BAU	Business-As-Usual
BNDES	Brazilian National Development Bank
BOE	Barrel of Oil Equivalent
BOGA	Beyond Oil & Gas Alliance
BRI	Belt & Road Initiative
BSE	Bovine spongiform encephalopathy
CADE	Brazilian Competition Authority
CAGR	Compound Annual Growth Rate
CBIRC	China Banking and Insurance Regulatory Commission
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPO	Crude Palm Oil
CRMA	Critical Raw Materials Act
CSDDD	EU Corporate Sustainability Due Diligence Directive
CSO	Civil Society Organisation
CSRD	EU Corporate Sustainability Reporting Directive
DCF	Deforestation-and-Conversion-Free
DDS	Due Diligence Statement
DRC	Democratic Republic of the Congo
DWP	Dissolving Wood Pulp
DRC	Democratic Republic of the Congo
EC	European Commission
EESC	EU Economic and Social Committee
EFTA	European Free Trade Association
EHS	Environmentally Harmful Subsidies
EIA	Environmental Impact Assessment
EPR	Extended Producer Responsibility
EU	European Union
EUDR	EU Deforestation Regulation
EUTR	EU Timber Regulation
EV	Electric Vehicle
FAO	Food and Agriculture Organisation of the United Nations
FCA	Fores Clearing Authority
FCDS	Foundation for Conservation and Sustainable Development
FI	Financial Institution
FiT	Feed-in-Tariff
FLEGT	Forest Law Enforcement, Governance & Trade
FPIC	Free, Prior and Informed Consent
FTA	Free Trade Agreement

HCS	High Conservation Stock
HCV	High Conservation Value
GDP	Gross Domestic Product
GFW	Global Forest Watch
GHG	Greenhouse Gas
IADB	Inter-American Development Bank
ICCA	Indigenous and Community Conserved Areas
IEA	International Energy Agency
IEF	Indonesian Environment Fund
IFC	International Finance Corporation
ILO	International Labour Organisation
ILUC	Indirect Land-Use Change
IMO	International Maritime Organisation
IPA	Indigenous Protected Area
IP and LC	Indigenous People and Local Community
ITTO	International Tropical Timber Organisation
JV	Joint Venture
Kt	Thousand metric tons
LFP	Lithium-Iron-Phosphate
LNG	Liquified Natural Gas
LSM	Large-scale Mining
MIFEE	Merauke Integrated Food and Energy Estate
MMCF	Man-Made Cellulosic Fibres
Mt	Million metric tons
NMC	Nickel-Manganese-Cobalt oxide
NZE	Net Zero Emissions
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of the Petroleum Exporting Countries
PAC	Growth Accaleration Programme (Brazil)
PFAD	Palm Fatty Acid Distillate
PGM	Platinum Group Metals
PNG	Papua New Guinea
PNGFA	Papua New Guinea Forest Authority
POME	Palm Oil Mill Effluent
PSN	National Strategic Project in Indonesia
PV	Photovoltaic
REC	Renewable Energy Credits (South Korea)
RED	UEU Renewable Energy Directive
REDD+	Reduced Emissions from Deforestation and Degradation
REE	Rare Earth Elements
RTA	Ready-to-Assemble
SABL	Special Agriculture & Business Lease
SAF	Sustainable Aviation Fuel

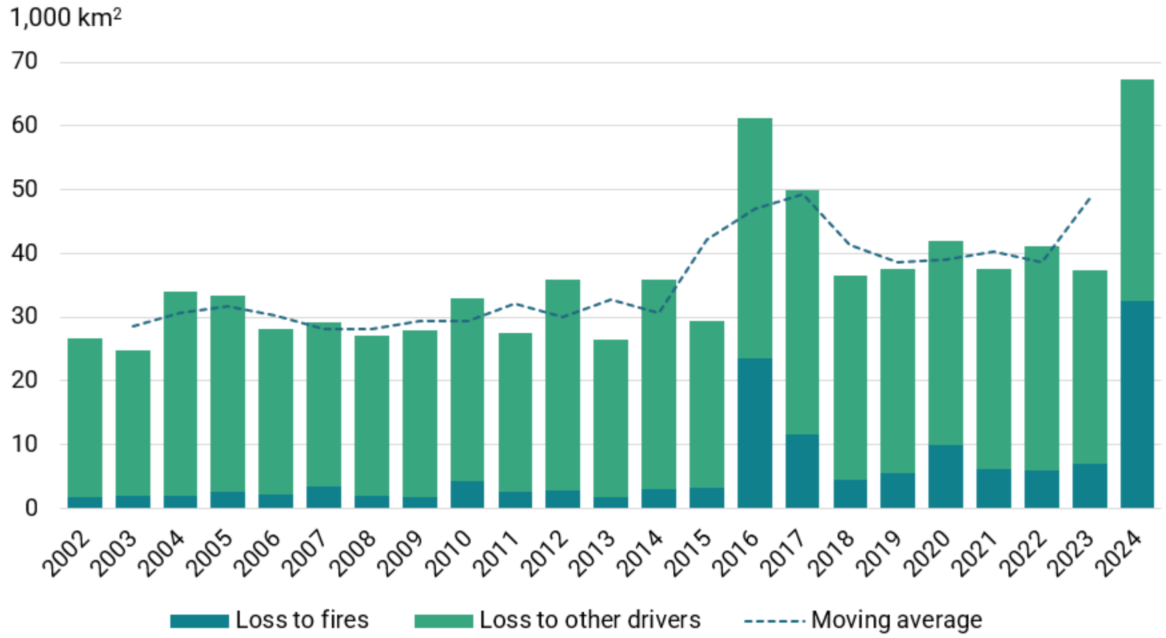
SEZ	Special Economic Zone
STEPS	Stated Policies Scenario (IEA)
TRQ	Tariff Rate Quota
TSD	Trade and Sustainable Development
UCO	Used Cooking Oil
UKFRC	UK Forest Risk Commodity Regulation
UNDP	UN Development Programme
UNEP	United Nations Environment Programme
UNGP	UN Guiding Principles on Business and Human Rights
UNODC	UN Office on Drugs and Crime
UPF	Ultra Processed Food
UPL	Undesignated Public Lands
VEC	Vector Error Correction model
VPA	Voluntary Partnership Agreement
WRI	World Resources Institute
WTO	World Trade Organisation
WWF	World Wide Fund for Nature

Introduction

Tropical deforestation remains one of the most pressing environmental challenges of our time, with wide-reaching impacts on biodiversity, water cycles, climate stability, and the livelihoods of millions that depend on healthy ecosystems. Forest-risk commodities from the agriculture, forestry, and mining sectors are key drivers of deforestation and associated human rights concerns across different regions. Regulatory frameworks, private sector pledges, and voluntary certification schemes have not reached the zero-deforestation goal. These efforts exist within a broader context shaped by volatile markets, economic interests, persistent poverty, political shifts, and emerging global trends that will continue to influence commodity demand and supply—and by extension, tropical rainforest outcomes—in the years ahead.

Tropical rainforests have already lost 830,000 km^2 (8.1%) of their area since 2002, and there is no persistent trend reversal in sight.[1] In 2024, the loss of tropical rainforests reached a record-breaking level of 67,000 km^2. This loss equalled 18 football fields per minute,[a] almost double the extent recorded in 2023. An important factor in the year-on-year surge of 30,000 km^2 was rainforest loss through fires, most of which were human-induced to clear land for agriculture and spread out of control into forests (Figure 1). This development was also driven by exceedingly hot and dry conditions due to regional biophysical changes caused by forest degradation and deforestation, and the impacts of global climate change.[2] The largest loss rates were observed in Brazil, Bolivia, the DRC, and Indonesia, although Indonesia showed a slight decrease year-on-year.[3]

Figure 1 Tropical rainforest loss 2002 to 2024



Note: The three-year moving average may represent a more accurate picture of the data trends due to uncertainty in year-to-year comparisons. The figure is calculated with a 30% minimum tree cover canopy density.

Source: Own elaboration, based on: Goldman, E. et al. (2025, May 21), "Fires drove record-breaking tropical forest loss in 2024", World Resources Institute, https://gfr.wri.org/latest-analysis-deforestation-trends.

Rainforest Foundation Norway (RFN) focuses on the three major rainforest regions: the Amazon, the Congo Basin, and Southeast Asia-Oceania. These regions contain the world's largest intact primary rainforest areas, which have been minimally influenced by human activity, alongside secondary forests that have been affected to varying degrees by outside influences and multiple forms of land management. RFN aims to strengthen the capacities of forest-dependent

[a] Based on the common dimension of a FIFA football field of 68 metres times 105 metres.

communities within the framework of rights-based sustainable rainforest management; encourage public policies that promote safeguards for rainforests and the human rights of indigenous peoples and forest-based local communities (IPs and LCs) that collectively manage rainforest areas; and halt deforestation, destruction of forest ecosystem services, and violations of indigenous and community rights. The latter means, in turn, that deforestation, forest degradation and human rights violations linked to private- or public-sector commercial activities, particularly from industrial-scale operations, should be halted.[4] Among the commercial drivers of forest destruction, commodity production has played a disproportionately large role in recent years.

RFN commissioned this report to gain insights into the diverse trends that influence the impact of large-scale commercial activities; to map where, how, and how much of these commodities are likely to be produced, traded, and consumed in the coming years; and to analyse how different policy and market trends may drive or slow down forest loss. Understanding these dynamics is a prerequisite for proactively addressing the risks of commodity-driven deforestation and advocating for policies that promote resilience and equity in global supply chains.

The report analyses a selection of forest-risk commodities linked to the three tropical rainforest basins and presents a forward-looking analysis of deforestation dynamics. While sectors such as cattle, palm oil, soy, and timber are already recognised as key drivers of forest loss, their future influence will vary depending on evolving regional, national, and global contexts. At the same time, new or previously underestimated commodities—such as mineral exploration and exploitation, which can have significant local and regional impacts—are gaining prominence due to shifting market forces, policy changes, or emerging technological developments. Recognising that a complex interplay of dynamic economic, political, and environmental factors will shape these trends, the study seeks to identify key underlying drivers of change while acknowledging that the analysis, by necessity, is partial in scope. To do so, the report draws on different scenarios and projections from existing literature and develops new prognoses.

Chapter 1 defines the objective and scope of the study, explains the concept of direct and indirect deforestation drivers, and explains the methodological approach. Chapter 2 provides a brief overview of the three tropical rainforest basins and the characteristics of their deforestation patterns. Chapter 3 discusses market trends and implications for the three basins linked to energy systems changes, with a focus on ‘critical’ minerals, bioenergy, and fossil fuels. Chapter 4 examines food system-related trends, including the shift from animal proteins to plant proteins, and processed foods as a driver of palm oil consumption. Chapter 5 covers several market trends in relation to rainforest impacts, including fast-turnover products, logging, and the market. Chapters 6 provides an overview of important underlying influences on deforestation trends—with the option to drive or slow the loss of tropical rainforests. Finally, Chapter 7 draws conclusions and recommendations based on the findings.

1

Research framing

Vast areas of the Earth's tropical rainforests have been deforested over the last decades. What is left is still disappearing at an alarming rate. Deforestation dynamics are influenced by a complex interplay of direct and indirect drivers, with emerging market forces and trends playing a key role. A multitude of sectors, actors and decision-makers worldwide have the power to affect deforestation dynamics. This report analyses market trends and dynamics relevant to the Amazon, Congo Basin and Southeast Asia-Oceania tropical rainforests, identifying pathways and leverage points to halt and reverse global tropical rainforest loss.

1.1 Research objective

This research examines emerging dynamics affecting forest-risk commodities relevant to tropical rainforests. It maps medium-term trends and impacts at the intersection of global trade, technological development, and shifting socioeconomic and policy priorities, and explores scenarios for alternative pathways.

The objective of the research is fourfold:

- To identify medium-term emerging market trends that may affect the demand for forest-risk commodities until 2030 and 2035.
- To analyse the importance of these trends for forest-risk commodity demand.
- To analyse the land use effects of the identified trends in key rainforest geographies.
- To identify measures that could address these dynamics.

1.2 Geographic scope

The research focuses on the three largest contiguous rainforest areas globally. Within these regions, the research focuses on selected countries that account for a considerable share of the forested areas and observed forest loss:

- the **Amazon** in South America: focus on Brazil, to a lesser extent, Colombia and Peru
- the **Congo Basin** in Central Africa: focus on the Democratic Republic of the Congo (DRC)
- **Southeast Asia-Oceania**: focus on Indonesia and Papua New Guinea (PNG).

Figure 2 Rainforest areas and countries considered

Source: Profundo.

1.3 Key drivers of tropical rainforest destruction

Deforestation drivers are commonly categorised into direct and indirect causes. Deforestation is often preceded by forest fragmentation, which contributes to the degradation of forests.[b] Degradation can also result from unsustainable logging practices or fire. Both forest degradation and deforestation are symptoms of broader political, social, and economic transformations.[5] Increasingly, regional biophysical changes, which are themselves induced by forest degradation and deforestation, as well as the environmental impacts of global climate change, are playing a role.[6]

In forest degradation and deforestation processes, generally, two types of drivers are distinguished:[7]

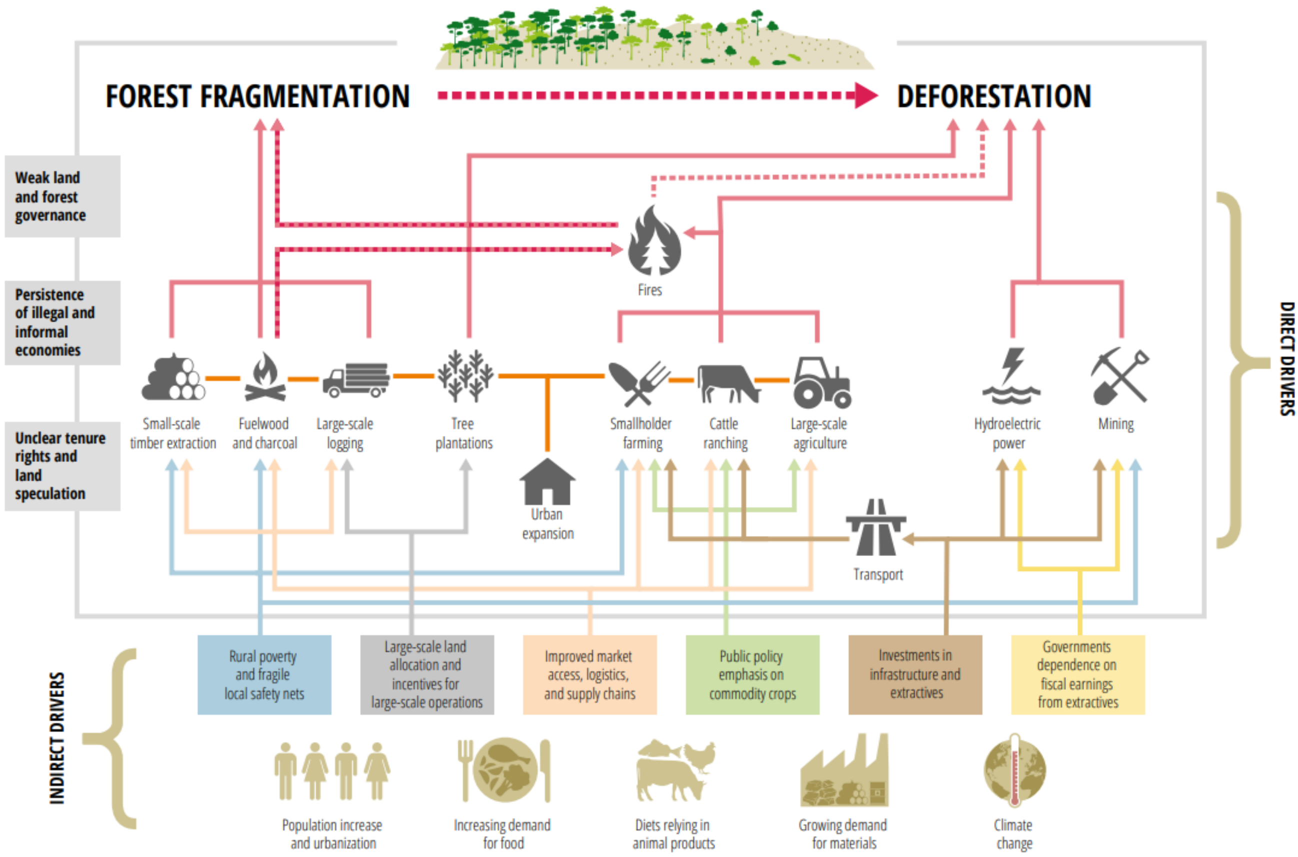
- **Direct causes** are defined as immediate human actions at the local level originating from intended land use and directly impacting forest cover.
- **Indirect causes** refer to fundamental social, economic, political or environmental processes that underpin the proximate causes and, in turn, trigger deforestation. Underlying causes can operate at the local level or have an indirect impact from a national or global level.

Broad synergies among various direct and indirect causes determine deforestation processes. Indirect drivers interact in multiple ways and may either stimulate or limit deforestation depending on the specific context.[8] Key direct causes that are observed in forest loss globally can be broadly categorised into twelve groups (Figure 3, grey symbols).[c]

b Whereby deforestation refers to the permanent conversion of forest to another land use or significant long-term reduction of tree canopy cover, while forest degradation results from changes within forests that negatively affect the capacity of forests to supply products or ecosystem services by does not involve its permanent clearing.

c The definition of direct and indirect causes is not always straightforward. Some authors categorise infrastructure, especially road construction, as an underlying cause of deforestation as it mainly has indirect impact upon forest cover. However, considering the many direct and indirect impacts of transport infrastructure, Geist and Lambin (2002) and other authors categorise it as a direct cause.

Figure 3 Interactions among drivers of deforestation and forest fragmentation



Source: Pacheco, P., K. Mo, N. Dudley, A. Shapiro et al. (2021), *Deforestation Fronts: Drivers and Responses in a Changing World*, Gland, Switzerland: WWF, p. 32.

Commodity-driven deforestation, urbanisation, and shifting agriculture within primary forests are considered to represent permanent deforestation. In the other categories (forestry, wildfire, and shifting agriculture outside of natural forests), tree cover is more likely to regrow.[9]

Demand increases and market dynamics play an important role in the expansion of commodity production in tropical rainforests. Economic returns are a key factor. In general, forest loss is more likely where agricultural conversion is attractive, due to favourable climate, topography, and access to markets.[10] Depending on the commodity, the share of domestic demand versus global market demand differs. Key traded forest-risk commodities with important export markets include, among others, palm oil, soy, beef, and timber.[11] However, it is not a given that added demand puts additional pressure on tropical rainforests, as it depends on the interplay of various factors and the choices made by decision-makers at the global, national, and local levels.[12] A series of underlying causes also indirectly drives deforestation and degradation of tropical rainforests: from population densities to investments in transport infrastructure, policy changes, and governance factors such as land tenure systems.[13]

It is also important to remember that complex biomes like the Amazon tend to be reduced to a single entity, whereas it is an example of an ecoregion with immense environmental, socio-cultural, governance, and economic diversity, and consequently, a diverse set of deforestation drivers and underlying causes. As a review by Hänggli et al. shows, Brazil, as the country with the largest share of the Amazon rainforest and high forest loss rates over many years, has seen considerably more analysis than Peru or Colombia. Certain drivers of deforestation have also received more research attention than others. For example, the large role of commodity agriculture expansion and cattle ranching as important proximate causes of deforestation in the Amazon is widely researched, while smallholder farming and small-scale clearing remain poorly studied.[14]

While the study focuses on direct economic drivers, it is crucial to consider that economic activities at times only have a comparably small direct deforestation footprint; however, the indirect impacts from, for example, transport, supply chain and energy infrastructure development, settlements, or agricultural activities developing in the slipstream of direct drivers can be much larger. Literature on deforestation footprints does not consistently approach this topic, as at times only immediate influences are considered, while other studies also take broader pull factors into account in estimates for forest loss.

In all ecosystems, deforestation is linked to the loss of biodiversity and ecosystem services, the destruction of livelihoods of Indigenous and other local populations and exacerbates climate change. Forest loss drivers are not static but change over time and in magnitude. Direct and indirect drivers also interact with each other, leading to complex interactions that are difficult to predict (Figure 3). Some of these effects create feedback loops. For example, climate change increases the risk of wildfires or human-induced fires getting out of control, which in turn leads to more forest loss and forest fragmentation. Displaced populations may move into previously unaffected forest areas to create new livelihoods, which can, in turn, be linked to forest fragmentation and deforestation.[15] At the same time, targeted efforts to halt deforestation in one area can unintentionally shift deforestation pressures elsewhere, a phenomenon known as leakage.[16]

This report focuses on three groups or complexes of commercial drivers of deforestation that, in the literature and by experts, are expected to continue playing a sizeable role in tropical rainforest loss *or* have been identified as emerging drivers that may see an increasing role in rainforest destruction in the coming five to ten years if not subject to effective safeguards. This role is closely linked to their relationship with commodity production, which has been and is expected to remain a significant driver of tropical deforestation. The three broad complexes discussed in this report are:

- **Energy systems:** mineral extraction for the energy transition, bioenergy, and fossil fuels
- **Food systems:** future meat consumption, livestock production, and processed food trends
- **Fast-turnover products and emerging forest-risk trends:** wood pulp demand linked to fast-fashion, packaging and e-commerce, logging for tropical timber, and global gold demand

Such a selection inherently limits the analysis to a few pieces of a complex puzzle. However, the three broad complexes are all driven by strong and growing commercial interests, linking the tropical rainforest regions of the Amazon, Congo Basin, and Southeast Asia-Oceania to global commodity markets, and illustrating the opportunities for various actors to achieve positive outcomes for rainforests. The scope of this project necessitates a focus on the broader picture, and therefore limits the analysis of the different forest-risk sectors to countries where the most significant impact can be anticipated.

1.4 Methodology

Our initial research step involved identifying and analysing an extensive body of recent scientific and grey literature on deforestation drivers to understand past dynamics and identify indicators and parameters of future trends. Relevant sources included peer-reviewed articles, government publications, market analysis and statistical databases, legal and policy documents, policy briefs and investigations by international institutions and reputable civil society organisations (CSOs), and media articles (→ Appendix 1 for an overview).

We then added additional relevant publications based on the initial body of references. Drawing on deforestation patterns and trends for the three rainforest regions, we consulted resources for market information on key commodity sectors, as well as socio-economic and regulatory developments. Finally, we conducted targeted internet searches to address emerging research questions.

We analysed the material using qualitative categorisation to identify patterns related to deforestation trends and stakeholders. We further investigated key emerging themes in relation to relevant underlying market drivers. Interviews, alongside resources and data shared by experts on the different geographies and topics, were used to corroborate and supplement findings (→ Appendix 1). All data and findings from other publications are clearly referenced throughout the report.

Considering the enormous volume of material covering topics related to deforestation in the focus geographies, the focus was put on countries with the highest impact, that is, where most deforestation has been observed historically or is expected to occur in the coming years, and on economic sectors that are most influential in the geographic context. These considerations led to the selection of three overarching complexes: energy systems, food systems, fast-turnover products, and emerging forest-risk trends. Within these three themes, a selection of relevant sectors is discussed in more detail.

We analysed the identified emerging dynamics and mid-term trends, as well as their potential impacts on the demand for forest-risk commodities over the next five to ten years and, importantly, the expected land-use effects on the tropical rainforests of the three basins. As literature refers to different forecast periods or available data only allows shorter projections, estimates at times cover shorter or longer timeframes.

To better understand both short-term dynamics and long-term relationships, data analysis employing a mix of qualitative and quantitative methodologies was employed to supplement forecasts identified in the literature. Qualitative information on production and demand trends formed the basis for identifying potential future impacts on forests. Where applicable, quantitative production and deforestation data related to the three themes were extrapolated based on historical data to illustrate potential future scenarios. While this simplifies the complexity of factors and dependencies, it does give helpful indications of the potential magnitude of impacts. For gold mining, Vector Error Correction (VEC) models were used to develop scenarios for future impacts, aiming to capture the relationships and dynamic interactions between multiple time series variables. Throughout the text, impact scenarios related to future deforestation are marked in **green**.

The findings on market dynamics and expected demand trends were used to identify key determinants of forest outcomes in the coming years and to develop scenarios of possible pathways, ranging from a pressured expansion to a managed transition and a resource-light transition, with the latter being the most optimistic option.

Although reaching similar conclusions, monitoring sources that publish deforestation data for the three rainforest regions tend to arrive at somewhat different results for annual forest loss, depending on the methodologies and definitions applied. For reasons of comparability, the historical data presented in Chapter 2 uses Global Forest Watch (GFW) data. However, the discussion of individual drivers refers to local sources, like Auriga Nusantara's Simontini platform for Indonesia or Amazon Conservation's Monitoring of the Andes Amazon Project (MAAP) and Mapbiomas data for the Amazon.

In accordance with other publications, the report refers to the three selected tropical rainforest regions as 'the three basins' for ease of reading.

2

Tropical rainforest regions, deforestation and forest risk commodities

The Amazon, the Congo Basin, and Southeast Asia-Oceania contain the largest contiguous rainforests on Earth. These forests are crucial for biodiversity and our climate and provide livelihoods for millions of people. However, they are disappearing at an alarming rate owing to a complex mix of direct and indirect drivers. To provide a basis for further analysis, the following sections briefly summarise the status of these forests and the main economic drivers of deforestation in recent years.

2.1 Amazon rainforest

The Amazon is home to the largest tropical rainforest area in the world. It is home to the highest diversity of known plant and animal species, many of which are endemic, and to almost 50 million people, including over 2 million Indigenous people from more than 410 distinct peoples, about 80 of whom remain in voluntary isolation. A network of protected areas and Indigenous territories encompasses around half of the Amazon. Its 5.3 million km^2 are dominated by Brazil with 62%, followed by Peru with 12%. Smaller shares are held by Colombia, Bolivia, Venezuela, Guyana, Suriname, Ecuador, and French Guiana.[17]

The Amazon Biome has seen significant forest loss in this century, with Brazil being the most affected. Identifying isolated impacts of economic activities on forests is complicated by multiple underlying drivers, including ineffective public and private policies, lack of policy enforcement, and commodity market influences.[18] Illegal land appropriations and a lack of law enforcement are also observed across countries in the Amazon Biome (→ section 6.5). Additional factors and local influences shape the specific country-level patterns.

Across the Amazon, MapBiomas identified 630,000 km^2 of tree cover loss between 2001 and 2022, of which 390,000 km^2 were deforestation in natural forests.[19] Agriculture and forestry commodities drove most clearing (380,000 km^2): cattle pasture 83%, cropland 17%, and forest plantations less than 0.1%; the remaining 10,000 km^2 relates to other factors, like mining, fossil fuel extraction, urbanisation, or clearing without subsequent productive use.[20]

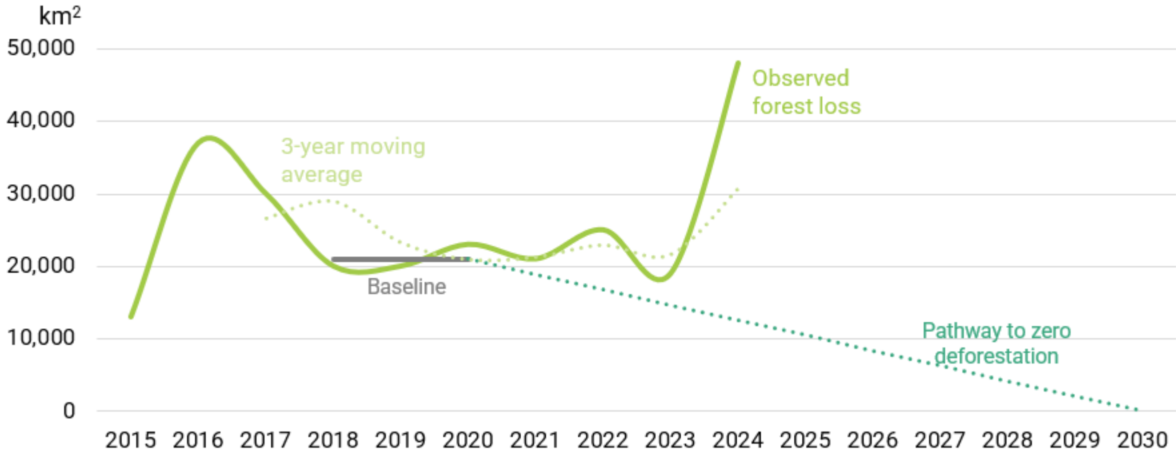
Additional drivers include new roads and other transport infrastructure, such as logging roads, energy infrastructure, and mineral and oil extraction. Mining and roads have significant pull effects for agricultural, small-scale mining and other economic activities. Across the basin, fire is commonly used to clear land after deforestation, but can also trigger forest loss itself.[21] Fires are often linked to illegal activities and organised crime (→ section 6.5).

Patterns vary across countries, but it is undisputed that agriculture was the leading direct driver of deforestation over the past two decades. In this period, pasture expansion was the primary cause of forest loss in the Brazilian, Bolivian, Ecuadorian, and Colombian parts of the Amazon,[22] and now covers ~9% of the Amazon. [23] This role has been enabled by a persistent lack of traceability in the cattle herd (→ section 4.2.4).[24]

Agriculture is often linked to land speculation (→ section 6.2). Large-scale agriculture typically occupies previously cleared land with good infrastructure, while displacing pastures further into forested areas. Mining, especially informal gold mining in Peru, shows significant but localised impacts (→ section 5.4.2).[25]

For the Amazon as a whole, forest loss dynamics of recent years are off track to meet the goal of zero deforestation by 2030 (Figure 4).[26] It is noteworthy that the data includes forest loss through fire, which surged in 2024. The impact of fire was particularly dramatic in Brazil, where 18,600 km² were lost to fire, compared to 2,800 km² in the previous year. This area was larger than the area lost in 2016, the last year with exceedingly high fire incidences.[27] While fires are considered a cause of temporary forest loss in official data, this finding is nonetheless troubling. Time to full recovery can be multiple decades, and drought-fire interactions, accelerating forest degradation, and recurring, oftentimes intentional fire incidents make a full regeneration of burnt areas increasingly unlikely.[28]

Figure 4 Progress toward ending deforestation by 2030: Amazon



Note: The steep increase in 2024 is almost entirely due to the impact of fires.

Source: Own elaboration, based on: World Resources Institute (WRI) (2024), "The world's three major rainforests", online: The world's three major rainforests; Global Forest Watch (2025), "Dashboards", online: https://www.globalforestwatch.org/dashboards/global/.

2.2 Congo Basin rainforest

The tropical rainforests of the Congo Basin span ~1.7 million km² across six countries in Western Central Africa and are renowned for their exceptional biodiversity and high endemism, extending across different ecoregions. The Democratic Republic of the Congo (DRC) contains the largest share of the tropical rainforest, with more than 1 million km² – the largest in Africa and the second largest globally. The remainder is divided between Cameroon, Gabon, the Republic of the Congo (RoC), and Equatorial Guinea.[29] These forests are not only critical for biodiversity, but are also the only remaining strong carbon sink among the three largest rainforests globally.[30] They are fundamental for the survival of Indigenous peoples and local communities who depend on them, as they provide subsistence for 60 million people and support food security for an additional 40 million in nearby urban centres.[31]

In recent years, the Congo Basin has become a global hotspot for deforestation and forest fragmentation.[32] Between 2001 and 2024, the region lost almost 100,000 km² of tropical rainforest. The DRC accounted for 78% of this loss, by far the largest share, and has shown a continuously increasing trend since the mid-2000s.[33]

Growing global demand for minerals, timber and farmland is creating an increasing risk for these forests.[34] Large-scale agriculture has thus far been a less significant driver of deforestation in the region, but pressure is expected to intensify.[35] Research by the University of Maryland found that the direct and indirect forest loss associated with commodity production in the DRC may considerably exceed prior estimates. The realistic share of commercial activities, such as logging, mining, and plantations, may be as much as ten times higher than prior estimates (less than 1%), when the broader landscape setting is considered. Workers and their communities are attracted by large-scale commercial logging, mining or plantation companies, and then utilise shifting cultivation and non-timber forest products to make a living. These interlinkages blur the distinction between subsistence farming and commercial commodity production, and therefore require attention when designing interventions for land use change.[36]

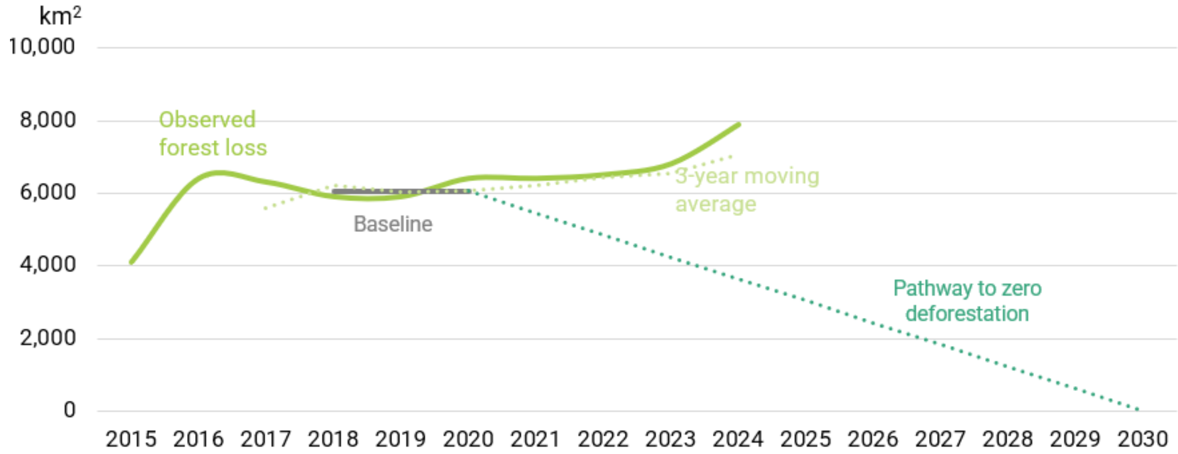
Unlike the other main tropical rainforests in the world, small-scale processes have historically played a more important role in deforestation and degradation in the Congo Basin, with subsistence farming identified as the leading cause.[37] Traditionally, subsistence farming with shifting cultivation was practised at low density, allowing for periods of forest regeneration during fallow periods and therefore linked to a lower and less permanent impact.[38] However, current practices often do not allow sufficient time for forests to recover, while increasing population pressure has driven expansion into primary forests and more intensive use of cleared land (→ section 6.1). This expansion is also driven by the aim to secure land capital that can be passed down from one generation to the next as part of lineage-based inheritance. In some of the world's poorest countries, farmers often lack viable economic alternatives.[39]

Degradation in many woodlands stems directly from fuelwood/charcoal extraction, not as a precursor to clearing, and through small-scale logging to supply domestic markets with artisanal sawn wood.[40]

Weak governance is a central enabler of deforestation and forest degradation. Challenges include insufficient and fragmented laws, opaque concession processes, conflicting interests, and insecure land tenure (→ section 6.2).[41] Many people rely on the forest for food and energy, but ongoing conflicts lead to displacement, especially in the DRC, forcing people to clear new land for their survival.[42]

Deforestation in the Congo Basin, largely driven by developments in the DRC, showed an increasing trend in recent years, making the 2030 target to end deforestation increasingly unrealistic (Figure 5).

Figure 5 Progress toward ending deforestation by 2030: Congo Basin



Source: Own elaboration, based on: World Resources Institute (WRI) (2024), "The world's three major rainforests", online: The world's three major rainforests; Global Forest Watch (2025), "Dashboards", online: https://www.globalforestwatch.org/dashboards/global/.

If current trends persist, Yuh et al. forecast another 170,000 km² to 200,000 km² of deforestation by 2050 under three climate change scenarios.[43] Business-as-usual (BAU) estimates by CIFOR (2022) for the DRC indicate a somewhat higher outcome; a continuation of the observed deforestation and degradation trends would result in the country losing 260,000 km² of its moist forests relative to a 2020 baseline.[44]

2.3 Southeast Asia-Oceania rainforest

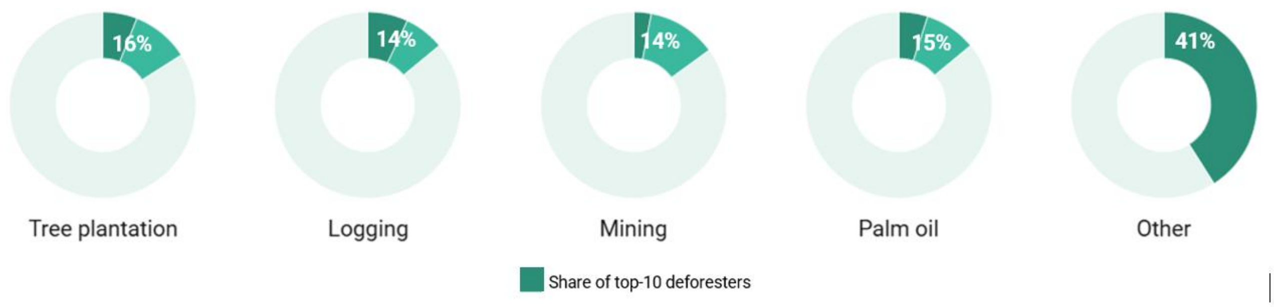
Southeast Asia and Oceania are home to some of the world's most diverse and complex ecosystems. While spreading over various countries in the region, Indonesia and Papua New Guinea (PNG) have the largest remaining rainforest areas,[45] and Indonesia is a global hotspot for tropical peatlands.[46] PNG shares the island of New Guinea with Papua Indonesia (Tanah Papua), home to the largest intact old-growth forest in the Asia-Pacific and a region of immense cultural and biological diversity, but increasingly threatened by mining, plantation, and infrastructure expansion.[47]

In the Southeast Asia-Oceania basin, oil palm and pulpwood plantations have been the primary drivers of deforestation in Sumatra and Borneo, alongside timber and coal mining. Some concession land granted to palm oil companies has become a stranded asset due to material reputational and financial risks when converting forests to plantations.[48] The role of rubber may have been underestimated so far. It was recently recognised as a more sizeable direct driver, also due to instances of overlap with key biodiversity areas.[49] Small-scale agriculture is another sizeable driver, with smallholders increasingly engaging in commercial crop production.[50]

Indonesia lost nearly one-quarter of its primary forest between 1991 and 2020, while about another quarter was degraded.[51] However, between 2017 and 2021, deforestation and peatland drainage, including oil palm, have declined sharply (Figure 7). New government policies were a key factor, including the delayed impact of the 2011 moratorium on new permits in primary forests and peatlands, as well as improved fire management and peatland protection in subsequent years.[52] However, legal loopholes allowing clearing within existing concessions remain a threat locally.[53] Around 24,000 km^2 of intact forest remains within Indonesia's oil palm concessions. Depending on market developments, this large area of forest designated for palm oil production could still be at risk of further oil palm expansion.[54] Additional governance gaps include exemptions for National Strategic Projects (PSN). Since the passage of the Omnibus Law in 2020, a legislative act aimed at stimulating economic growth and reforming environmental regulations, government projects can freely clear existing natural forests. Hence, in 2024, more than half of the observed deforestation occurred on land controlled by the state or in a forest estate.[55]

Forest loss has slowed in Sumatra and parts of Kalimantan; however, these provinces have little remaining forest cover.[56] Conversely, rates recently increased in frontier provinces with comparatively abundant forest cover, such as Tanah Papua and Sulawesi.[57] In 2024, four sectors accounted for almost 60% of deforestation in Indonesia, and a relatively small number of companies within these sectors accounted for a significant share (Figure 6).[58] Among commodities, palm oil remains important, while pulp (particularly in Kalimantan) (→ section 5.2.3) and mining (in Sulawesi) (→ section 3.2.7) are on the rise.

Figure 6 Sector-share in 2024 deforestation and share of top-10 deforesters



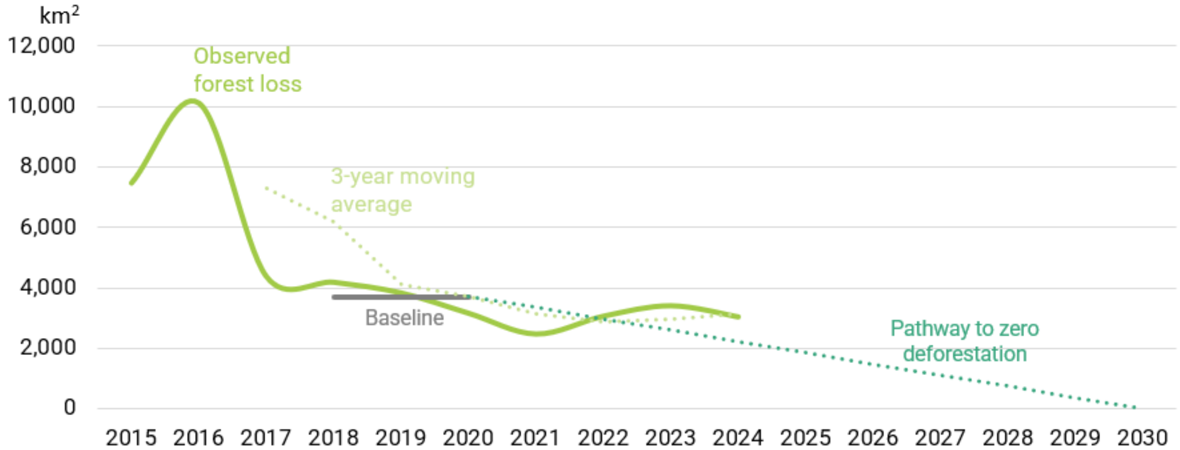
Source: Own elaboration, based on: Simontini (2025), "Status of deforestation in Indonesia 2024", Auriga Nusantara, online: https://simontini.id/en/status-of-deforestation-in-indonesia-2024.

Marked by exceptional species endemism and high biodiversity, and home to many indigenous groups,[59] the island of New Guinea has become a frontier area for primary tropical rainforests. However, forest loss and degradation have also increased here. Timber trade remains a major driver of forest loss, but has been overtaken by pulpwood and palm oil plantations in recent years.[60]

Deforestation patterns are more dispersed in PNG, with high-risk areas in the Western Province, Sepik, Madang, and Gulf. In Tanah Papua, deforestation is more often found close to so-called 'ghost roads': illegally or informally constructed roads that do not appear on official maps, often built for logging, mining, and agricultural development purposes. Logging, oil palm expansion, pulpwood plantations, and mining are important commercial drivers of forest loss in Tanah Papua.[61] Larger-scale commercial agriculture, including palm oil, has also experienced expansion in PNG as some smallholders are switching to cash crop production. The controversial Special Agricultural and Business Licenses (SABL) system (→ section 6.3.3) has driven large-scale conversion of customary lands for palm oil plantations since 2010.[62] Volumes are still small compared to Indonesia, but most of the production is exported (84% in 2024), mostly to markets in Europe and India for use in food and energy (→ sections 3.3.4 and 4.3.3).[63] PNG has also established a Palm Oil Ministry, reflecting the government's ambition to expand the industry.[64] Pulpwood plantations are an increasingly important driver, and growing road development opens opportunities for further deforestation in both parts of the island (→ section 6.6).[65] Illegal deforestation, weak law enforcement, and widespread corruption across forest-risk sectors, combined with ambitious economic development projects, remain a serious concern in PNG (→ sections 5.3.4 and 6.3.3).[66]

Tree cover loss in Indonesia and PNG has fluctuated in recent years, but the trend has been nearing a 2030 zero-deforestation pathway (Figure 7; Indonesia dominates the pattern due to significantly higher overall rates). However, regional patterns deviate from this trend. While in some provinces of Indonesia, little forest that could be deforested remains, forest-rich provinces contribute more to deforestation.[67]

Figure 7 Progress toward ending deforestation by 2030: Southeast Asia-Oceania basin



Note: only considering deforestation in Indonesia and Papua New Guinea.

Source: Own elaboration, based on: World Resources Institute (WRI) (2024), "The world's three major rainforests", online: The world's three major rainforests; Global Forest Watch (2025), "Dashboards", online: https://www.globalforestwatch.org/dashboards/global/.

A study by Parsch et al. assessed different development scenarios for the island of New Guinea and aimed to identify differences in drivers between Indonesia and PNG, areas of highest future deforestation risk, and the effect of four different deforestation scenarios in the period 2020 to 2040. A BAU scenario based on deforestation rates 2015–2020 would total more than 26,000 km² in Tanah Papua and 39,000 km² in PNG; a high development scenario mirroring Kalimantan deforestation trends between 2001 and 2020 resulted in 114,000 km^2 and 146,000 km^2, respectively. The lowland areas in both regions would be particularly affected.[68]

The following chapters focus on the role of forest-risk commodities and market dynamics linked to three broad commercial complexes—energy systems, food systems, fast-turnover products, and emerging forest-risk trends—and their current and projected impacts on the main tropical rainforest regions under different scenarios.

3

Energy systems

Global energy systems rely on the extraction and supply of large volumes of resources, ranging from the energy transition's surging demand for minerals to agri-commodities for bioenergy production, as well as the ongoing reliance on fossil fuels. This relationship links energy systems on multiple levels with tropical rainforests and their future.

Key findings

- **Mineral demand for renewable energy** has a large indirect forest footprint, and tropical rainforests show extensive overlap with 'critical' mineral reserves and concessions. Demand for electric vehicles (EVs) is increasingly driving mineral pressure, particularly in Indonesia and Brazil. Depending on the dominant battery chemistry, we estimate cumulative deforestation linked to the global EV fleet by 2050 under a business-as-usual (BAU) scenario for the transport sector at 1,500 km^2 to 4,700 km^2. Improved chemistries and sufficiency measures could significantly reduce the EV industry's forest footprint.
- First-generation **biofuels** and **wood pellets** increase pressure on tropical rainforests in the Amazon and Southeast Asia-Oceania. In Indonesia, pellet co-firing policies could drive the conversion of tens of thousands of square kilometres of forest in the coming decade. Rising biofuel mandates across various countries bolster the demand for palm oil, soy, and sugarcane. Truly sustainable waste feedstocks are limited and prone to fraud or leakage.
- **Fossil fuel** use in power generation and road transport shows a declining trend; however, hard-to-abate sectors like shipping, aviation, and heavy industries, and increasing demand from petrochemicals, continue to rely on fossil fuels. Where regulatory environments are failing and the industry's narrow, profit-seeking strategies prevail, greenfields are still being developed.
- Energy and mining projects often overlap with **Indigenous Peoples and Local Communities (IPs and LCs) lands** and **protected areas**; conflict incidents are rising without stronger safeguards.

3.1 Why is it relevant?

Global energy demand is forecast to continue growing, driven by economic and technological development, population growth, and the goal of ending the persistent energy poverty in many low-income countries.[69] Energy markets are shaped by public policy ambition and enforcement, industrial strategies, geopolitics, trade, and technological innovation, and the system is highly exposed to volatility. At the same time, the distribution of energy remains highly uneven. While the world uses significantly more energy than is required for a decent living standard for all, half the world's nations have an energy shortfall, and inequalities persist.[70]

In recent years, the search for alternatives to fossil fuels has been driven by emission reduction goals aimed at achieving carbon neutrality, as the global community pledged to significantly lower carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions under the Paris Climate Agreement.[71] Reaching these goals requires a radical shift in the way energy is produced and transport takes place, such as scaling up renewable energy sources and electrification. Simultaneously, energy demand is surging, driven by continuously growing needs from industrial consumption, e-mobility, cooling, data centres, and AI. Renewable energy deployment has indeed accelerated across regions in recent years, albeit with near-term uncertainty from policy volatility, inflation, and variation in regional achievements. Fossil fuels remain dominant in the near term, but their prospects are weakening in light of growing renewable energy shares.[72]

At the same time, strategic interests in reducing fossil fuel trade dependencies in the energy sector are an increasingly important factor shaping global markets. Russia's war on Ukraine and sudden policy changes under the second Trump administration have highlighted energy market vulnerabilities. Energy self-sufficiency ambitions have become increasingly relevant, drawing attention to locally produced energy sources, such as those derived from biomass.

Transition processes will likely reshape energy systems and affect multiple commodities, including minerals that support renewable technologies, vegetable oils, grains and forest products that feed into biofuels and biomass, as well as ongoing demand for fossil fuels to meet energy needs. Many options are land- and resource-intensive, including agricultural land conversion, mineral mining, oil drilling, and the establishment of new infrastructure corridors. These dynamics risk creating new dependencies and further intensifying existing pressures on forests.

This analysis synthesises recent patterns across key geographies, explores different pathways, and assesses implications for the tropical rainforest regions related to three key energy market segments: mineral demand for the transition to renewables, biomass demand for liquid and solid bioenergy, and the exploitation of conventional fossil fuels.

3.2 Minerals for the energy transition

3.2.1 Global market landscape

Fossil fuels have long underpinned energy systems, with oil, gas, and coal still accounting for the largest share of primary energy consumption globally (→ section 3.4). Their heavy contribution to climate change, pollution of air, water and soil, and their detrimental health impacts, alongside their finite nature and rising marginal extraction costs, create economic and energy security risks.[73] Together, these factors underscore the need to reduce reliance on fossil fuels. This transition entails a large-scale shift to electricity-based systems to achieve decarbonisation goals:[74] the rapid deployment of solar photovoltaic (PV) and wind, expansion and strengthening of transmission and distribution grids, growth in storage capacity, and widespread electrification of transportation via electric vehicles (EVs). GHG emissions over the full lifetime of EVs are significantly lower than those of conventional cars, and this gap is expected to grow as the overall electricity mix continues to decarbonise.[75]

However, renewable energy systems differ from conventional energy facilities in that they are considerably more mineral-intensive than their fossil-fuel counterparts, and specifically require large volumes of so-called 'critical' minerals.[76]

For example, a typical EV requires around six times the mineral inputs of a conventional car; onshore wind needs nine times more mineral resources per energy unit than a gas-fired power plant (Figure 8). Consequently, the energy transition drives a rapidly rising demand for minerals across technologies.[77]

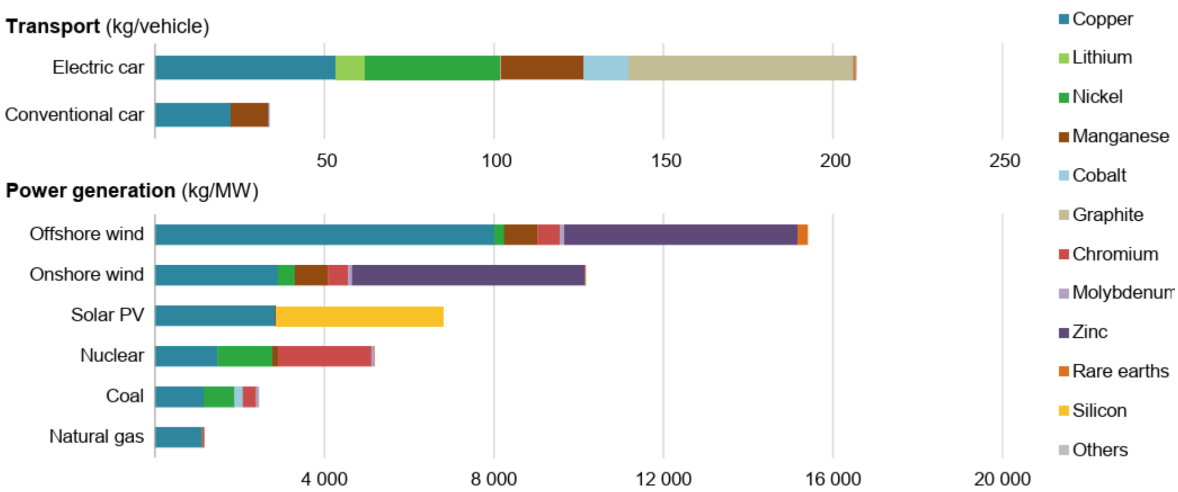
The growing industry significance of these minerals is reflected in companies' exploration budgets. Using the example of key battery minerals, the global budget spent on nickel, lithium and cobalt exploration increased more than fivefold from 2016 to 2023.[78]

What are 'critical' minerals?

The concept of so-called 'critical' minerals has primarily been defined by governments, referring, broadly speaking, to those minerals that have an essential role in strategically important economic sectors or for the national security of countries, are difficult to substitute, the absence of which would have significant consequences, and that have supply chains vulnerable to disruption.[79] These criteria can, but do not necessarily, refer to rare minerals. As a specific subset of 'critical' minerals, the criticality of 'transition' minerals is determined by their necessity for the global energy transition towards low-carbon technologies.[80] In some cases, energy applications still represent only a small share of overall consumption, for example, in the production of copper and nickel. By contrast, materials such as lithium and rare earth elements (REEs), which historically had limited use, may see sharp relative increases.[81] Other sectors with increasing demand include, for example, information and defence technologies, as well as healthcare.[82] The growing demand, price volatility, supply chain disruptions, and geopolitical tensions have placed these minerals on government agendas worldwide, driving partnership agreements and the fast-tracking of mining permissions.[83]

The definition of 'critical' minerals can differ: the EU Commission lists 34 minerals, while the US Department of Energy (DoE) has a broader list of 50. These include minerals that are also considered critical for defence purposes. The IEA's selection is most relevant for this section, as it focuses on the energy transition minerals pertinent to renewable energy and e-mobility.[84]

Figure 8 Minerals used in selected clean energy technologies



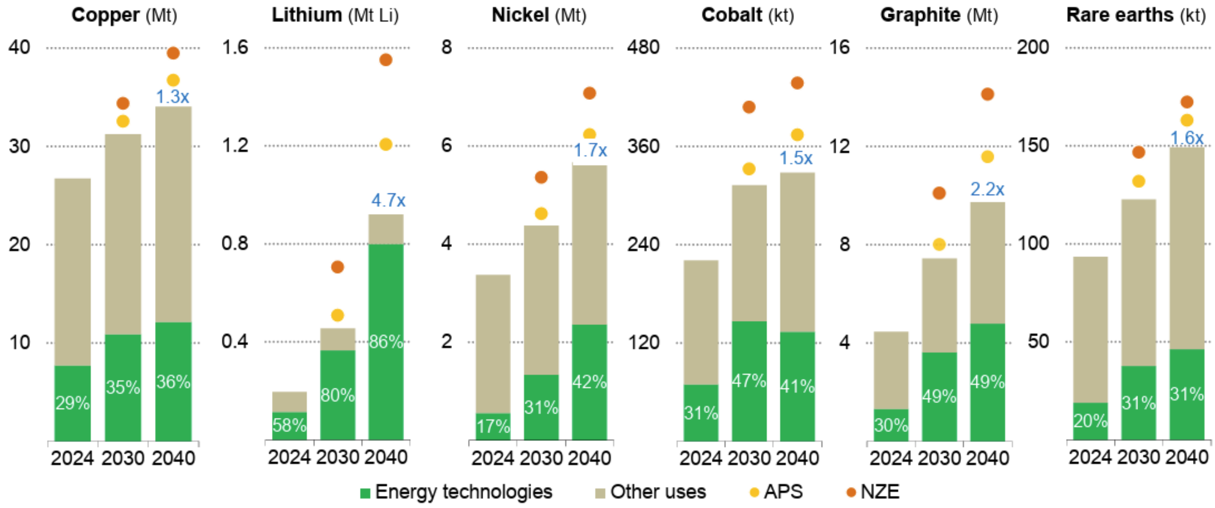
Note: kg = kilogramme; MW = megawatt. Steel and aluminium are not included.

Source: International Energy Agency (IEA) (2021), *The Role of Critical Minerals in Clean Energy Transitions*, Paris, France: IEA, p. 26.

3.2.2 Demand trends

Across different scenarios, the IEA forecasts a strong ongoing increase in 'critical' mineral demand for energy technologies from a 2024 baseline until 2040. In the IEA's most conservative estimate, the Stated Policies Scenario (STEPS), lithium increases about fivefold by 2040; graphite and nickel roughly double; cobalt and magnet rare earths grow by about 50–60%; and copper—already the largest market—expands by ~30%. EV and stationary batteries drive lithium, graphite, nickel, and cobalt, while grid and industrial electrification underpin copper and aluminium; growing use of permanent magnets in EVs and wind power raises rare earth elements (REEs) demand for high-performance magnets (Figure 9). The wider deployment of renewable energy technologies will increase the share of these minerals in the total global industry demand.[85]

Figure 9 Critical mineral demand forecast in IEA's Stated Policies (STEPS) scenario



Notes: STEPS = Stated Policies Scenario (prevailing direction of energy system progression, based on an in-depth review of the current policy landscape; Mt = million tonnes; Kt = kilotonnes; APS = Announced Pledges Scenario (based on major national announcements of ambitions and targets as of August 2024); NZE = Net Zero Emissions by 2050 Scenario (normative scenario showing a pathway for the global energy sector to achieve net zero CO_2 emissions by 2050, with advanced economies reaching net zero sooner). The figures for copper are based on refined copper (excluding direct-use scrap). Rare earth elements are limited to magnet rare earth elements. Growth rates (in blue) for the period 2024 to 2040.

Source: International Energy Agency (IEA) (2025), *Global Critical Minerals Outlook 2025*, Paris, France: IEA, p. 85.

As with all forecasts, insecurities are linked to various volatile and unpredictable factors, including policy changes, geopolitical shifts, and technological advances.[d] Global EV sales and the shift to renewable energy sources are subject to a wide range of uncertain factors, including shifting policy ambitions, lower oil prices, and the impact of tariffs on car prices. Rapid product innovation and the creation of new markets may lead to higher-than-expected mineral needs and an even higher demand for certain minerals. Lower outcomes may be due to substitution, efficiency, and the recovery of metals from products at the end of their life, or higher extraction rates, which could temper the expansion of mining.[86] Lower projected EV sales in the latest IEA outlook already tempered some battery-metal trajectories.[87] Despite uncertainties and a slowdown compared to earlier forecasts in some markets, the aggregate impact is expected to be mitigated by global demand growth, particularly from the Chinese and Southeast Asian markets,[88] and will likely slow down the demand increase rather than lead to a long-term decrease.

Recycling

The mineral demand can be broadly met from two sources: mining and recycling. Recycling is a growing and important source. It has the potential to secure supplies within a circular economy and to significantly reduce pressure for new mine development. The EU Battery Regulation sets mandatory targets for end-of-life batteries, with specific recycling efficiency and material recovery requirements for different battery types (→ section 6.3.4).[89]

In a scenario in which countries deliver on all announced pledges on energy and climate, the IEA predicts that 'critical' mineral recycling could reduce new mine development needs by 40% for copper and cobalt and by 25% for lithium and nickel by 2050. It is difficult, however, to predict how realistic these commitments are in light of the currently limited progress in the availability of recycled materials.[90] Importantly, technology to economically recover the minerals for reuse is often not yet available in the short- to medium-term. It is forecasted that significant shares of

[d] For example, projections for cobalt demand have been lowered compared to previous IEA outlooks, owing to the expected demand impacts from the increasing adoption of lithium-iron-phosphate (LFP) chemistries at cost of cobalt-containing chemistries like nickel-manganese-cobalt (NMC).

recycled 'critical' minerals will be supplied only by the mid-century.[91] While early-generation energy transition products, such as EV batteries or wind mills, reach the end of their life in the coming five years,[92] there are often not yet enough recyclable products to supply the volumes needed, as many of the minerals required in the energy transition were not used in comparable volumes in older products. For example, the copper required to produce an average EV currently would require the recycling of at least four internal combustion engine vehicles.[93]

Securing 'critical' mineral supplies

Meanwhile, governments from countries with supply gaps scramble to secure stable flows of strategically important minerals. The EU Commission, as part of its Raw Materials Diplomacy, has already formed partnerships with 13 countries around the world, including the DRC. Related to its partnership agreement with the DRC, the EU emphasises its commitment to secure, sustainable, and resilient value chains for 'critical' raw materials by supporting the EU's strategic autonomy as well as the economic development of its partner country, mainly in the mining sector, through concrete projects and investments.[94] The agreement with the DRC is also listed as a project under the EU's Global Gateway initiative that seeks to mobilise a total of €300 billion of public and private financing between 2021 and 2027 to invest directly in "*[…] smart, clean and secure links in digital, energy and transport sectors and to strengthen health, education and research systems across the world.*"[95] As part of its Critical Raw Materials Act (CRMA), the EU aims to establish additional relations and letters of intent with another eight countries and regions, including Brazil, Colombia and Peru,[96] to reduce strategic dependencies by diversifying sourcing, improve the EU's capacity to monitor and mitigate risks of supply chain disruptions, and improve circularity and sustainability (→ section 6.3.4).

The efforts of the US to secure supplies include a controversial peace deal between the DRC and Rwanda brokered in June 2025. It provides the US with access to 'critical' minerals in the two countries, with their rich deposits of cobalt, copper, and lithium, among others.[97] In April 2025, the US and Ukraine signed a profit-sharing deal for future exploitation of the country's reserves of manganese, graphite and other 'critical' minerals.[98] The Strategic & Global Partnership Action Plan (2025) between Japan and Brazil calls for a deepened cooperation on base metals and 'critical' minerals.[99] Meanwhile, the UK and others have conducted dedicated critical mineral missions to Brazil and dialogues to strengthen cooperation.[100]

China dominates global mineral supply chains, rooted in its long-term policy to advance technologies, especially in the midstream (processing) segment for batteries, and to secure control of key mineral supply chains.

These partnerships and initiatives illustrate the growing geopolitical interest in securing mineral access and reflect how 'critical' minerals are becoming central to international cooperation and energy transition planning.

China's Belt and Road Initiative

China plays a particularly important role in investments in 'critical' mineral mining. Within its Belt and Road Initiative (BRI), strategically important metals and mining are a focus area. In 2024 alone, investments of US$21.4 billion (€20.5 billion) focused on African countries, Bolivia, Chile, and Indonesia.[101]

Several BRI mining and minerals projects backed by Chinese firms that have been under execution or planning since 2024 overlap with rainforest regions. In the DRC, the growth of copper and cobalt is tied to BRI projects. CMOC (China Moly) expanded output at Tenke Fungurume and Kisanfu in 2024.[102] Meanwhile, the Chinese-Congolese Sicomines package for a copper-cobalt JV, originally from 2008, was renegotiated in 2024, raising China-financed infrastructure commitments to a multi-billion US$ level through 2040.[103] The Kamoa-Kakula copper mine, operated by Chinese ZiJin Mining-led JV, commissioned phase 3 in May 2024 and is bringing one of the world's largest smelters online.[104]

In Indonesia, BRI flagship platforms include expanding battery and stainless steel supply chains at industrial parks in Sulawesi and Halmahera (Indonesia Morowali Industrial Park (IMIP),[105] Konawe Industrial Park in Sulawesi, and Weda Bay Industrial Park (IWIP)).[106] The Indonesian government's export ban on raw minerals led to investments in local value-added activities.[107] In PNG's Madang Province, the Ramu NiCo mine joint venture (JV) led by Metallurgical Corporation of China (MCC) remains the country's sole industrial nickel-cobalt operation; management has flagged expansion ambitions for 2025.[108]

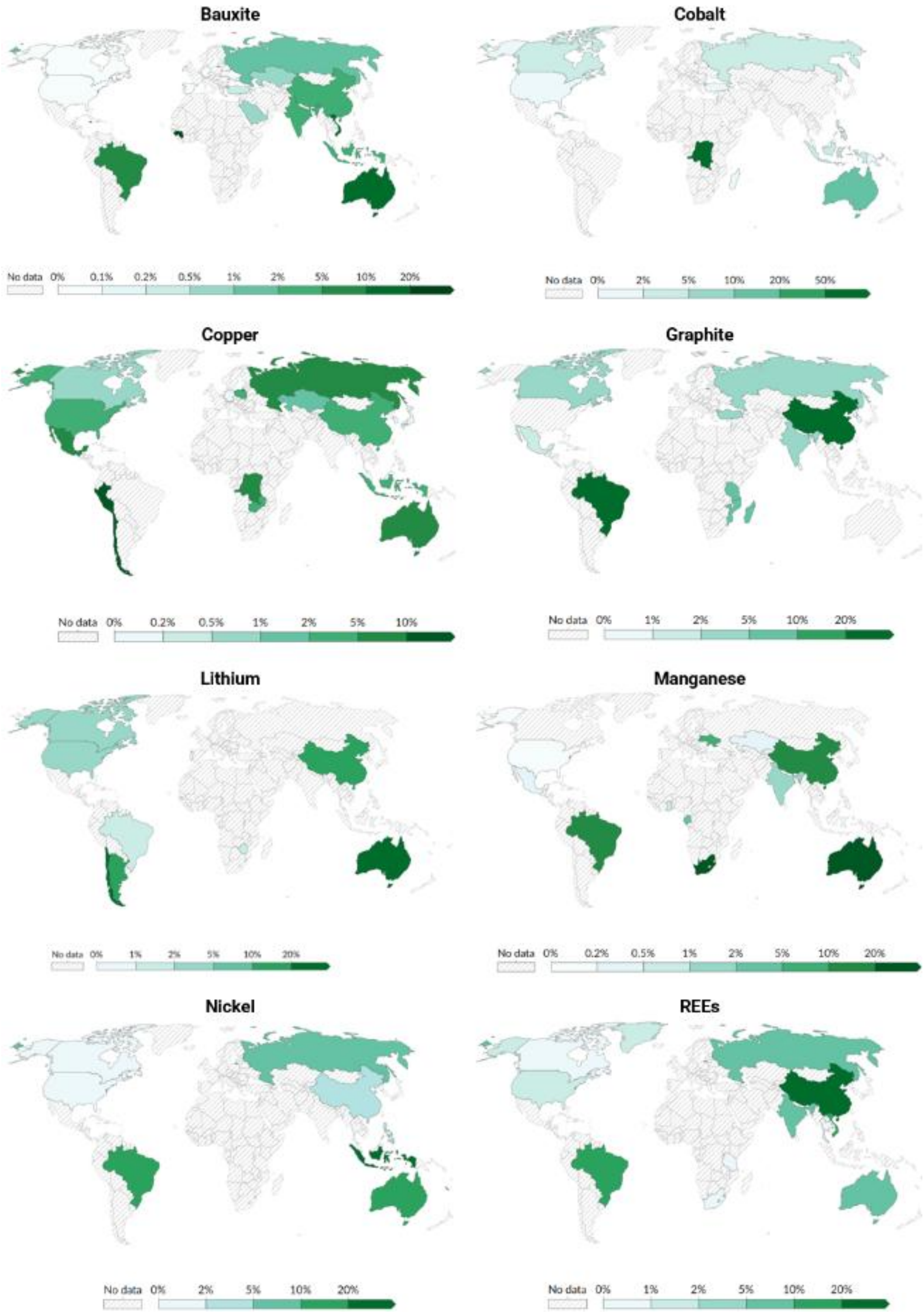
These activities are guided by Chinese policy, and formal green guidelines exist; however, these policies are soft law and largely voluntary (→ section 6.3.6). Examples include the "Green Development Guidance for BRI Projects" (BRIGC), which features a "traffic-light" classification for biodiversity, climate, and pollution risks.[109] The 2022 "Guidelines for Ecological Environmental Protection" urge Chinese companies overseas to apply international or higher Chinese standards where host rules are weak and to avoid important biological habitats.[110] However, implementation gaps are commonly observed, ranging from high accident rates at Indonesian nickel parks to controversial tailings dumping in PNG.[111] In the Amazon, Ecuador's authorities both advanced Chinese-backed expansions despite various breaches (Mirador)[112] and suspended concessions for environmental breaches in other cases,[113] illustrating active but irregular oversight. Overall, host-country regulations and enforcement appear to be more important determinants of outcomes than safeguards under the BRI.

3.2.3 Geographic patterns of 'critical' minerals for the energy transition

Minerals considered critical for the energy transition are mined in diverse geographies. Often, the countries that currently dominate the mining of certain minerals are not the same as those with the largest reserves. Therefore, the hotspots for today's mining can differ from the hotspots for future development. Reserves refer to known and assessed mineral deposits that are suitable for economic mining under current technological and market conditions.[e, 114] The following maps (Figure 10) illustrate the reserves geography for a selection of 'critical' minerals based on a country's share in the total global known reserves. However, a mineral may abundantly occur in a region but still be difficult to access. For example, the typical lead time for a new copper mine to go online is about 20 years.[115]

[e] Contrary to the broader category of mineral resources, which refers to a natural concentration of minerals in the earth's crust in sufficient form, grade or quantity that may be of economic interest for extraction.

Figure 10 Critical mineral reserves in key countries



Source: US Geological Survey (USGS), in: Ritchie, H. and P. Rosado (2024, September), "Which countries have the critical minerals needed for the energy transition?", *Our World in Data*, online: https://ourworldindata.org/countries-critical-minerals-needed-energy-transition.

The different types of mining

Mineral extraction in forested areas can be large-scale mining (LSM) or artisanal and small-scale mining (ASM), with organised illicit mining activities forming an additional complex. ASM is more common for certain minerals, such as gold and cobalt. Therefore, higher proportions of illegal or informal ASM are observed in some regions, such as gold mining in the Amazon.[116] LSM and ASM exhibit significant differences in their direct and indirect impacts on deforestation. LSM is a formal and regulated activity that utilises modern industrial-scale extraction and processing technologies, and has a significant impact on forest loss in terms of time, scale, and space. Due to its large scale, the sector is more often obliged to comply with at least minimal environmental and social standards.[117] ASM is largely an informal activity that can serve as a significant source of income for local populations. However, its informality makes ASM particularly vulnerable to exploitation, unsafe and exploitive working conditions, child labour, and negative environmental impacts.[118] ASM often operates in a regulatory grey zone, where its activities may be illegal or not explicitly considered in relevant legislation and largely tolerated.[119] Other unofficial mining operations, such as 'wildcat' gold mining in the Brazilian Amazon, are illegal by nature, using heavy machinery and environmentally harmful extraction methods, building airstrips in the forest, and invading Indigenous lands and conservation zones.[120] Such activities scarcely benefit the livelihoods of local people but are rather linked to land invasion and other human rights violations. In the DRC, the profits from poorly organised ASM of gold, coltan and other minerals have fuelled decades of violent conflict.[121]

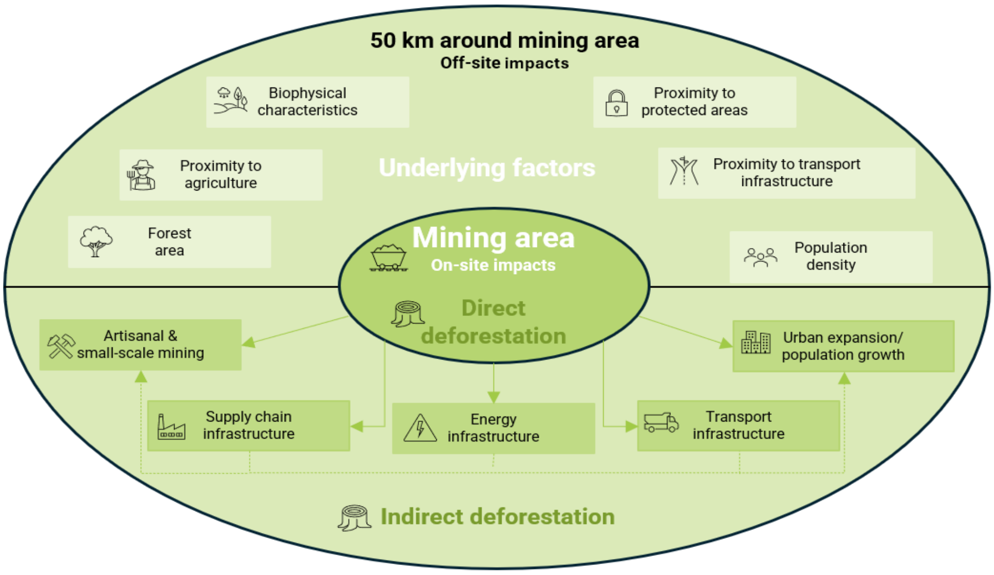
3.2.4 How demand may put pressure on tropical rainforests

Mining for mineral extraction directly causes deforestation through land clearance for extraction sites, tailings storage, waste dumps, on-site processing facilities, and access roads. Estimates suggest that between 2001 and 2020, 8,533 km^2 of tropical and subtropical rainforests were lost as a direct consequence of mining. Since the beginning of the century, almost 84% of total direct mining-related deforestation worldwide has been concentrated in just ten countries. Indonesia (3,537 km^2) and Brazil (1,654 km^2) stood out as the countries with the highest exposure to directly mining-related deforestation.[122]

According to Kramer et al., gold and coal accounted for the largest share of all global directly-caused deforestation in the past. In the case of the EU, for example, gold and coal contributed 40% and 20%, respectively, to the region's total mineral demand-driven deforestation footprint over the 20-year period from 2001 to 2020, followed by bauxite (11%) and copper (7%). The main countries of origin for the EU's global mining deforestation footprint were Indonesia (20%, primarily linked to hard coal), followed by Brazil (13%, linked to gold, bauxite, copper and iron), and Russia (11%, linked to gold and hard coal).[123] However, as the energy transition to phase out fossil fuels continues, this picture can be expected to tilt towards 'critical' mineral mining.

The direct mining-related deforestation footprint may seem comparatively small, but it is crucial to consider that mining significantly amplifies other drivers of forest loss on top of these direct impacts (Figure 11).

Figure 11 **Direct and indirect forest loss drivers connected to mining activities**



Source: Own elaboration, based on: Giljum, S., V. Maus, N. Kuschnig et al. (2022), "A pantropical assessment of deforestation caused by industrial mining", *PNAS*, Vol. 119(38): e2118273119.

Although attribution is rarely straightforward, it is very likely that the cumulative impacts of mining on forest areas were significantly underestimated for many years.[124] Important indirect drivers of forest loss include transport infrastructure, such as roads, railways, or river ports, as well as industrial processing hubs adjacent to mines, and energy corridors. A major concern is the feedback loop between mining projects and infrastructure development for transport and energy, which enables population influx, settlement extension, and agricultural expansion into remote, underdeveloped forested areas (→ section 6.6).[125] A 2019 World Bank study observed forest loss and degradation within a 50 km radius of most mines, and at times, up to 100 km. The findings suggest that mining may affect at least 10% and up to one-third of the world's forests.[126]

Research by Giljum et al. confirms that deforestation is significantly higher near industrial mining operations,[f] with intensity increasing with proximity to mine sites. They found particularly high statistical significance for mining driving deforestation in the surrounding areas up to 50 km outside the mining areas[g] in, among other countries, Brazil and Indonesia. These indirect effects are often difficult to quantify, as they are typically recorded under broader categories of deforestation drivers, such as agriculture, infrastructure expansion, and settlement growth. Environmental impact assessments (EIAs) and other permitting requirements for industrial mining often fail to adequately cover territories outside of mining project concession areas and overlook the cumulative impacts of other economic activities in their surroundings.[127]

A comparatively small number of countries control a significant share of the current extraction and identified reserves for potential future mining of these 'critical' minerals, among them various countries with important shares of the remaining tropical rainforests (Figure 10 and Figure 12).

[f] Analysis of ASM impacts is hampered by a lack of data for ASM locations and extents covering the global tropical biome.

[g] Including open cuts, tailing dams, waste rock dumps, water ponds, processing infrastructure, and other types of land cover related to the mining activities.

Figure 12 'Critical' mineral production and reserves in tropical rainforests (2023, examples)

Brazil	Colombia	Peru	DRC	Indonesia	PNG
Production					
Bauxite #4 Lithium #5 Manganese #7 Nickel #8	Nickel #9 Copper #43	Copper #3	Cobalt #1 Copper #3	Nickel #1 Cobalt #2 Bauxite #4	Cobalt #9 Nickel #12
Reserves					
Nickel #3 REEs #3 Bauxite #4 Lithium #7 Manganese #4		Copper #2	Cobalt #1 Copper #4	Nickel #1 Cobalt #4 Bauxite #6 Copper #10	Cobalt #11

Source: US Geological Survey (USGS), in: Ritchie, H. and P. Rosado (2024, September), "Which countries have the critical minerals needed for the energy transition?", *Our World in Data, online: https://ourworldindata.org/countries-critical-minerals-needed-energy-transition*; Idoine, N.E., E.R. Raycraft, S.F. Hobbs et al. (2025), *World Mineral Production 2019 to 2023*, Nottingham, United Kingdom: British Geological Society (BGS); Colombian Geological Survey (2024), *Fact Sheet Copper*, p. 1.

In several of the countries mentioned in Figure 12, relevant mining concessions widely overlap with vulnerable tropical rainforests and IP and LC territories.[128] The expansion of industrial and illegal mining across the rainforest regions poses severe future threats to ecosystems and communities. Steeply rising investment in "critical" minerals is expected to exacerbate pressure on forests in all three regions.[129]

3.2.5 Outlook for the Amazon rainforest

Mineral exploitation may not have had a large direct deforestation footprint in the Amazon rainforest; however, considering the region's huge mineral wealth, the industry's importance is growing, and its indirect impacts on surrounding nature can be sizeable.[130]

Brazil

Estimates on the primary forest loss directly connected to mining in the Brazilian Amazon differ considerably. While Giljum et al. observed 327 km^2 of tropical rainforest loss within Brazil's actual mining areas between 2000 and 2019, Global Forest Watch (GFW) estimates 1,144 km^2 in the period 2001 to 2020.[131] In both cases, considering the deforestation linked to indirect factors within the wider mining concessions, especially in relation to the opening of new forest areas through road infrastructure,[132] would increase the actual impact by at least a factor of ten.

A study in the Brazilian Amazon found that mining induces deforestation up to 70 km from concessions; moreover, indirect deforestation is 12 times higher than forest loss within mining leases. Including affected off-lease areas, estimates suggest that mining in the Brazilian Amazon resulted in 11,670 km^2 of deforestation between 2005 and 2015 alone, equivalent to 9% of all Amazon forest loss during this period.[133]

Considering future developments, the increasing mineral demand associated with the energy transition could become a significant driver of mining impacts in the Amazon rainforest. Brazil holds significant shares of several mineral reserves that are forecast to experience increased demand in the coming years, including 19% of global REE reserves, 14% of manganese, 12% of nickel, and 9% of bauxite, among others.[134] Varying shares of these reserves lie beneath the Amazon. For example, demand for bauxite is rising, reflected in the large number of concessions requested around existing bauxite mines in Pará state and new areas in Amazonas state.[135]

EV deforestation footprint until 2050

Growing sales of EVs are projected to drive increasing demand for 'critical' minerals in the longer term. A study by négaWatt and Vienna University evaluated the cumulative metal requirements and associated direct deforestation impacts of the EU's transition to EVs in the period 2025 to 2050.[136] The assessment considers six scenarios (Table 1), with two transport assumptions and variations based on battery technology (lithium-ion batteries with lithium-nickel-manganese-cobalt oxide (NMC) 811 cathodes, lithium-ion batteries with lithium-iron-phosphate (LFP) cathodes, or a diversified mix). NMC 811 cathodes have high deforestation rates as cobalt and nickel are often mined in countries like Indonesia.

Table 1 Underlying assumptions of EV-fleet scenarios for the EU

Transport assumptions	**MIX** Battery prospective mix ensuring diversification	**NMC 811** ✓ Nickel ✓ Cobalt ↓ Less copper per kWh	**LFP** ✗ Nickel ✗ Cobalt ↑ More copper per kWh
↑ Increasing car transport demand →Car sizes maintained Race for battery autonomy (growing battery sizes)	BAU Scenario	BAU NMC811 variant	BAU LFP variant
↓ Reduction of car demand ↑ Car pooling & modal shift ↓ Reduction of car sizes Adjusted battery autonomy	CLEVER Sufficiency scenario	CLEVER NMC811 variant	CLEVER LFP variant

Source: Giljum, S., V. Maus, J. Kreimel et al. (2025, May), *Driving Change, Not Deforestation*, Vienna University of Economics and Business and The négaWatt Association, p. 21.

Notwithstanding the substantial environmental advantages of EVs compared to combustion vehicles in terms of lifecycle CO_2 emissions, the study underscores the significant impact of the battery technology in combination with sufficiency measures on potential deforestation outcomes.
Cumulative deforestation linked to the EU fleet from 2025 to 2050 is estimated at:

- 652 km^2 under the BAU scenario with mixed battery technology, increasing to 1,178 km^2 with NMC811 chemistry dominating, and decreasing to 373 km^2 with LFP batteries.
- 374 km^2 under the CLEVER scenario with mixed battery technology, increasing to 725 km^2 with NMC811, while decreasing to the lowest value of the scenarios of 213 km^2 with LFP batteries.

These estimates are conservative, as important indirect deforestation from mining activities has not been considered. Under the BAU scenario, Indonesia (275 km^2) and Brazil (139 km^2) have the largest deforestation footprints. Indonesia's share decreases sharply under BAU LFP (7 km^2), while Brazil sees an increase (156 km^2).

Impact scenarios

A simple extrapolation of these data allows us to give an indication of what this might mean on the global level. In IEA projections until 2035, Europe accounts for just over one-fifth of the global EV fleet.[137] Extrapolating the above deforestation estimates for the EU fleet to the global scale by assuming a 25% EU share until 2050 and a comparable market trajectory, this leads to a rough estimate of cumulative deforestation linked to the global EV fleet's mineral consumption:

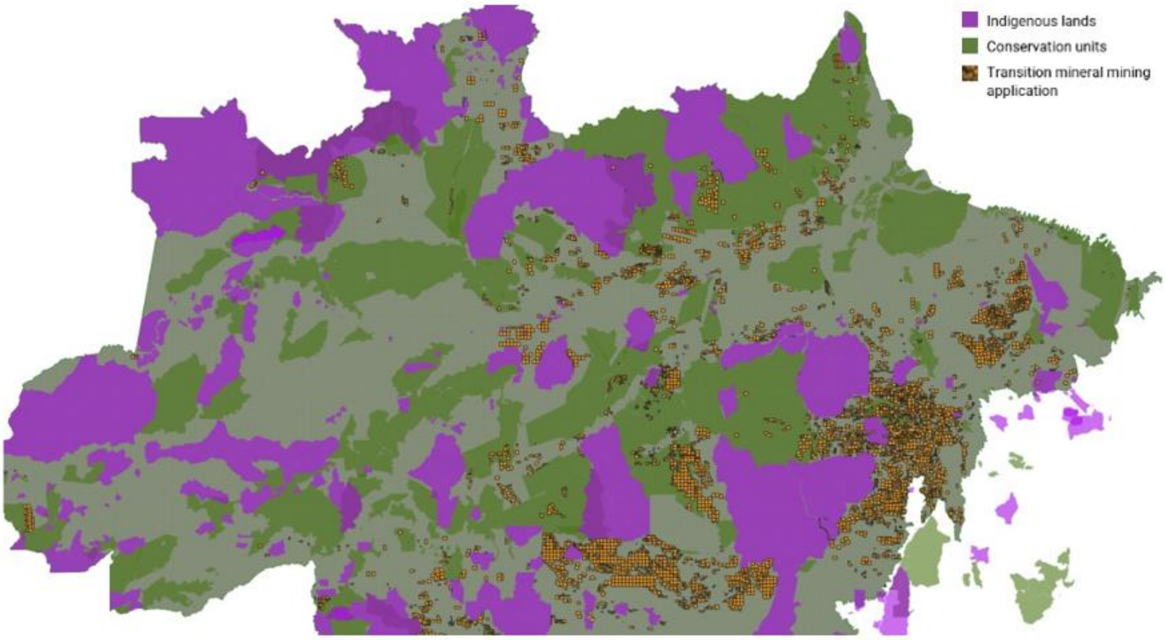
- ~2,600 km^2 under the BAU scenario with mixed battery technology, increasing to ~4,700 km^2 with NMC811 dominating, and decreasing to ~1,500 km^2 with LFP batteries.
- ~1,500 km^2 under the CLEVER scenario with mixed battery technology, increasing to ~2,900 km^2 with NMC811, while decreasing to the lowest value of the scenarios of ~850 km^2 with LFP batteries.
- Zooming in on key countries in the three rainforest regions, for Brazil, these estimates range between ~290 km^2 and ~623 km^2; for the DRC, between ~9 km^2 and ~206 km^2; and for Indonesia, between ~28 km^2 and ~2,968 km^2, with shares of individual countries heavily influenced by the battery technology.

The potentially vast expansion of mining activities will require careful management, planning and monitoring to avoid sacrificing the Amazon for the energy transition, especially in remote regions with limited state presence and law enforcement.[138] A survey by InfoAmazonia revealed that 5,046 mining applications had been filed with Brazil's National Mining Agency (ANM) as of May 2024. The procedures were filed by more than 800 companies, to exploit minerals like bauxite, copper, lithium, manganese, nickel, niobium, cobalt and REEs. Pará state is a hotspot for these requests.[139] Mining applications have experienced significant growth since 2017, in parallel with the increasing demand for minerals to support the energy transition.[140]

The area identified by InfoAmazonia covers 260,000 km^2 within the biome, and many requests reach into areas with direct impact on Indigenous lands and protected areas: more than 1,200 projects are located within 10 km of 137 Indigenous lands, of which 390 are illegally invading these territories. Another 1,200 applications in the Brazilian Amazon overlap with 107 conservation units (Figure 13).[141]

The Brazilian government sees big potential to attract investments in 'critical' mineral exploration, offering the country "*[…] the opportunity to be the main investment frontier in the sector and strategically position itself as a credible partner and supplier to raise social and environmental standards in the global market for critical minerals for the energy transition*."[142]

Figure 13 'Critical' mineral exploration applications Brazilian Amazon



Note: applications filed with the ANM until May 24, 2024.

Source: Bispo, F. (2024, July 17), "Energy transition creates a race for strategic minerals with 5,000 applications in the Amazon", InfoAmazonia, online: https://infoamazonia.org/en/2024/06/11/energy-transition-creates-a-race-for-strategic-minerals-with-5000-applications-in-the-amazon/.

Under the Mineral Research sub-axis of the new Growth Acceleration Program (PAC) launched by the Brazilian government in 2023, R$307 million (€49 million) was made available for geological mapping, geochemical surveys, and the evaluation of potential strategic mineral projects.[143] In May 2024, the Brazilian Development Bank (BNDES) and mining company Vale announced the creation of an investment fund focused on energy transition, mineral mining, and soil fertilisation projects.[h] Aiming to serve as catalysts to leverage private investments, BNDES and Vale will each subscribe to shares worth up to R$250 million (€40 million).[144]

In August 2025, the Brazilian government announced plans to make large investments and bolster its position as a reliable global partner for the energy transition. Initiatives already underway include expanding mining output and investing in downstream processes for value addition, such as the MagBRAS project, which would become the Southern Hemisphere's first research laboratory for the production of permanent magnets.[145]

Already in 2021, the Brazilian government had established Decree No. 10,657 to 'Support the Environmental Licensing of Investment Projects for the Production of Strategic Minerals'.[146] Building on this, recent regulatory initiatives include the National Policy on Critical and Strategic Minerals for Energy Transition and Food Security, expected to be launched later in 2025, the Critical Minerals Fund of the BNDES, and the Guide for Foreign Investors in Critical Minerals for the Energy Transition in Brazil.[147] The bill PL 2.159/2021, which was signed into law in August 2025,[148] allows for the fast-tracking of environmental licensing for mining activities considered to be of strategic importance to the country. Environmental and indigenous organisations refer to it as the 'devastation bill' due to concerns over simplified licensing procedures for projects with high environmental risks (→ section 6.3.1).[149]

In August 2025, the ANM created a dedicated Division of Critical and Strategic Minerals to deal with issues related to 'critical' minerals. This formalisation was fast-tracked in reaction to the growing foreign interest in relevant mineral supply chains.[150] The ANM had already informally accelerated the approval of mineral mining projects critical for the energy transition. The new division will consolidate this approach by directly advising the ANM board and prioritising handling of strategic projects, notably those related to copper, lithium, nickel, and niobium.[151] In combination with the significant critical mineral reserves, these initiatives suggest an accelerating development of critical mineral mining in Brazil, with potentially far-reaching implications for the Amazon.

Environmental, social and economic vulnerabilities are insufficiently considered in Brazil's current plans for the energy transition. The Amazon is most affected as project areas for mining, solar and wind plants, and power transmission lines often overlap with preserved forest areas and IP and LC territories, contributing to deforestation, biodiversity loss, and reduced water availability, among other disruptions. Projects also carry the risk of intensified territorial conflicts. Considering settlements, conservation units, Indigenous territories, and traditional communities (Quilombos) covering an area of 4.5 million km^2, a recent study by Brazilian university researchers estimated that 179,000 km^2 of these territories are already affected by mining, energy, and transmission projects, including 90,000 km^2 in conservation units.[152] A study by the Brazilian Mining Conflict Observatory illustrates the link between 'critical' mineral mining and territorial conflicts: between 2020 and 2023, ~46% of the total 380 documented cases of mining-related conflicts occurred in the Amazon, with 142 cases (~37%) in Pará. Out of the total cases, ~10% of the conflicts around mining involved Indigenous people, ~24% small settlers, and ~12% workers.[153]

Colombia

In the Colombian Amazon, exploration of copper and accompanying minerals is leading the 'critical' mineral impact. Colombia considers copper and other 'critical' minerals as a key driver of reindustrialisation and a strategic tool in shifting from the country's dependency on oil and coal. This is reflected in the country's National Development Plan (Law 2294) and the National Mining Agency's Resolution 1006.[154] While prospective areas of cobalt, copper, lithium, nickel, silver, and

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[h] Target companies for selection by the fund should hold, directly or indirectly, mining titles or rights over mineral resources for cobalt, copper, tin, graphite, lithium, manganese, platinum group metals (PGMs), molybdenum, niobium, nickel, silicon, tantalum, REEs, titanium, tungsten, uranium, vanadium, zinc, phosphate, potassium or other minerals to promote soil fertility.

REE mining are concentrated along the Andes in Colombia, the subsoil of the country's Amazon region holds prospective zones for REEs, silver, and lithium mining. The total potential areas of sought-after 'critical' minerals in Colombia add up to ~310,500 km^2. Of this, the Amazon share accounts for several tens of thousands of square kilometres.[155]

The Copper Route, recently launched by the National Mining Agency, highlights Mocoa, located on the Western edge of the Amazon, as a flagship copper deposit that can support local industries, boost regional development, and contribute to a more sustainable economy.[156] Exploration for the first mega open-pit copper mine in the Mocoa Copper-Molybdenum Project is ongoing,[157] but has drawn protests from local communities and the Indigenous Inga people over concerns for deforestation, landslides, pollution, loss of livelihoods, owing also to its overlap with a forest reserve.[158] The six mining titles by Canadian mining company Libero Copper cover more than 110 km^2,[159] and lie in an area highly susceptible to landslides, as experienced during the catastrophic landslides that hit Mocoa in 2017.[160] If developed, the estimated ore body of ~2.1 million tons (Mt) of copper and ~232 kilotons (Kt) of molybdenum would be valued at ~US$20 billion (€18.1 billion) at 2023 market valuations for copper.[161]

3.2.6 Outlook for the Congo Basin rainforest

Democratic Republic of the Congo

Large deposits of some of the world's most valuable commodities can be found in the Congo Basin, especially the DRC: from diamonds to gold, coltan and multiple 'critical' minerals. The DRC already plays a key role in the mining of 'critical' minerals. The country is the world's leading cobalt producer, the third-largest copper producer and home to large reserves of both minerals.[162] Together, these two minerals generated ~90% of the DRC's export revenues in 2024.[163] Large industrial operations have expanded in recent years, largely dominated by Chinese companies or joint ventures with major Chinese stakes, and additional large investments by Chinese companies in DRC mining infrastructure have been announced.[164] However, the large-scale mines that operate in the DRC are mostly located outside of the rainforest region, in the southern part of the country.

The DRC also holds major undeveloped reserves of other minerals, including lithium and coltan.[165] The EU estimates the value of untapped resources at roughly US$24 trillion (€20 trillion). This endowment positions the DRC to play a pivotal role in the global energy transition (through minerals used in batteries, renewables, and grids), and is often presented as a means to lift millions of people out of poverty. However, developing all these deposits without establishing effective and strong governance would put tremendous pressure on the Congo Basin forests if not implemented with strong safeguards.[166]

Excluding artisanal operations, almost 12% of DRC is covered by mining titles for a variety of minerals, of which 35%–almost 100,000 km^2–overlap with forests.[167] When selecting only industrial mining titles involving the 'critical' energy transition minerals cobalt, copper, or nickel, and excluding the Southern provinces outside the Congo Basin rainforest, ~38,000 km^2 are covered by exploration permits and ~710 km^2 by exploitation permits.[168]

Extensive ASM is a widespread phenomenon in the Congo Basin Forest of the DRC, particularly for cobalt. An estimated 2 million people are directly involved in ASM, and about 10 million depend on the sector for their livelihoods. According to estimates, more than 70% of the world's cobalt production is mined in the DRC, with ASM accounting for 15-30% of the volume.[169] These individual operations are generally considered to cause only minor damage to forests due to their short-term nature and small surface, though the cumulative negative impacts of many small operations can also drive more significant localised deforestation.[170] ASM for coltan and the so-called 3Ts (tin, tungsten, tantalum) in the Eastern DRC is fuelling persistent conflict; armed groups illicitly transport the minerals to neighbouring Rwanda.[171]

Mining and other commercial pressures are not yet described as major direct drivers of deforestation in the Congo Basin. Direct, on-site deforestation in the DRC increased from 2.5 km^2 in the period 2000-2004 to 38 km^2 in the period 2015-2019. More than three-quarters of the direct deforestation observed in the twenty-year period occurred in the last ten years.[172] When considering the indirect impacts on forests, the effect is also more substantial, as mining concessions and tree cover loss have shown significant overlap over the last few decades. According to estimates from 2020, ~12% of forest loss within the rural complex expansion and 9% of the area of isolated forest perforations was found within 5 km of mines, logging, or plantations, supported by infrastructure development.[173]

Cobalt and copper are currently transported by truck to Tanzania, Mozambique or South Africa, a weeks-long journey that in the future may be shortened by the revival of the Lobito corridor railway (→ section 6.6).[174] This could become another encouraging factor for further expansion of mining activities.

3.2.7 Outlook for the Southeast Asia-Oceania rainforest

Indonesia

Indonesia is the world's largest nickel producer, delivering more than 60% of the world's output in 2024,[175] and a leading miner of cobalt, copper, and bauxite, while also holding significant reserves of these and other minerals.[176] The large copper mines in the Grasberg minerals district in Tanah Papua are among the world's major copper-gold mines in terms of production and reserves.[177] As nickel demand has boomed in recent years, driven particularly by the mineral's crucial use in current EV battery technologies, Indonesia's nickel ore output increased by 158% over the period 2019-2024, from 0.85 Mt to 2.2 Mt.[178]

Nickel mining and refining operations are concentrated on Sulawesi and Halmahera. In the past, these islands were spared the high rates of deforestation observed on Sumatra and Borneo, where deforestation has been driven mostly by oil palm, pulp and paper, rubber, and coal extraction.[179] However, with growing global nickel demand, the natural forests on the islands are increasingly at risk in these mining hotspots.[180] According to official sources, nickel mining business permits (IUP) covered 8,000 km^2 as of January 2024.[181]

Out of more than 350 existing and planned nickel projects mapped by China Global South Project throughout Indonesia, 25% involved foreign actors, particularly from China. Many of the projects have been linked to deforestation and other ecological impacts, as well as various social issues, ranging from land grabbing to poor workers' treatment and loss of traditional livelihoods.[182]

Though only a fraction of license areas is subject to active mining at any one time, no precise data on exposed or rehabilitated areas exists. However, it is clear that, in addition to direct deforestation linked to mines, smelters, and related infrastructure, indirect forest conversion in mining areas has been significant, enabled by nickel mining infrastructure such as roads, bridges, and jetties, and fueled by population growth around mines.[183] According to conservative estimates by Mighty Earth that only consider forest loss within the legal boundaries of nickel concessions, nickel mines in Indonesia have already caused the clearing of more than 760 km^2 of forest, and data for the period 2020-2023 suggests an accelerating deforestation rate (from 26 km^2 in 2020 to 61 km^2 in 2023).[184] Greenpeace recorded more than 5 km^2 of deforestation for nickel mines on small West Papuan islands.[185] Estimates by Nusantara Atlas suggest that for the Indonesian mining industry as a whole, more than 1,500 km^2 of primary forest were converted for mining infrastructure between 2001 and 2023.[186]

The outlook for the Indonesian nickel sector is complex. According to government sources, Indonesia had 54 smelters in operation as of March 2025 and another 60 in the process of securing permits.[187] However, industry analysts consider Indonesia's current smelter capacity to be excessive, given the weakening demand from China and an oversupply that has led to a significant decline in international nickel ore prices.[188] Smaller or high-cost operations are currently running at thin margins or losses, and some smelters are idle. Analysts expect the global nickel surplus to persist into 2027–28, given Indonesia's project pipeline and weaker battery demand, which is partly driven by the rise of cheaper LFP batteries. Compared to a 2023 consensus forecast of 1.5 Mt of battery nickel demand by 2030, this estimate has been reduced to 0.97 Mt, compared to an actual battery-driven consumption of 0.52 Mt in 2024.[189]

In response, the Indonesian government is tightening control of nickel ore supply, including reviewing mining quotas, and has floated production cuts to stabilise prices; the existing export bans on nickel ore, which aim to increase domestic value-adding, remain in force.[190]

An important influencing factor in the coming years will be the battery cathode mix (LFP versus nickel-rich chemistries) and the demand for stainless steel in China.[191] Stainless steel is used across various industries, including power generation, chemical and petrochemical, mining, food and beverage, construction, and transportation.[192] Steel demand is expected to grow at an annual rate of 0.7% through 2030, and is projected to continue increasing in the years ahead.[193] As of 2024, 66% of nickel was used in stainless steel, while 16% was used for batteries.[194] Despite the current situation of nickel supply outstripping demand, the IEA expects this situation to change soon,[195] increasing the likelihood of concessions being activated and a growing risk of deforestation.

Papua New Guinea

In PNG, principal mineral export commodities include cobalt, copper, gold, and nickel, which contribute significantly to the country's income. On a global scale, PNG is a notable producer of cobalt and nickel and holds significant cobalt reserves.[196] Mining operations are primarily conducted by ASM.[197] The still small number of large-scale mining operations is predominantly focused on gold. Two industrial mines for 'critical' minerals are the Ok Tedi copper and gold mine and the Ramu nickel mine.[198]

Mining and infrastructure expansion are considered emerging drivers of more recent deforestation in the country.[199] Important impacts on forests and their inhabitants are also linked to controversial environmental standards, as mine tailings and waste rock are approved for discharge into rivers or oceans on a large scale. This leads to contamination of waterways, sedimentation, and significant impacts on local communities.[200] The role of mining may also increase in light of several large-scale mining operations in the planning or advanced permitting phase and the potential expansion of the Ramu Nickel Cobalt mine (Table 2).

Table 2 Status of critical mineral mining development Papua New Guinea

Project / Province	Status (latest)	Main minerals	Surface area	Reference
Ramu NiCo (Madang)	SML 8 valid through 2040; EL 2579 pending renewal	Nickel-Cobalt	249 km² (EL 2579) (54 km² (SML 8))	201
Wafi-Golpu (Morobe)	Advanced permitting	Copper-Gold	129 km² (EL440 & EL1105)	202
Frieda River / Sepik Development Project (Sandaun / East Sepik)	EIS filed, principal mining lease application	Copper-Gold	~160 km² (mine & corridors/tailings dam/hydropower)	203
Yandera (Madang)	Feasibility/financing	Copper-Molybdenum	2.5 km² (EL)	204
Panguna (Autonomous Region of Bougainville)	Re-opening under discussion; exploration licence re-granted (2024)	Copper (gold by-product)	38 km²	205

Note: Surface area refers to the principal mining lease (SML) or exploration licence (EL) footprints where available. Some projects include additional leases, easements and infrastructure corridors beyond the main SML/EL areas. EIS=Environmental Impact Statement.

Impact scenario

Only considering the principal mining sites, the approval of all projects and expansions related to critical mineral mining in PNG (Table 2) could total an area of ~578 km². As this estimate mostly excludes broader, indirect forest impacts from infrastructure and other contributing factors, the forest footprint would be considerably larger.

3.3 Bioenergy's role in the energy transition

3.3.1 Global market landscape

Bioenergy is energy derived from biomass, the organic material that makes up plants. The main types are liquid biofuels (biodiesel and bioethanol) used primarily in transportation, and solid biomass (notably wood pellets) used for industrial and household heating.[206] 'Modern bioenergy'[i] is currently the largest source of renewable energy globally, accounting for almost 55% of modern renewables and over 6% of global energy supply.[207]

In recent years, governments worldwide have implemented policies, subsidy programmes, and mandates to support the implementation of biofuels. These measures are driven by climate goals and the interest of enhancing energy security and reducing import dependencies.[208]

3.3.2 Demand trends

Crude oil prices, which are volatile and difficult to predict, strongly influence biofuel market outlooks.[209] However, policy incentives support and encourage the production and uptake of bioenergy worldwide, even where prices are not competitive. As difficult-to-decarbonise sectors, such as shipping or power generation, are also searching for alternatives to fossil fuels without retiring their existing fleet or facilities, bioenergy sources offer options that can be implemented without requiring major changes.[210]

The IEA Net Zero Emissions (NZE) 2050 Scenario foresees a rapid increase in the use of modern bioenergy to displace fossil fuels by 2030. Its use has increased by about 4% per year on average over the last 15 years, and it remains on an upward trend. In the IEA scenarios, bioenergy deployment would need to accelerate by 8% annually between 2023 and 2030 to achieve net-zero ambitions; however, the organisation points out the need to avoid negative social and environmental consequences.[211]

Biofuels

Based on energy content, global biofuels production increased by 8.1% in 2024, reaching a record volume.[212] The OECD/FAO forecasts that biofuels will remain relevant in the transport sector in the coming years, but annual demand growth is expected to slow to ~1.2%, considerably less than in the last decade. Key determinants of growth are overall transport-fuel demand and policy support. The main feedstocks for ethanol remain maize and sugar, while vegetable oils such as palm, soybean or rapeseed oil are used for biodiesel production. Despite the known sustainability issues, first-generation biofuels, which use primary feedstocks such as oilseeds or grains, are forecast to continue dominating the biofuel market over the next decade. Future market developments are expected to focus on advanced biofuels (second-generation biofuels) derived from waste and non-food products and so-called sustainable aviation fuel (SAF); however, high investment costs slow down the expansion of these production capacities.[213] With the increasing electrification of road transport in the medium term, biofuels are expected to remain particularly relevant in sectors that are difficult to electrify, namely aviation and shipping.[214] In April 2025, the International Maritime Organization (IMO) agreed on the use of marine biofuel blends of up to 30% in conventional bunker ships, up from 25%. These include both first- and second-generation marine biofuels.[215]

The expected demand drop in high-income markets is anticipated to be stronger than the global average as EV uptake and improved vehicle efficiency are expected to reduce liquid-fuel needs. In the EU, the contribution of biofuel demand is expected to decline as the third iteration of the Renewable Energy Directive (RED III) tightens sustainability rules with a cap on food/feed-crop fuels and feedstocks with high indirect land-use change (ILUC) excluded by 2030. The anticipated EV promotion efforts in the EU are likely to curb the expansion of traditional transport fuels and,

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[i] Modern bioenergy excludes the traditional, small-scale use of biomass like fuelwood or charcoal for cooking or heating.

therefore, the demand for biofuels. However, this slowdown will be offset in middle-income markets, driven by rising transportation demand, energy security goals, and GHG-reduction targets.[216] For example, Indonesia introduced a B40 blending mandate for biodiesel in 2025 (up from B35),[217] aiming for B50 in 2026.[j,218] Brazil mandated B15 biodiesel blending (up from B14) and B30 bioethanol blending (up from B27) in August 2025.[219]

Advanced renewable fuels, including biogas, hydrogen and e-fuels, are expected to remain negligible drivers for renewable capacity in the coming five years, with hydrogen forecast to reach only a 1% share in total global renewable capacity expansion by 2030. Demand for hydrogen and e-fuel will, for now, be limited to a few countries that have policies in place: e-fuel growth in the EU due to a mandatory use of 1.2% renewable fuels of non-biological origin (including hydrogen and e-fuels) in aviation by 2030, and 1% in road transport; hydrogen demand expansion in the EU, China, and the US due to financial incentives.[220]

Wood pellets

Despite scientific knowledge that burning wood pellets can emit more CO_2 than coal and is a threat to forest biodiversity,[221] government subsidies have fuelled the growth of the supposedly sustainable energy alternative industry. Between 2010 and 2021, forest biomass supply rose by 50%. The IEA's NZE scenario projects a phase-out of traditional biomass use through the introduction of modern cooking technologies by 2030, while the use of modern solid biomass would be expanded.[222] The role of short-rotation woody crops would need to increase the most, 13-fold by 2030, compared to 2021 levels, while forestry plantations would need to increase by 11%.[223]

According to market analysts, the demand for woody biomass is expected to plateau in some regions, notably in Europe, over the next five years. However, further growth potential is anticipated in others, including North America and Asia, provided conducive policies are in place. Under a favourable policy environment, global wood pellet demand may experience a potential annualised growth rate of 3.4 Mt between 2025 and 2030, up from an average of 2.4 Mt in the period 2010-2024.[224] The increasing consumption of wood pellets in utility-scale power plants is an important contributing factor.[225]

According to broader projections until 2050 under different scenarios, the total global fuel wood consumption volume may reach ~2.5 billion m^3, an increase of around one-third from 2020 (1.9 billion m^3).[226] This confirms the observation that the ongoing energy transition on the global scale may, for the time being, rather be characterised by a 'layering' than a substitution of energy sources.[227]

3.3.3 Geographic patterns

In 2024, the top biofuel producers were the US with 37.4% of the world total, followed by Brazil with 22.3%, and Indonesia with 8.9%. These countries were also the top consumers of biofuel. During the period 2014-2024, the strongest consumption increases were observed in India (31.8%), albeit from a low level, and Indonesia (20.8%).[228]

Based on 2023 data, the top producers of wood pellets were the EU (40%), the US (21%), and Vietnam (9%). Strong absolute and relative output growth in the period 2014-2023 was observed in South Korea and Brazil (93% each), Indonesia (87%), and Vietnam (82%).[229]

The EU and the UK historically dominated wood pellet consumption, largely supplied by the US and Canada. The EU's revised Renewable Energy Directive (RED II+), which entered into force in March 2025, sets a binding renewable energy target of 42.5% by 2030. The sustainability criteria of the directive also cover forestry biomass. In combination with the requirements of the EU Regulation on Deforestation-free Products (EUDR, which is supposed to enter into force by December 30,

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[j] With a potential B45 interim step while dealing with technical and economic hurdles.

2025, but according to recent news, may be delayed by another year (→ section 6.3.4)), the EU aims to ensure deforestation-free supply chains.[230] Domestic EU wood pellet production is insufficient to meet demand due to the limited supply of woody biomass fulfilling the sustainability requirements under the RED. Therefore, in the short term, imports are projected to increase again in 2025 after a dip in 2023 and 2024. The US remains the main supplier to the EU; however, growing demand is increasingly attracting imports from countries such as Brazil, Vietnam, Malaysia, and Thailand. This development is also driven by the EU's ban on wood pellet imports from previously significant suppliers, Russia and Belarus, that was implemented in 2022.[231] While these sustainability criteria and due diligence obligations may reduce EU-attributed risk, non-compliant supply may be pushed toward less-regulated markets, leading to a leakage effect driven by a lack of policy convergence (→ section 6.3.4).[232]

While Europe still accounted for ~66% of the global pellet demand in 2024, the Asia-Pacific region has been quickly catching up in recent years, with an increasing number of coal-fired power plants converting to co-firing capability. Future markets may also emerge in the Middle East and Africa, where nascent uptake from pilot projects for cement kilns and off-grid power may develop upon policy clarity and logistics improvements.[k,233]

3.3.4 How demand may put pressure on tropical rainforests

Forest risk remains a factor that must be considered in relation to different forms of bioenergy. First-generation bioenergy sources have been widely criticised as a false solution, but remain a key market segment. Their use is determined by countries' mandated blending ratios that are set in biofuel policies.[234] Biodiesel derived from virgin vegetable oils, such as palm and soybean oil, or bioethanol from sugarcane or grains, compete with food crops or farmland suitable for food production. When linked to land-use change, they contribute to deforestation and higher GHG emissions than fossil fuels.[235]

This risk is particularly high for palm oil and soybean oil as they are key drivers of forest loss in tropical regions. Globally, ~18% of palm oil production was used as biodiesel feedstock in 2023.[236] Moreover, biodiesel consumed 5.9 Mt of soybean oil in 2024, up from 5.8 Mt the previous year.[237] This volume equals ~9% of global soybean oil production.[238]

Decarbonisation goals in aviation (Sustainable Aviation Fuels (SAF)) and shipping (IMO decarbonisation goals) could lead to strong demand growth for biofuels.[239] DNV expects that, despite the important role advanced, second-generation biofuels could play in shipping in the coming years, capacity limits and competition from other sectors will mean that availability will remain limited in the years to come.[240] The IMO's Net Zero Framework, introduced in April 2025, does not exclude or cap specific fuel types, increasing the risk of incentivising the use of the most affordable and readily available first-generation biofuels.[241]

Increasingly promoted as the sustainable biofuel solution, advanced and waste-based biofuels could present more sustainable alternatives to food crops, but also come with significant challenges. Waste products, such as used cooking oil (UCO) and palm oil mill effluent (POME), as well as animal fats and by-products like palm fatty acid distillates (PFAD), are today the most used non-food crop feedstocks for biofuel production.[242] However, the limited availability of UCO and animal fats, and the risk of fraud in imported UCO and POME mean that domestic use should be prioritised.[l,243] Other advanced feedstocks, such as forestry and agricultural residues, already have

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[k] Taiwan was also seen as an emerging market as it had intended to convert one of its largest coal-fired power plants to burn wood pellets by 2025/26; however, this plan was postponed in early 2025 in favour of using additional volumes of natural gas for power generation.

[l] Authorities in the EU and the US have investigated suspicions of fraudulent UCO in recent years. For the EU, as much as one-third of the used UCO may be falsely labelled to qualify for renewable energy targets while actually consisting of virgin palm oil. Similarly, investigations by Transport & Environment found that POME imports to the EU surpassed available volumes.

other uses, and municipal and industrial waste and sewage sludge are limited and decreasing in volume. Therefore, direct electrification and renewable hydrogen fuels seem the most promising alternatives to decarbonise transport,[244] but the latter are only expected to play a larger role in the longer term (the EU has a target of renewable hydrogen to cover ~10% of its energy needs by 2050).[245]

Solid biomass in the form of wood pellets is also linked to forest conversion and a 'carbon debt': emissions from combustion are higher than forest regrowth can capture.[246] The recent shift to co-firing wood pellets in coal-fired power plants, for example, in Indonesia and Japan, is boosting demand for pellets and is criticised as greenwashing and an unsustainable life extension of fossil fuels.[247]

The IEA's NZE Scenario projects a continuous increase of 'modern solid biomass' but points to the need for strict control to avoid forest conversion and land-use conflict issues linked to the expansion of wood energy plantations.[248] Environmentalists are concerned, though, that this development will nonetheless lead to expanded monoculture plantations, especially in Southeast Asia, where the conversion of native tropical rainforests to short-rotation plantations for crops, timber and wood pellets is already a substantial driver of deforestation.[249]

3.3.5 Outlook for the Amazon rainforest

Brazil

In 2022, renewable energy sources supplied 50% of Brazil's total energy, ~60% of which came from biomass. Unlike gas and oil, these energy sources are not import-dependent, giving them an important role in the country's energy security. Solid biomass supplies more than half of the country's heat, while hydropower dominates electricity generation.[250]

Brazil is the world's second-largest producer of bioethanol and the third-largest producer of biodiesel.[251] The key regulatory framework is the RENOVABIO (2017), which introduced measures to revitalise the sector, including decarbonisation credits (CBios).[252] Constitutional Amendment No. 123 (2022) further promoted biofuel competitiveness.[253] Brazil's biofuel share in transportation energy is 22%, high by international standards. Bioethanol is the most important, providing on average nearly 40% (in terms of energy content) of the combined gasoline-ethanol pool. Biodiesel, intended to replace diesel in heavy-duty fleets, accounted for 9.3% of total diesel use in 2022.[254]

Soy

In 2024, soybean oil provided ~73% of total biodiesel production (6.0 Mt output).[255] For bioethanol, sugarcane remained dominant (~94%, 307 Mt processed), with maize at ~2% (7.1 Mt).[256] These large crop volumes account for huge crop cultivation areas that are not available for food production, and carry the risk of further land conversion to accommodate for the cultivation of biofuel feedstock.

According to a September 2025 announcement by the Brazilian Ministry of Mines and Energy, ethanol demand is projected to rise by 33% and biodiesel by 38% by 2035, driven by a favourable domestic policy environment that supports capacity expansions and industry-wide decarbonisation targets.[257]

Impact scenarios

Under a BAU scenario of a stable soybean oil share in biodiesel at ~73%, a 38% demand increase for biodiesel implies ~2.1 Mt of additional soybean oil demand by 2035. At an average oil yield from crushing of 18.5%, this requires the additional availability of ~11.3 Mt of soybeans. We estimate the required area to grow this additional volume of soybeans, assuming three different scenarios:

- a standard scenario of a yield increase of 12% by 2035;
- a climate impact scenario of a yield increase of 6%; and
- a severe climate impact scenario of a 10% yield loss by 2035 compared to today.

Depending on the scenario, this could correspond to ~31,600 km^2 to 35,000 km^2 of soybean cultivation, driving up pressure also on the Amazon rainforest.[m, 258]

Demand for soy-based biodiesel is not only expected to increase due to domestic forces, but growing foreign interest, including from China, may also contribute.[259] This could become an additional factor increasing soy-related pressure on the Brazilian Amazon, as has been increasingly observed in recent years.[260] The likely fall of the Amazon Soy Moratorium would further raise this risk.

The Amazon Soy Moratorium

The voluntary Amazon Soy Moratorium, the first private-sector zero-deforestation agreement that was initially launched in 2006, has been widely credited with curbing soy-driven deforestation in the Amazon biome.[261] The Brazilian Forest Code permits landowners in the Amazon to legally clear up to 20% of their land for economic purposes. However, under the Moratorium, the leading soybean traders committed to not purchasing soybeans from Amazonian farmers who cleared land after a 2008 cut-off date. The agreement prevented at least 18,000 km^2.[262] In 2022, soy production in the Amazon was linked to 1,170 km^2 of deforestation, much less than in the neighbouring Cerrado biome.[263] However, in recent years, the soybean cultivation area has continued to increase in Brazil's north, with a new frontier emerging in the Amazon rainforest. Data by the National Supply Company (Conab) shows that in the five years since 2019/20, soy area doubled in Rôndonia (from 3,480 km^2 to 6,947 km^2), almost tripled in Roraima (500 km^2 to 1,400 km^2), increased more than four-fold in Acre (40 km^2 to 186 km^2) and ~60-fold in Amazonas (from 20 km^2 to 135 km^2).[264] Growing foreign demand, particularly from China, is an important driver for Brazil's record soybean production. Rising demand encourages soy farmers to expand production, as the trade war (→ section 6.4) between the US and China continues after the initial dispute in 2019.[265]

Recently, several Amazon states have weakened rainforest protections by annulling protection areas and formalising illegal land grabs. Since the end of 2024, the attempts to dismantle the Soy Moratorium have raised concerns among civil society and leading downstream customers.[266] Initiated in December 2024 by Aprosoja, the soy farmers' organisation, the powerful farmers' lobby in Congress, the Bancada Ruralista, promoted bills that would penalise producers participating in the moratorium. In August 2025, it pushed Brazil's competition authority (CADE) to investigate the agreement.[267] The future of the moratorium is now uncertain, as government agencies clash over its legality: CADE launched an investigation in mid-August regarding potential cartel-building,[268] but a court reinstated the moratorium a week later, while allowing the investigations to continue.[269] At the end of September 2025, CADE's councillors postponed the suspension until January 1, 2026.[270]

In the context of the Soy Moratorium, it is important to consider that, despite its local success, a single-commodity focus and narrow geographic coverage risk leakage: in this case, a further increase in soy-related deforestation in the Cerrado, another valuable but less protected biome.[271] The indirect effects of soy expansion via the displacement of pasture into new forest areas also remain problematic for the Brazilian Amazon.[272] Similar concerns have been voiced in relation to the EUDR (→ section 6.3.4), as the limited focus on 'forests' as defined by the FAO means that other valuable ecoregions are not considered and are at risk of additional pressure.[273]

Palm oil

Palm oil covers ~80,000 km^2 in the Amazon of eastern Brazil, central Peru, northern Colombia, and northern Ecuador. Palm oil is not yet a sizeable oilseed in Brazil, with production accounting for less than 1% of global production in 2024.[274] However, despite its small base, the cultivation area increased by ~50% over the last ten years, from 1,470 km^2 to 2,200 km^2,[275] and further expansion for biofuels is planned.[276] The industry is promoted as sustainable, as several support programmes are limited to degraded areas.[277] Deforestation, fires, land conflicts, and exploitative

[m] Applying the following factors: 0.9 t soybean oil per m^3 used in biodiesel; an average crush ratio of 78.5% soybean meal and 18.5% oil; an average yield of 343.6 t per km^2 in 2023/24 and 2024/25 to account for volatility.

working conditions have been documented repeatedly in recent years.[278] Analysis by de Barros et al. documented a deforestation rate of 20.24% or ~157 km^2 for new palm oil areas between 2014 and 2020.[279]

The expansion of the palm oil area has also resulted in higher land prices in recent years, further exacerbating conflicts between indigenous groups and new settlers.[280] In June 2025, Brazil's first sustainable aviation fuel (SAF) project hit the news, as the producer behind a planned palm oil biorefinery in Manaus (Grupo BBF) was accused of possible rights abuses. The company was found to be growing oil palm on areas subject to sanctions by Brazil's environmental agency (Ibama) over illegal deforestation.[281]

Sugarcane

Sugarcane production, which supplies ethanol and bagasse for heat production, currently has a low direct link to Amazon deforestation, as it is concentrated outside the biome. However, the revocation of the Sugarcane Agricultural Zoning under former President Bolsonaro, which had protected sensitive biomes from sugarcane expansion, opened possibilities for expansion into vulnerable regions like the Amazon or the Pantanal, which flags the risk of future expansion.[282] Maize for bioethanol production is largely double-cropped with soy as the first crop. According to Gurgel et al., soy-maize rotations are linked to less land-use change pressure than first crops, such as soy.[283] Yet, expansion at the Amazon edges still warrants attention.

Another biofuel-related topic relevant to the Brazilian Amazon is the increasing demand for waste and co-products as biodiesel feedstock, including from the livestock industry. Growing markets for beef tallow for biodiesel and SAF, where demand far exceeds supply,[284] support the economic viability of vertically integrated meatpacker operations. In 2024, beef tallow was the second most important biodiesel feedstock in Brazil after soybean oil, accounting for a 6.4% share. Beef tallow volumes used for domestic biodiesel production oscillated between 380 Kt and 510 Kt in the five years from 2020 to 2024.[285] However, exports saw a significant jump in the same period from 6 Kt in 2020 to 320 Kt in 2024, driven by a boom in exports to the US (95% of the total in 2024).[286] Given cattle ranching's key role in Brazil's Amazon deforestation dynamics (→ section 4.2), this indirectly sustains an economic driver of forest conversion.[287] The first half of 2025 saw a further increase in tallow exports to the US; however, according to industry sources, the recent imposition of a 50% import duty on certain Brazilian products, including tallow, has made further sales to the US "prohibitive".[288] Considering the volatility in current US trade politics, it remains difficult to predict how this situation will develop in the coming years.

Meanwhile, additional displacement, such as the substitution of palm oil for diverted tallow in other applications, can displace land-use pressure to other regions.[289]

Colombia

In Colombia, palm oil production is closely tied to the country's biodiesel blending target, which has remained largely unchanged at B10 in recent years. Arguing with low deforestation rates and sustainable expansion practices, the country's palm-based SAF may qualify to meet international requirements for GHG emission reduction under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and the EU Renewable Energy Directive (REDII).[290] The palm oil cultivation area is mostly located outside the Amazon. For example, the area in the Amazon province of Meta increased from ~1,400 km^2 in 2014 to ~1,770 km^2 in 2023.[291] While the risk of rainforest deforestation is currently considered low, environmental human rights risks have repeatedly been documented. Palm oil also competes with other land uses, such as pasture, which may lead to indirect land-use change (ILUC).[292] Pressure may also come from cultivation in areas immediately adjacent to the Amazon watershed.[293]

For the expansion of palm oil cultivation in the Peruvian Amazon, food demand has been more important than biodiesel targets (→ section 4.3.4).

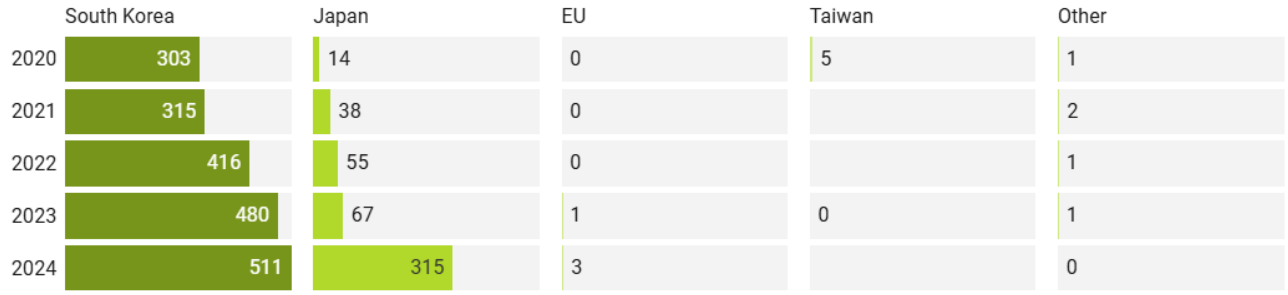
3.3.6 Outlook for the Southeast Asia-Oceania rainforest

Indonesia

Biomass

In Indonesia, Increased demand for wood pellets and other biomass products as supposedly 'green' energy alternatives is expected to contribute to tropical deforestation in the coming years. Chip mills and co-firing plants represent a significant threat as bioenergy companies are clearing highly biodiverse forests and replacing them with monocultures for wood pellet production.[294] So far, export opportunities have been a key driver of this industry. The key export market for Indonesian wood pellets is East Asia, namely South Korea and Japan, with small volumes going to the EU and other destinations (Figure 14).

Figure 14 Export destinations of Indonesian wood pellets, 2020 to 2024 (kt)



Note: 0 indicates volumes below 0.5 kt.

Source: Own elaboration, based on: UN Comtrade Database (2025), online: https://comtradeplus.un.org/.

Both South Korea and Japan saw record imports of wood pellets in 2024, with Indonesia accounting for 6.4% and 2.5%, respectively.[295] In recent years, both countries have expanded imports under supportive subsidies and feed-in tariffs, and have rapidly increased pure biomass as well as co-firing capabilities in coal-fired power plants.[296] Japan has removed subsidies for new biomass plants in 2024, but planned and existing plants remain eligible for support.[297] The country is expected to see a 30% increase in demand by 2030.[298]

In response to reports on biomass-driven deforestation, South Korea announced in January 2025 that it would end subsidies for new biomass and gradually reduce renewable energy credits (RECs) for biomass-fired power generation.[299] For state-run production, RECs will be reduced to 0.5 by 2027 for dedicated biomass utilities and zero for co-fired generation; for independent producers, RECs will be reduced to the same respective levels over 20 years from 2026. Consequently, it is expected that the gradual reduction will bolster pellet imports in the short term but lead to lower overall imports in the longer run.[300]

While it has so far almost exclusively produced for the export market, the Indonesian government plans to introduce biomass co-firing at 52 coal power plants (107 generating units) by 2025 to meet its Nationally Determined Contributions in the Paris Agreement. During 2024, 47 plants were converted. Feedstock consisted of sawdust, wood chips, and various types of agricultural waste products.[301] However, timber plantations will be needed to meet the quickly growing demand for biomass. The Indonesian Ministry of Environment and Forestry promises to promote plantation forests for energy development, indicating that more than 10,000 km² of "production forest" could be utilised. However, CSOs fear large-scale conversion. Instead of using degraded land, timber plantations have often been established on deforested land in the past, which comes with the advantage of generating income from tropical timber to bridge the time until the plantation reaches maturity.[302]

In Tanah Papua, ~30 km^2 of primary rainforest has already been converted for a biomass project in the ancestral territory of the Marind people, hunter-gatherers indigenous in South Papua province.

The project was financed by two government bodies whose mission is to support Indonesia's climate change commitments: PT Sarana Multi Infrastruktur, a state-owned company under the control of the Ministry of Finance, and the Indonesian Environment Fund (IEF). While driven by the aim to burn less coal, the example demonstrates that the sourcing pressure from increasing demand carries the risk of severely negative impacts on indigenous peoples and their livelihoods, and the destruction of the rainforest.[303]

Auriga Nusantara documented more than 97 km^2 of deforestation in areas where biomass production has been permitted since 2020. Overall, permits for more than 14,000 km^2 of energy plantation forests had been issued by 2024, with more than one-third of these overlapping with undisturbed forests. In Sulawesi, more than 30 km^2 were deforested in one concession between 2021 and 2024, plus an additional 28.5 km^2 for logging roads, illustrating the significant indirect impacts.[304]

Co-firing subsidies increase pellet demand, consequently increasing sourcing pressure in supplier regions, including Vietnam and Indonesia, which are important Southeast Asian producers. Trend Asia estimated that the co-firing policy could drive the conversion of more than 20,000 km^2 of forest.[305] Critics argue that promoting biomass co-firing to mitigate GHG emissions risks sustaining the use of coal rather than supporting a just energy transition.[306]

Impact scenario

Research by the Environmental Paper Network (EPN) concluded that the Indonesian biomass plans will eventually require an estimated annual supply of ~10 Mt of wood pellets. This volume could fuel annual deforestation rates of up to 21,000 km^2, with the potential for total forest loss of up to 100,000 km^2 by 2040.[307]

Biofuel

Ramped-up biofuel targets under the Indonesian renewable-energy plan are linked to palm oil-based biodiesel and sugarcane-based ethanol. Biodiesel production increased from 1.2 billion litres (~1.1 Mt) in 2015 to ~13.0 billion litres (~12 Mt) in 2024, supported by high subsidies primarily funded from crude palm oil (CPO) export levies.[308] Palm oil accounted for the majority of the feedstock.[309]

Driven by a strong interest in energy self-sufficiency, Indonesia continues to increase blending mandates. Biodiesel mandates reached 35% in 2024 and 40% in 2025, pushing the expected consumption to 14.5 billion litres (~13.3 Mt) this year. A further increase to B50 was planned for 2026; however, owing to ongoing infrastructure and supply chain problems, government officials in September 2025 signalled a possible reduction to a B45 target for 2026.[310] Officials estimate that five plants with large capacities are needed to fulfil demand,[311] with plans for a plant in South Papua already advancing.[312]

Biodiesel exports are generally comparatively small and volatile, as they are heavily influenced by diesel prices, particularly in China.[313] To secure the domestic biodiesel supply under the B40 blend mandate, biodiesel exports dropped to virtually zero since October 2024. Despite officials specifically mentioning waste products as biodiesel feedstock, the country so far relied heavily on palm oil; exports of feedstocks like used cooking oil (UCO) and palm oil mill effluent (POME) were only limited in January 2025. UCO is also the preferred feedstock for the country's SAF plans, which foresee a 1% blending target by 2027, 2.5% by 2030 and 30% by 2050.[314]

Overall, the continued increase in domestic biodiesel mandates gives the sector an important role as a driver of palm oil demand. Unless production increases can be met by yield increases from replanting and no-deforestation policies are fully implemented, the growing demand for biodiesel may increase the risk of land-use change for plantation expansion, especially at frontiers and near new biodiesel facilities. A 2024 study by a CSO coalition, including SPKS, Greenpeace, Satya Bumi and Transisi Bersih, estimated the potential deforestation linked to the cumulative need for palm oil plantation expansion to meet demand until 2039, with biodiesel as a key driver. It considers three scenarios:

- BAU: B35 implemented 2023-2042
- Ambitious: B35 in 2023 and B40 in 2024-2042
- Aggressive: B35 in 2023, B40 in 2024, and B50 in 2025-2042

The ambitious scenario already appears conservative today, considering recent developments, while the aggressive scenario in fact reflects the latest government ambitions.

Impact scenarios

By applying the average deforestation rate in newly developed oil palm plantations in the period 2001 to 2022 of about 28% per year, the analysis by the CSO coalition forecasts a cumulative deforestation of ~3,850 km^2 to ~9,970 km^2 in 2033 and ~7,700 km^2 to ~15,000 km^2 in 2039 (Table 3). Additionally, indirect impacts, such as the construction of new biodiesel facilities and infrastructure development, need to be considered. These results highlight the importance of considering the availability of land and the palm oil demand for food and other purposes as mandatory determinants in revising biodiesel blending targets.[315]

Table 3 Cumulative deforestation for palm oil expansion in Indonesia until 2039

Scenario	Impact (km^2)	2023	2028	2033	2038	2039
BAU	Expansion requirement	-	3,359	13,751	25,136	27,534
	Deforestation potential	-	941	3,850	7,038	7,709
Ambitious	Expansion requirement	-	9,646	21,037	3,350	36,231
	Deforestation potential	-	2,701	5,890	9,402	10,145
Agressive	Expansion requirement	10,035	22,220	35,610	50,470	53,627
	Deforestation potential	2,810	6,222	9,971	14,132	15,015

Source: SPKS, Greenpeace, Satya Bumi and Koalisi Transisi Bersih (2024), *Oilpalm and Biodiesel: Trends, Deforestation, and Efforts to Protect Natural Forests*, p. 20.

During recent years, India, China, Pakistan, and the EU were the top recipients of virgin palm oil from Indonesia, jointly accounting for more than half of the country's exports in 2023 and 2024. Biodiesel mandates may drive demand in some of these countries in the coming years, alongside food use (→ section 4.3.3). India has an ambitious goal of achieving 5% biodiesel blending by 2030, with animal fats, non-edible oils, UCO, and imported palm oil and palm stearin as main feedstocks. Palm oil use oscillated around ~100±50 Kt in recent years, but is expected to increase to ~217 Kt in 2025. The current blend rate of 0.7% remains far below the 5% target for 2030, as all primary feedstocks remain limited in supply.[316] Depending on progress in increasing biodiesel blending in India, demand for imported palm oil products is likely to increase in the coming years, with Indonesia as an important source.

In the EU, the use of palm oil in biodiesel is expected to continue declining, as palm oil has been capped due to its high-ILUC-risk status under RED II/RED III and is scheduled for a complete phase-out by 2030; in the meantime, several EU member states have already excluded palm oil from eligibility as feedstock.[317] However, as mentioned earlier, PFAD, POME, and UCO remain important palm oil-linked feedstocks and carry the risk of fraudulent use of virgin palm oil (→ section 3.3.4).

Indonesia's sugarcane-based bioethanol market remains comparatively small, but the country is committed to developing a domestic sugar-based industry, as outlined in Presidential Regulation 40/2023 on sugar self-sufficiency and bioethanol. Production is forecast at ~300 Kt in 2025;[318] however, the government sees potential to 1.2 Mt, though current availability is limited to E5 offered on Java.[319] In this context, the government plans to boost sugarcane planting in Tanah Papua, where it has identified ~20,000 km^2 of land in Merauke to host an industrial estate for sugarcane plantations, mills, a bioethanol plant, and a biomass power plant.[320] As it was designated a National Strategic Project (PSN), it enjoys the benefits of fast-tracked permits and minimum oversight on environmental and social safeguards.[321]

Indonesia has a long history of large-scale state agriculture projects. Since the mid-1990s, presidents have planned grand schemes to transform vast areas of forests and community lands into crops. These schemes have repeatedly faltered, but have already caused deforestation, fires, flooding and conflicts with Indigenous communities who opposed the seizure of their land.[322] Most of the areas also overlapped with critical ecosystems such as peatland areas in Sumatra and Kalimantan.

The designated area in Merauke overlaps with the savannah and protected forests and the ancestral lands of Indigenous communities.[323] Negotiations on the project design only included central and regional governments without seeking free, prior, and informed consent (FPIC) from the local population. CSOs have raised concerns about human rights violations, particularly in a region with a longstanding history of alleged military abuses amid ongoing separatist tensions.[324] They also expressed alarm over the scale and anticipated environmental impacts of the project, which has been dubbed the 'world's largest deforestation project'.[325] Despite Indonesia's high deforestation rates over the years, Tanah Papua is still home to large tracts of rainforest and many endangered species. In light of the expansion of palm oil plantations and nickel mining projects, a project of this size poses significant additional risks of destroying large tracts of these forests. It presents a setback to Indonesia's climate goals.[326] According to estimates by Celios, this single project could increase Indonesia's global GHG emissions contribution from 2-3% to 3.96-4.96%, a strong increase for an individual country and project.[327] It would also significantly contribute to Indonesia's deforestation footprint, considering that a comparable area was deforested country-wide over eight years.[328]

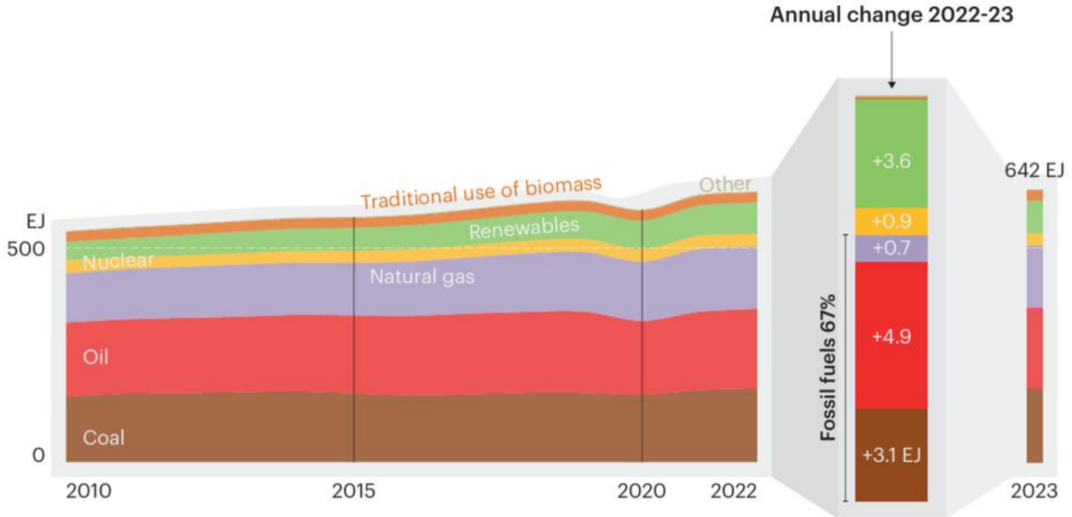
The size of the current and planned developments for the PSN is difficult to ascertain, as even government statements differ. Still, it reportedly could involve deforestation for 20,000 km^2 of sugarcane plantations and 10,000 km^2 of rice fields, in addition to related port and road infrastructure.[329] Since its launch in early 2024, the PSN has already resulted in the permanent conversion of ~100 km^2 of forest and a total of 223 km^2 of land, including Melaleuca swamp forests, natural grasslands, wooded savannas, mangroves, and dense primary forests. The construction of a logistics seaport and a 135 km road across Merauke, of which 45 km had been constructed by June 2025, also contributes to deforestation. During the same time, an additional ~70 km^2 were deforested for palm oil plantation expansion.[330] In line with the project plans, further deforestation can be expected to occur for the project in the coming years.

3.4 Fossil fuels' role as an energy source

3.4.1 Global market landscape

Despite a record high level of renewable power capacity coming online in recent years, fossil fuels remained the main energy source globally, with oil and coal accounting for the majority of newly added capacity in 2023 (Figure 15). Fossil fuels met 80% of global energy demand in 2023.[331] In 2024, global wind and solar generation increased by 16%, nine times the pace of total energy demand. Yet, fossil fuel consumption still rose by just over 1%, indicating a layering of different energy sources rather than a displacement of fossil fuels by renewable deployment.[332]

Figure 15 Global energy demand 2010 to 2023



Source: International Energy Agency (IEA) (2024, October), *World Energy Outlook 2024*, Paris, France: IEA, p. 68.

3.4.2 Demand trends

The IEA expects fossil fuel demand to peak by 2030 under its STEPS scenario, which is based on current market data, technology costs and analysis of policy settings globally.[333] Yet, political influences, particularly an increasing scepticism towards climate change science and mitigation under a growing number of populist governments, may slow the phase-out of fossil fuels in the coming years.[334] The IEA reiterated recently that limiting global warming to below 1.5°C would require no new long lead-time oil and gas projects to be approved.[335]

Important gains have been achieved and are expected to remain on track, resulting in a significant reduction in fossil fuel use in power generation and road transport through 2050. However, aviation, shipping, and petrochemical industries are important demand drivers for fossil fuels, which are forecast to remain intractably high or even increase until 2050.[336]

- Demand recovered after reductions in air traffic during the Covid-19 lockdowns and is expected to grow quickly through 2030. For Europe alone, an average annual flight growth of 2.0% is expected between 2026 and 2030.[337] While new planes can be up to 20% more efficient, growth in passenger numbers has historically outpaced improvements in efficiency. SAF are seen as one solution to achieving climate goals, though some of the current feedstock options are controversial. However, production volumes remain below previous forecasts, reaching just 0.3% of global jet fuel production in 2024;[338] roll-out is expected to remain slow in the coming years, with planned SAF capacity matching only a small share of aviation fuel demand by 2030.[339]
- The global shipping market is expected to grow at a compound annual growth rate (CAGR) of 3.8% between 2024 and 2030,[340] fuelled by increasing cargo volumes. At the same time, like aviation, electrification is less cost-competitive than in road transport.[341] Orders for new ships in recent years indicate a growing trend towards alternative fuels; however, this refers predominantly to dual-fuel ships, meaning that they only need minimal modifications to use ammonia, methanol, hydrogen, or LNG when available, applying to 5.1% of the active fleet and 47.1% of the orderbook in tonnage as of early 2023.[342] However, methanol, for example, is moving towards initial application, and ammonia is still in the piloting phase. Scaling is not expected before 2030.[343] In combination with growing cargo volumes, this means that, for the time being, fossil fuels will remain the primary energy source in the sector.

- The example of Indonesia illustrates how the increasing demand for 'critical' minerals in energy transition technologies paradoxically creates additional demand for coal due to energy-intensive processing. Meanwhile, Brazil wants to use the proceeds from oil expansion to finance a transition to renewables (→ section 3.4.5).
- The petrochemical sector is expected to gradually shift towards higher rates of recycled and bio-based feedstock, but demand for oil as a petrochemical feedstock is nonetheless expected to remain an important driver of oil markets for the time being.[344] Industry assessments forecast a CAGR of 5% for the worldwide petrochemical market from 2025 to 2030, with Asia-Pacific as the largest consumer market, driven by expanding industrial capacity and growing population.[345] Key industries contributing to this steady rise include packaging, automotive, construction, pharmaceutical, and synthetic textiles. The increasing consumption of polyethylene and polystyrene, used in plastic packaging for food and other commercial products, is considered another important driver in the sector.[346] Across all fibre sectors (textiles and apparel, healthcare, automotive), synthetics account for 64% of total fibre volumes and materials,[347] and recycling rates remain low.[n, 348] Synthetic fibres for textiles are forecast to grow at a CAGR of 7.4% from 2023 to 2030, driven also by the increasing volume of fast fashion (→ section 5.2.1).[349]
- Other highly energy-intensive heavy industries, like steel, aluminium, and cement, still rely heavily on fossil fuels, particularly coal.[350] The challenge to achieve very high temperatures with renewable electricity means that a transition away from fossil fuels will require significant technological innovation. At the same time, the long life cycles of the industries' capital assets mean that investment decisions made now will lock in technologies for decades, illustrating the urgency to implement alternative technologies.[351] Circular economy strategies, including reducing, reusing, and recycling, will be particularly important in these industries.[352]

Important geographic differences can be observed. In contrast to an expected ongoing contraction in high-income economies through 2030, oil demand growth is expected to remain robust in emerging and developing economies, with rising oil use particularly in India and Southeast Asian countries.[353] Natural gas demand is also anticipated to remain strong in emerging markets and developing economies, while coal demand is predicted to decline only gradually.[354]

3.4.3 Geographic patterns

Notwithstanding the consensus that new oil and gas projects are incompatible with a 1.5°C pathway, companies (including majors, national oil companies, and independents) continue announcing new discoveries; in 2023 alone, 20 fields were approved for development. This will enable the extraction of 8 billion barrels of oil equivalent (boe), with plans to develop 31.2 billion boe across 64 additional fields by 2030. Most top-producing countries expect to increase output through 2030 versus 2021.[355] Various countries across the three tropical rainforest regions are emerging as important oil and gas developers based on greenfield projects that have received the final investment decision, including Brazil, Peru, Colombia, and Indonesia.[356]

Incremental demand is concentrated in Southeast Asia, Africa, and South America, driven by industrialisation, mobility, petrochemicals, population growth and urbanisation, as well as the imperative to expand reliable and affordable energy. Many lower-income governments consider fossil development as an important tool to ensure reliability and universal access to affordable energy, even as they add renewables, implying parallel build-out rather than swift substitution over the next five to ten years.[357] The balance depends on policy ambition, but outlooks also differ between sources. The IEA, even under its conservative stated-policies trajectories (STEPS), forecasts a modest ease in fossil use in emerging economies in the coming years.[358] While non-OECD economies are expected to continue experiencing demand growth until 2030, global oil

n In 2023, recycled polyester accounted for 12.5% of global polyester production. However, nearly all of the recycled polyester comes from plastic bottles, not the reprocessing of polyester textiles.

demand is forecast to plateau by 2030, as OECD oil consumption is projected to decline.[359] The Organization of Oil Exporting Countries (OPEC) expects continued oil demand growth concentrated in non-OECD to 2050,[360] and the Trump administration is attacking the IEA for predicting near-term peaks in oil and gas demand,[361] highlighting that outcomes strongly hinge on policy ambition and assumptions.

3.4.4 How demand may put pressure on tropical rainforests

Oil and gas exploration and extraction continue to pose a significant threat to tropical rainforests. According to estimates by Grantham et al., 422,000 km^2 of tropical intact forest,[o] or ~8% of its global area, overlapped with oil and gas concessions based on 2018 data. The biggest overlap was found in the DRC and PNG, with considerable overlap also in the western part of the Amazon rainforest.[362] A more recent analysis by WWF Norway and Rainforest Foundation Norway, based on 2023 data, indicates that more than 1,000 (5.34%) of identified active oil and gas concessions globally have a direct spatial relationship with tropical tree cover.[p,363] However, not all concessions are eventually developed, and it remains difficult to identify those that are more likely to become operational.

According to Lawson et al., 8.3% (107,000 km^2) of the total tropical peatland area overlaps with a 30-km buffer area around oil and gas infrastructure. Significant intersection was documented for the Sumatra basin in Indonesia, the Niger Delta in Nigeria, and the Putumayo-Oriente-Marañón basin in Peru, Ecuador, and Colombia.[364]

The exploration and exploitation of oil fields are directly linked to deforestation and habitat loss, as well as contamination from on-site oil spills, well brine water, and pipeline spills. Wider impacts of deforestation connected to road and pipeline infrastructure can also be observed.[365]

Coal mining, which is particularly relevant in the Indonesian context, is connected to concerns similar to the indirect mining-induced impacts described in relation to ‘critical’ minerals (→ section 3.2.4). [366]

3.4.5 Outlook for the Amazon rainforest

The Amazon has been described as ‘the new global oil frontier’, as it holds nearly one-fifth of the world’s oil and natural gas reserves identified between 2022 and 2024. These are primarily located offshore along South America’s northern coast between Guyana and Suriname, but also include onshore blocks in the Amazon rainforest. As ~70% of oil and gas blocks in the region are currently unproductive (under study or available for bidding), the Amazon is regarded as a promising area for industry expansion, although any further expansion is at odds with global climate goals.[367]

Like mining, fossil fuel exploration in the Amazon often has a pioneering character in opening up remote forest areas for further development. While its direct deforestation footprint tends to be comparatively small, indirect impacts linked to transport and supply chain infrastructure can be considerable. A clear correlation between oil exploration and deforestation, as well as frequent oil spills, has been observed in the past in the Peruvian[368] and Ecuadorian Amazon forest,[369] accompanied by strong opposition from Indigenous groups due to infringement and contamination of land and water in their territories. According to an analysis by Arayara International Institute in 2024, 81 awarded blocks overlap with 441 ancestral lands on almost 40,000 km^2 across the Amazon region, and another 38 affect 61 protected natural areas. An

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o ‘Intact forest’ in this context is defined as an area of at least 500 km^2 of forest, including naturally treeless ecosystems, that has no remotely sensed signs of human activity but can have low-intensity and historic human influence (for example, hunting, scatter small scale shifting cultivation, and preindustrial selective logging).

p Concessions refer to licenses granted to explore and/or extract oil and/or gas from within a set area for a fixed period.

additional 114 blocks under study or available for bidding at the time were located on Indigenous territories, and 58 within protected natural areas.[370]

Brazil

The OPEC forecasts Brazilian oil production to increase until 2040. Assuming current patterns remain in place, part of the production would be consumed domestically, while key export destinations may include China, the EU, and the US.[371] In the Brazilian Amazon region, 451 oil and gas blocks are under study, offer, or concession, of which 328 are offshore, and 123 are in the Amazon rainforest.[372] Recently, oil and gas development has focused on the Amazon River mouth (Foz do Amazonas) and neighbouring offshore regions. Despite the region's sensitivity, 19 out of 47 Amazon river-mouth blocks up for auction were awarded in June 2025, covering a total of 16,312 km^2.[373]

In the run-up to COP 30, President Lula has pressed the environmental agency, IBAMA, to grant an exploratory license for Petrobras's Block 59, off Amapá at the biodiversity-rich mouth of the Amazon.[374] The move is seen as contradicting Brazil's bid to show climate leadership; Lula argues any revenues could help finance the country's shift to renewable energy.[375] IBAMA had previously denied a license for the block in 2023,[376] which covers an area of 766 km^2.[377] Indigenous and coastal communities cite a lack of consultations under ILO 169 (The Indigenous and Tribal Peoples Convention) and a significant risk to mangroves and fisheries from spills. Critics argue that the area is too sensitive for licensing and fear that an approval at the river mouth could set a precedent for additional projects in the Amazon region.[378] While Petrobras obtained approval for pre-operational steps, no final drilling license for Block 59 has been granted yet as of August 2025.[379]

Colombia

Colombia also shows a considerable overlap of oil and gas concessions in its Amazon region. However, unlike neighbouring countries, Colombia decided to join the Beyond Oil and Gas Alliance (BOGA) in 2023, with a commitment to a socially just global energy transition and phase out of fossil fuels.[380] Already at the end of 2022, the country committed not to extend new licenses for oil and gas exploration.[381] Yet, it must honour 381 existing oil and gas contracts, and industry pressure persists to continue exploration. Colombia ranked among the top-10 for new discoveries in 2022–23, and new gas was found in 2024. Numerous environmental complaint cases are reported in the Colombian Amazon, and Indigenous communities report repeated rights violations. Seventy-nine Indigenous lands and 30 protected areas overlap oil blocks, covering ~2,600 km^2. Historical conflict dynamics add to the industry's risk profile, as violent disputes over the control of resource-rich zones between former guerrilla members and emerging armed groups also affect local communities and cause lasting pollution of rivers and habitats.[382]

Peru

The threat of oil-driven deforestation and its broader impacts on the Amazon rainforest remain highly relevant in Peru. As of July 2024, Arayara International Institute had mapped 71 oil and gas exploration blocks in the Peruvian Amazon, including 52 blocks under study, eight blocks on offer, and 11 blocks under concession and exploration contracts. The country has experienced a high frequency of oil-related accidents. Between 2009 and 2019 alone, 474 oil spills were documented, often affecting Indigenous lands in the Amazon.[383]

Efforts by the Peruvian government to auction off Amazon blocks have had little success in the past, largely due to a combination of environmental liabilities, social conflicts, and infrastructure risks. Pacific Exploration & Production (Canada) withdrew from a large Amazon concession in 2017.[384] In 2023, members of the Peruvian Congress proposed opening 31 oil blocks overlapping with the lands of 435 Indigenous communities, threatening 25 reserves for uncontacted peoples. The bill was rejected, but pressure to expand oil operations persists, especially in Block 64 in Loreto province, which overlaps with titled and customary Indigenous territories. The government's push to develop the block is raising serious concerns for negative forest impacts and renewed conflict with Indigenous communities that resist oil drilling in the region.[385] A recent auction in May 2025 received no single bid,[386] likely also due to the controversial nature of the block. The highly controversial Loreto Block 192 was operated by Pluspetrol Norte from 2000 to 2015, during which over 2,000 environmental incidents were documented. Frontera Energy then ran the block until 2021, withdrawing under force majeure amid community resistance, unremedied impacts, and issues with the North Peruvian Pipeline.[387] After unsuccessfully attempting to find a new operator, an agreement with Upland Oil & Gas (US) was announced in August 2025 as a new partner in the development of Block 192.[388]

3.4.6 Outlook for the Congo Basin rainforest

The fossil fuel industry also targets the Congo Basin. Within its forests, 1,603 active oil and gas wells have been mapped across 109 active oil and gas concessions covering an area of 265,000 km^2.[389] As of 2022, more than 35% or 640,000 km^2 of tropical rainforests in the Congo Basin overlap with existing or planned oil and gas blocks. Many of them also overlap with key biodiversity areas and community forests.[390]

Democratic Republic of the Congo

In May 2025, the DRC approved the opening for exploration of 52 new oil blocks spanning over 1.24 million km^2 in the Cuvette Centrale peatlands,[391] the world's largest terrestrial carbon sink and a highly biodiverse critical ecosystem.[392] Currently, three blocks have already been assigned to the Cuvette Central peatlands (→ section 6.6.2).[393] The new blocks represent a significant expansion from a 2022 tender that was annulled in 2024 due to widespread criticism over legal irregularities and environmental and human risks.[394] Local and regional opposition points to the negative impacts of oil and gas development on biodiversity, communities, land rights, and its threat to the country's commitments in the fight against climate change.[395]

3.4.7 Outlook for the Southeast Asia-Oceania rainforest

Southeast Asia has more than 348,000 km^2 of rainforest that overlaps with oil and gas blocks designated for production or exploration.[396]

Indonesia

In Indonesia, ~70% of oil wells are mature, and new discoveries have been scarce. Investments have decreased as the development of renewable energy sources has become a higher priority. The government still views the oil and gas sector as a key pillar in meeting the country's energy needs, and the discovery of new reserves in the many unexplored basins with potential reserves is seen as critical.[397] If new reserves are discovered, this could substantially increase the future risks for forested areas.

Coal production has been a significant driver of mining-driven deforestation in Indonesia in the past. Estimates by Giljum et al. suggest that the expansion of mining resulted in direct deforestation of ~1,900 km^2 between 2001 and 2019, making Indonesia the most affected country. Particularly important was the expansion of coal mines in East Kalimantan on the island of Borneo.[398] The TreeMap identified a conversion of 7,210 km^2 for mining infrastructure between 2011 and 2023, of which 1,500 km^2 was primary forest. With ~45%, coal mining had the largest impact.[399] The removal of topsoil across hilly landscapes encourages flooding and landslides, which cause further loss of tree cover.[400] Including indirect impacts in the analysis significantly increases the areas affected by coal mining in Indonesia. Giljum et al. found a high statistical significance in the surroundings up to 50 km around direct mining activities.[401]

Indonesian coal production has accelerated in recent years, making the country one of the world's largest coal exporters. Production increased from 92.5 Mt in 2001 to 775 Mt in 2023 and 836 Mt in 2024.[402] In parallel, the capacity of coal-fired power plants doubled in the last decade, reaching 49.7 GW today, including 38.5 GW grid-connected and 11.2 GW of captive power, mostly used for the country's large mineral smelting industry, notably for nickel, a 'critical' mineral for the energy transition (→ section 3.2). Despite an electricity oversupply in recent years, total coal-fired capacity is still forecast to reach 76.5 GW by 2031, with additions of 6.6 GW of grid-connected and 20 GW of captive coal capacity. Annual coal consumption for power generation is estimated to increase from 183 Mt in 2024 to 298 Mt by 2037, although this does not align with the country's Low Carbon Scenario - Compatible with Paris Agreement target (LCCP).[403]

The rapid expansion of nickel smelters, which require large amounts of reliable and low-cost energy, has become the primary driver of captive coal power growth in Indonesia, creating a direct link between the mining and energy sectors and locking in carbon-intensive infrastructure.[404] Driven by both domestic demand and exports, Indonesia currently has a coal expansion of 31 Mt per year under development, of which around half is already permitted. Additionally, more than 40 mine projects are in the very early stages and lack reported capacity data.[405] Several expansions of existing concessions and new titles are underway already, including 11 projects under construction in South Kalimantan, three in Central Kalimantan, and one in East Kalimantan.[406] These developments are likely to lead to further mining-induced direct and indirect deforestation, particularly where mines are located in or near forests.

Papua New Guinea

Significant oil and gas deposits, such as those in the Kikori River Basin, are being exploited in PNG, often overlapping with forested areas. The first liquefied natural gas (LNG) project, the PNG LNG Project, commenced operations in 2014, spanning the provinces of Hela, Southern Highlands, Western, and Gulf, and connecting to Port Moresby via over 700 km of onshore pipelines. The LNG is exported to markets in China, Japan, and Taiwan,[407] with little economic benefit for the local economy.[408] There have been long-standing land-related conflicts surrounding this project, as well as a second major LNG project in planning, Papua LNG, both of which are operated by foreign companies and target Asian export markets.[409] CSOs criticised a lack of transparency that hinders the FPIC of affected communities and highlight severe environmental impacts in areas with unique biodiversity. For the Papua LNG, the final investment decision is pending, and various international banks have committed not to participate.[410]

Impact scenario

Around 60 km of the 320 km pipeline that would link the project with the existing LNG plant on the coast will be onshore.[411] At an average pipeline right-of-way (ROW) of 18-36m around the pipeline, this alone would require clearing a corridor of 1.1 km^2 to 2.2 km^2.

According to TotalEnergies, the operator of Papua LNG, 95% of the production is expected to be exported to Asian markets, perpetuating an economic model that relies on extractivism, with minimal benefits for the local population.[412] PNG itself has a vast renewable energy potential; government agencies have already identified renewable energy projects that could foresee 78% of its on-grid energy by 2030 while drastically expanding electricity access.[413] According to government estimates, this would come at a cost of US$110 million (€100 million), compared to US$10 billion (€9 billion) for the Papua LNG project.[414]

3.5 Possible scenarios

Transitioning from fossil fuels to renewable energy sources is crucial to reaching climate goals and reducing the pressure on forests from additional coal, gas, and oil production. However, if not implemented with strong safeguards, the energy transition risks adding pressure on forests rather than removing it.

Renewable energy systems are mineral-intensive, while bioenergy increases land and feedstock demand: both create direct and indirect deforestation risks in tropical regions. Mining's indirect footprint dwarfs its direct one, as new roads, power lines, ports and settlements are developed beyond mines and plants. New roads lead to forest clearing at large distances from sites, with Brazil and Indonesia showing especially strong spillover effects. Bioenergy increases pressure to convert forests to farmland to meet its increasing demand for crops, alongside food and industrial uses. The growing market for wood pellets cannot be served by sufficient waste supplies, leading to the replacement of natural forests with tree plantations. At the same time, the co-firing of pellets with coal sustains the use of fossil fuels.

What will determine outcomes?

The extent to which risks linked to energy systems will result in further deforestation in the coming decade depends on many different factors. Important ones include:

- **Global energy demand**: While uncertainty persists, scenario benchmarks, such as the IEA World Energy Outlook, indicate that efficiency policies like the EU Energy Efficiency Directive, the revised Act on Rationalising Energy Use in Japan, and the most recent cycle of the Perform, Achieve, and Trade scheme in India, are gaining traction: global energy intensity relative to GDP fell by 2% in 2022 and 1% in 2023. Following an average annual demand increase of 1.4% over the past decade, global energy demand growth is projected to slow to 0.5% per year from 2023 to 2035, despite steady GDP and service demand growth. This expected slowdown reflects:
  - stronger technical efficiency and policies;
  - structural shifts toward less energy-intensive activity, especially in China; and
  - more renewables and electrification that reduce conversion losses compared to fossil fuels.[415] Importantly, China, as a large energy market, continues to invest heavily in wind and solar energy both domestically[416] and in countries like Brazil.[417]

  These developments suggest that the world is moving closer to a genuine transition, although it has not yet achieved it. The growth of renewable energy thus far has not replaced fossil energy, and demand growth and a lack of renewable alternatives for hard-to-abate industries make this a moving target. Shifting government priorities in energy policies add to the unpredictability.
- **Production-side measures**: Governments in producer countries can limit deforestation outcomes through spatial planning, licensing rules, and strategic partnerships. Emerging production countries can increasingly assert control over value chains, as exemplified by Indonesia's ban on raw-nickel exports. Companies across the value chain can adopt higher operational and sourcing standards that have a material impact on forest outcomes. This includes upstream operators and mid- to downstream manufacturers, with China as a pivotal actor. Capping land use for biofuel feedstock production, enhancing yields, and promoting local, community-based biofuel production from diverse feedstocks can help reduce deforestation associated with biofuel strategies.[418] Financiers and off-takers can influence capital flows by withholding funding from high-risk projects or conditioning it on robust safeguards against deforestation and rights breaches.
- **Demand-side measures**: Government and corporate choices are critical for preventing deforestation linked to energy systems. When certain technologies are given preference, such as new battery development and 'car-light' scenarios, demand shifts to other and/or less minerals, which materially improves deforestation outcomes. Circularity is a crucial factor in reducing resource extraction and processing. Similarly, the risks of deforestation caused by bioenergy decrease significantly with the phase-out of first-generation biodiesel and wood pellets. Policy outcomes for fossil fuels depend on whether decision-makers prioritise phasing out coal, oil, and gas, or continue supporting new greenfield developments, also influenced by powerful fossil fuel lobbying and political influence.

  Policies and design choices that reduce material intensity, increase the lifespan of products (through reuse, repair, and refurbishment), and introduce new technologies allowing for material substitution could play a crucial role in reducing demand for newly mined minerals. A system-level redesign that scales circular economy strategies with strong socioenvironmental safeguards linked to the bioeconomy development would, at the same time, reduce the risk exposure of whole value chains to material price volatility, supply disruptions, and supply-demand gaps.[419] However, considering the barriers and resistance to such a system shift, in the short to medium term, recycling and broader circular economy strategies are unlikely to eliminate the development of new mines under current demand scenarios.[420]

Scenario pathways

Taking these different factors into account, we have defined three scenarios for how the impact of energy systems on tropical deforestation risks may develop in the coming decade:

- **Pressured Expansion**: This scenario assumes strong global minerals and metals demand, encouraging the development of new mining projects. Permissive governance, characterised by lax production-side policies and unambitious demand-side policies, means that supply chain monitoring and due diligence are insufficient to prevent minerals with significant environmental and social impacts from entering international value chains. First-generation biofuel production is growing significantly as biofuels are presented as a solution to the energy transition in transportation, and producing countries aim to increase their energy self-sufficiency. Fossil fuel extraction and wood pellet production benefit from rapid permit approvals. Policy support for co-firing strengthens wood pellet production in Southeast Asia-Oceania, while sustaining the Indonesian coal industry. At the same time, oil and gas exploration and exploitation continue, and further growth in global energy demand slows down a real transition from fossil fuels to renewable energy sources.

  Likely rainforest outcomes:

  - Mining: As a consequence of increased mining activities, 'impact halos' around mines intensify, with new corridors driving additional clearing. Indirect deforestation from infrastructure and settlement expansion extends over considerable distances from the actual mines.
  - Biofuels: Vegetable oils, animal fats, and sugarcane are key feedstocks for meeting blending targets, aviation and global shipping goals, putting pressure on oil palm, soy, and cattle frontiers.
  - Biomass: Growing Asian demand keeps pressure on pellet supply, and leakage from tighter EU rules to buyers with laxer requirements persists.
  - Fossil fuels: Government efforts to auction oil and gas blocks in rainforest regions are ongoing. The ability to find investors depends on oil price trends and extraction costs.
  - Geographic hotspots in rainforest basins: Pará State (Brazil); Cuvette Centrale/DRC corridors (DRC); Sulawesi, the Maluku Islands (including Halmahera), and the island of New Guinea (comprising Indonesian provinces of Papua (Tanah Papua) and Papua New Guinea).

- **Managed Transition**: This scenario assumes solid mineral demand to persist, but no-go zones are installed to protect key biodiversity areas and the livelihoods of IPs and LCs. Stronger production-side policies are implemented, including mandatory cumulative-impact EIAs, FPIC, lender covenants, and traceability. Stricter demand-side policies include supply chain transparency obligations and legislation requiring environmental and social due diligence. Circularity principles are gaining increasing attention, with short- and medium-term goals to boost recycling rates across various geographies. Bioenergy feedstocks focus on advanced residue feedstocks. No new fossil fuel development is approved, and the phase-out of existing production is initiated as renewable energy sources continue to gain market share. Research into alternative energy sources for hard-to-abate industries is scaled up.

  Likely rainforest outcomes:

  - Mining: Higher safeguards constrain deforestation at mining sites and along corridors. On-lease loss persists, but indirect deforestation is curtailed. The designation of no-go zones reduces pressure on forests, IPs and LCs and their territories.
  - Bioenergy: Prioritising residues and implementing robust deforestation-and-conversion-free (DCF) policies reduces direct forest conversion for bioenergy, which is particularly relevant

- in the Amazon and Southeast Asia-Oceania. In the absence of policy convergence across markets, the leakage of deforestation-linked commodities remains a risk.
    - Fossil fuels: A halt to new oil and gas blocks reduces their role as deforestation drivers and reduces the risk of conflicts for IPs and LCs.

- **Resource-Light Shift:** This scenario builds further on a 'managed transition', assuming additional strong production- and demand-side policies in relation to rainforest protection and production standards. Due diligence obligations and supply chain transparency are broadly implemented. Repair, reuse, and recycling are scaled within comprehensive circular economy strategies. Material efficiency and sufficiency in the transport sector are achieved, among other measures, through public and shared mobility, while chemistry shifts reduce demand for controversial minerals. New technologies are emerging and being supported to enable hard-to-abate sectors to transition to renewable energy sources.

  Likely rainforest outcomes:

    - Mining: The expansion of existing mines, the development of greenfield mining, and new corridors into intact forests are significantly constrained. The forest footprint of EVs and renewable energy sources falls with high recycling rates and improved battery technologies (LFP, sodium batteries),[421] the advancement of fuel cell EVs using green hydrogen, and the overall reduction of car fleets and car sizes.
    - Bioenergy: The use of bioenergy is governed by tight residue rules and the complete phase-out of first-generation biofuels, significantly reducing forest conversion risk.
    - Fossil fuels: The advancement in renewable alternatives, especially for hard-to-abate sectors, supports the phase out of fossil fuel production.

Conclusion

The transition to renewable energy sources, alongside the continued exploitation of fossil fuels, still creates substantial pressure on tropical rainforests under current policy landscapes and expansion plans. Governments and supply chain companies could improve outcomes and limit forest loss by working towards a 'managed transition', with enforceable safeguards on the production side. Deforestation could be reduced much further if these production-side restrictions could be complemented with ambitious demand-side policies in a 'resource-light' pathway that prioritises innovation, circularity, and efficiency while avoiding the extraction of resources at the cost of tropical forests and their communities. Given the current political and market dynamics, as well as weakened due diligence obligations for supply chain companies, a hybrid trajectory between pressured expansion and managed transition appears most likely in the near term.

The production of renewable energy is growing rapidly, and this growth is expected to continue. However, the push for new fossil fuel developments, ongoing demand for first-generation bioenergy, and reliance on mineral-intensive technologies without adequate safeguards will continue to impact tropical rainforests in the Amazon, the Congo Basin, and Southeast Asia-Oceania in the near term. This outlook also reflects weakening global prospects for near-term ambitious, enforceable policy frameworks that limit new fossil fuel developments, and enable a just and clean energy transition with minimal impacts on tropical rainforests.

4

Food systems

Agri-commodity production has been the main driver of deforestation in tropical rainforests in the past decades. Cattle ranching, feed production, and palm oil cultivation continue to play an outsized role in the use of agricultural land and forest encroachment. This chapter addresses two important issues for deforestation and food systems: the potential for lower deforestation pressure from a shift towards plant-based proteins, and the link between palm oil demand and the expansion of markets for processed foods.

Key findings

- **Agri-commodities** are the main economic driver of tropical deforestation, particularly cattle ranching and large-scale oil palm, soy, and cereal production. Telecoupled demand from distant markets significantly amplifies impacts.
- Without **strong safeguards**, increasing demand and expanding trade risk pushing agri-commodity production further into rainforests. At the same time, resource distribution and consumption remain heavily skewed towards high-income markets. A BAU growth in global meat production would further intensify pressure on the Amazon from cattle pasture and soy. The anticipated growth in Brazilian beef production may lead to deforestation of ~57,000 km^2 until 2034.
- Outcomes of **intensification** in existing production areas hinge on tenure, enforcement and planning. A shift from animal to **plant proteins**, especially in high-consumption markets, could lead to much bigger gains, potentially freeing up millions of square kilometres of land and easing forest pressure.
- **Ultra-processed foods**, controlled by a small number of powerful corporations, are heavily pushed onto markets in Asia and Africa and boost palm oil demand. In combination with pressure from biofuels, forest risks are particularly high in Southeast Asia-Oceania.

4.1 Why is it relevant?

The expansion of agricultural areas has been a key driver of deforestation and forest degradation across tropical and subtropical countries.[422] Globally, the food commodity production systems most closely linked to tropical deforestation are cattle ranching and large-scale cultivation of oil palm, soybeans, and cereals.[423] It is important, though, to consider that several important food and feed commodities are subject to competing demand from non-food markets, especially bioenergy (→ Chapter 3).

Overall, deforestation linked to food systems occurs through direct forest-to-farmland conversion and indirect pressures from rising demand for forest-risk commodities. The indirect pathway underscores how changes in one region's food system can reshape land use and lead to broader socio-ecological impacts in geographically distant places.[424] This relationship, referred to as 'telecoupling', has received growing recognition. It has focused attention on globalisation as a key force shaping today's consumption patterns and land-use dynamics across commodities.[425]

The role of food system-based interventions was researched by Sylvester et al., considering consumption/demand, production/supply and trade/distribution and deforestation drivers in 40 tropical and subtropical countries (2004–2021). The results indicate that trade- and demand-side dynamics, particularly foreign direct investments and urban population growth, are key factors prompting deforestation trends at the food commodity level in Asia and South America. Food-system interventions have the potential to meaningfully curb deforestation. By contrast, the model's weaker fit for Africa suggests that drivers outside of the global food system may currently play a larger role there. Overall, the evidence highlights the importance of targeting both trade- and demand-side dynamics to address commodity-driven forest loss.[426]

Economic development, population changes, income disparity, dietary shifts, and the expansion of bioenergy affect global demand for food commodities (→ section 3.3).[427] The various forecasts for food demand trends differ, depending on the underlying factors and scenarios, and carry considerable uncertainties. However, there is broad agreement that food demand will continuously increase in the coming decades, within a certain bandwidth. For example, van Dijk et al. show that food demand is projected to increase by between 30% and 62% by 2050 compared to a 2010 baseline, taking into account various socio-economic and climate change factors.[428] Research by Tian et al. suggests an increase in global food demand by 46.8% in 2050 relative to 2020,[429] while Falcon et al. project an increase in total global food demand by 50-60% between 2019 and 2050.[430] Based on different scenarios for population growth and calorie yield increases through intensification, a USDA study based on a 2011 historic baseline predicts a medium outcome of a 42% yield increase and a 4% or 500,000 km^2 increase in food and feed crop area globally until 2050, an area equalling the surface area of Spain.[431]

Widely discussed options to meet the projected growth in global food demand include expanding cultivated areas, which carries high risks for forests and other ecosystems, or increasing yields on already productive lands. Sustainable agricultural intensification is often proposed as a means to curb deforestation by increasing yields on existing farmland, thereby reducing the need for expansion.[432] Practices such as climate-smart and agroecological farming, with diversified cropping systems tailored to local environmental and socio-economic conditions, have the potential to maintain or enhance yields while building resilience.[433] Therefore, intensification should be part of broader integrated land-use planning, especially as climate change is expected to reduce crop yields and shrink growing zones.[434]

However, agricultural intensification has a natural limit, and itself carries considerable risks if poorly managed, as the overuse of inputs can lead to pollution of land and water. Scientific evidence on whether it helps to curb deforestation remains limited. Outcomes depend, among others, on the type of intensification, target markets, proximity to deforestation fronts, and the strength of land governance.[435] Where land governance is weak, yield gains may still drive forest encroachment; in a rebound effect, higher yields may incentivise land conversion due to increased revenue opportunities.[436] Evidence from tropical dry forests suggests that intensification rarely curbs deforestation in commodity-crop economies. However, in countries with widespread Indigenous land stewardship, rebound effects were more efficiently prevented, and intensification was associated with reduced forest loss.[437]

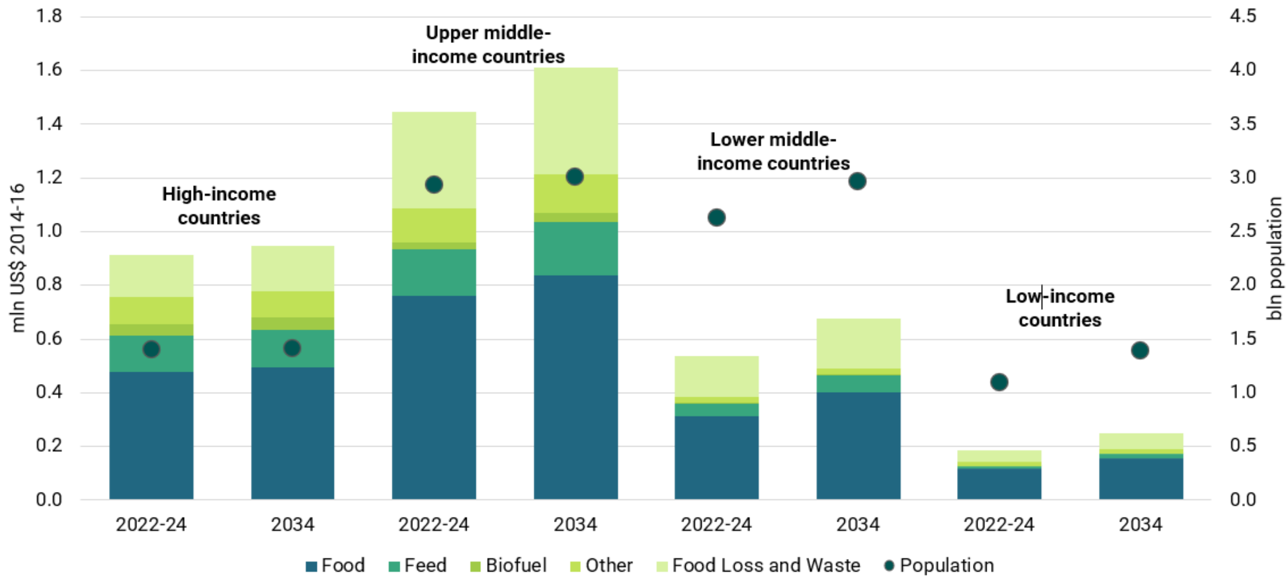
Considering the current progress in implementing innovation measures, the expected demand growth and the increasingly manifesting impacts of climate change on farmlands, it is unlikely that supply-side actions, despite their potential, will suffice to meet projected demand growth without further land conversion. The implementation of demand-side measures supported by policy incentives could facilitate a more efficient and equitable use of available food, including improved distribution models, waste reduction, and, importantly, a shift to less resource-intensive diets rich in plants and low in animal protein and processed foods.[438] Estimates for the EU, for example, suggest that ~10% of food available to EU consumers currently goes to waste. The introduction of new, binding food waste reduction targets by the EU is an important development.[439] However, implementation by 2030 means that an impact will not be felt in the short term.

The roles of commercial agriculture, directed at both local and global markets, versus small-scale or subsistence farming, which supports rural livelihoods, differ significantly across regions. According to FAO analysis of data for the period 2000-2018, small-scale farming accounted for 97% of agriculture-driven deforestation in Africa (80% for cropland, 16% for livestock), 59% in Asia (54% for cropland, 6% for livestock) and 52% in South America (46% for livestock, 6% for cropland).

The highest shares of forest loss to large-scale farming were observed in Latin America, with 30% linked to large-scale livestock production and 18% from large-scale crop production, including soybeans, and in Asia (38% linked to large-scale crop production, particularly oil palm plantations in Southeast Asia).[440] It is, however, noteworthy that attribution of deforestation to forest-risk agri-commodities other than soy and oil palm is often less granular, as data is based on rougher agricultural statistics, dated or modelled maps, or local case studies. Furthermore, although most tropical forest loss occurs in landscapes with dominant agricultural land use, only about half of the converted land becomes productive farmland, while the remainder is linked to speculative clearing, land tenure conflicts, abandoned projects, and fire spillovers.[441]

According to OECD/FAO projections, total food commodity consumption is expected to increase by 13% by 2034 compared to current levels, based on constant prices. Nearly all the growth is expected to occur in low- and middle-income countries, driven by rising incomes and population growth. This refers notably to demand for animal proteins, which are directly and indirectly linked to deforestation and are a major source of GHG emissions. Yet, in relation to their global population share, high-income countries are expected to clearly remain the main users of agri-commodities. As global demand for food and feed grows, with production often located far from consumption areas, 22% of all calories is expected to cross international borders over the next ten years. Without strong safeguards, current and future global trade in food commodities can drive resource-intensive expansion, deforestation, and biodiversity loss.[442]

Figure 16 Use of agricultural commodities by type and income group



Note: Values at constant US$ 2014-16.

Source: Own elaboration, based on: OECD/FAO (2025), "OECD-FAO Agricultural Outlook", *OECD Agriculture Statistics (database)*.

Traditional tropical export crops, such as sugar, coffee, and cacao, contribute comparatively small shares to deforestation embodied in commodity production; however, their contribution is playing a more sizeable role in a small number of countries. Within the three focus regions, this is concretely the case for coffee in PNG and Peru, and cacao in the Republic of the Congo and Cameroon.[443] For both commodities, strong growth rates are forecasted for the period 2025 to 2030,[444] suggesting further increasing cultivation areas. While small-scale agriculture is primarily associated with subsistence farming or supplying local markets, it is noteworthy that coffee and cocoa are exceptions among crops that contribute to deforestation. Both commodities are cultivated mainly by small producers but are predominantly supplied to international markets.

This chapter dives into selected trends in the global protein sector and the impact of shifting food trends on global palm oil demand, highlighting the significant relevance of global food system shifts to deforestation driven by food commodities.

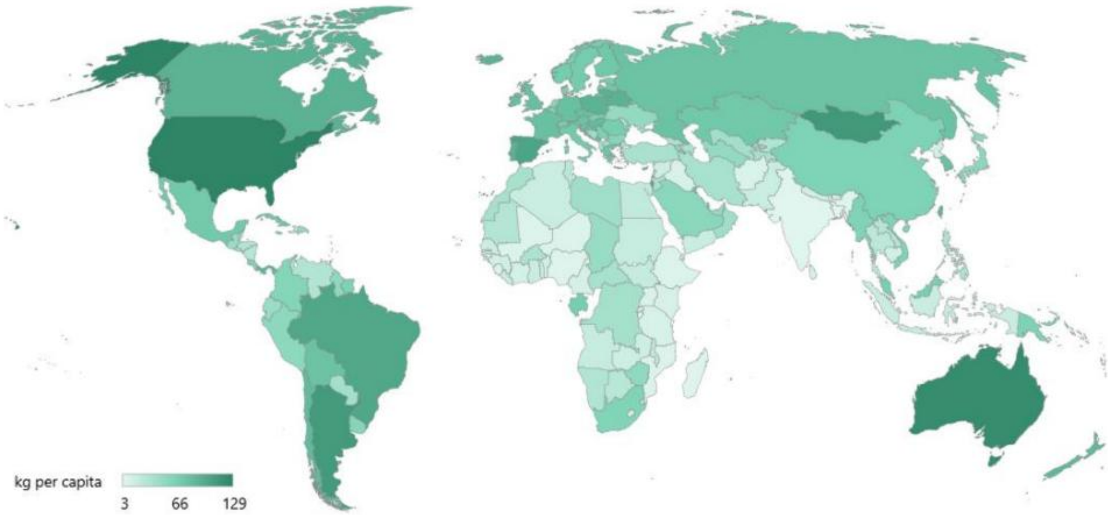
4.2 Animal protein versus plant protein

4.2.1 Global market landscape

It is widely acknowledged today that global livestock production has become unsustainably high. Livestock agriculture is a significant contributor to human-made GHG emissions. This role is due to direct emissions, including the release of the highly potent GHG methane from ruminant enteric fermentation processes and manure management, as well as indirect emissions resulting from high feed consumption, including oilseeds and grains. Meat production has a significantly larger land and water footprint compared to plant proteins, such as legumes, grains, or nuts.[445]

The consumption of beef, pork, and chicken has reached unprecedented levels and is forecast to continue increasing. However, consumption patterns are complex and vary significantly between countries and within countries based on socioeconomic circumstances. High-income countries, and some emerging economies, have the highest consumption levels (Figure 17).

Figure 17 Average meat consumption per capita (kg/year, 2020)



Source: Own elaboration, based on: FAOSTAT (2023), "Food balances – 2020", online: https://www.fao.org/faostat/en/#data/FBS.

The fact that ~70% of the world's agricultural land is currently occupied by the livestock industry offers a large potential to decrease land pressure while increasing food production. This land is used directly for cattle ranching and indirectly for feed production. Considering livestock's inefficient feed conversion ratios, a dietary shift towards a higher share of plant proteins, notably in industrialised countries with high meat consumption, could potentially make vast areas of arable land available for more efficient food crop production.[446] Consequently, pressure to convert more land for the feed market would decrease.

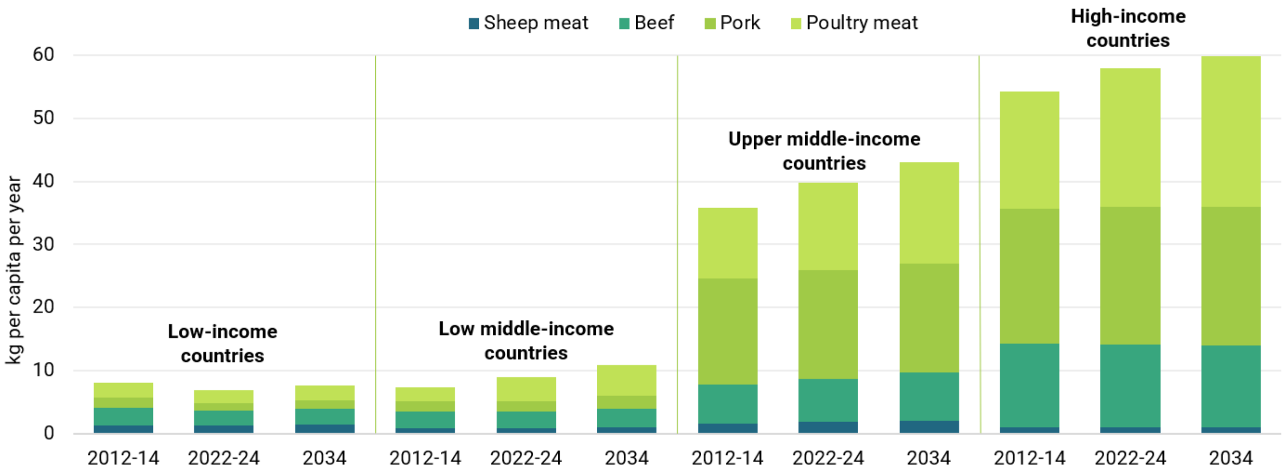
Impact scenario

A 2023 analysis by Profundo found that reducing the meat produced and consumed in regions with exceedingly high animal protein intake and substituting it with a mix of alternative proteins could save large volumes of human-made GHG emissions, but also large areas of land. Based on a scenario of a 30% reduction of conventional meat production with a focus on high-income and high consumption geographies against a 2021 baseline and substitution with a mix of alternative protein products,[q] the analysis concluded that this could reduce global land requirements by more than 3 million km^2, or the entire surface area of India.[447]

4.2.2 Demand trends

Current OECD/FAO forecasts to 2034 do not indicate a significant shift in global meat consumption trends. Yet, per person, the increase is slowing: global intake rises ~3% to 29.3 kg per capita per year, about half the pace of the previous decade. Meanwhile, global meat production is expected to increase by 13%, driven by population and income growth within a broader set of systemic drivers, including subsidies, advertising and lobbying efforts:[448] poultry +21%, beef +13%, and pork +5% until 2034. Keeping in mind that levels of meat consumption in high-income economies are already exceedingly high today (35% of consumption vs. 17% of population in 2024), ~45% of the absolute growth is expected to occur in upper-middle-income countries, as populations and incomes rise. The largest country-level gains are expected in China, India, Brazil, and Indonesia. Coming from a significantly lower level than other geographies, African countries are forecast to experience a ~33% increase in regional demand by 2034 compared to current levels.[449]

Figure 18 Per capita meat consumption by income group and meat type (kg per year)



Source: Own elaboration, based on: OECD/FAO (2025), "OECD-FAO Agricultural Outlook", *OECD Agriculture Statistics (database)*.

In this context, most projections consider rising meat demand as an almost inevitable outcome of economic growth and higher incomes. It is less clear to what extent they consider that the future may diverge from the past: although growth has historically increased meat consumption, evolving environmental and health awareness, climate change impacts, and a range of social factors could lead to different future patterns.[450]

Another demand factor that deserves attention is the price of animal proteins. The OECD/FAO outlook to 2034 expects overall falling meat prices in real terms during the period, largely due to reduced real feed costs and ongoing productivity improvements.[451] This projection does not address the substantial externalised environmental and social costs associated with livestock production: a 2023 study on the European market estimated external costs for different livestock products at €2.24-10.15/kg beef (depending on dairy or beef cattle), €1.91/kg pork and €1.44/kg chicken.[452]

Gradual steps can be taken to reduce the environmental footprint of meat consumption. Within the meat complex, beef has by far the largest land use, GHG emissions, and water footprint.[453] Encouraging an accelerated transition towards less impactful types of animal protein could bring

[q] Based on a mix of 35% pulses, 35% tofu, 15% fermentation-based products, and 15% mycoprotein-based products.

comparatively fast results. However, because pork and poultry production rely heavily on soy for animal feed, the land footprint of these types of meat remains considerable.

A faster shift to protein-rich plants and alternative protein products could have a more significant impact. Plant-based products can play a crucial role in reducing the deforestation associated with food systems. Protein-rich plants, such as legumes, are widely available, more affordable than other protein sources, and have been traditionally incorporated into many diets. Replacing animal protein with legumes, grains, or nuts would be the most resource-efficient alternative.

To accelerate the transition from animal proteins, particularly in high-meat-consumption economies, alternative meat products with comparable texture and taste, such as cell-cultured and fermentation-derived products, can play an important role.[454] Their market is projected to reach 6% of the global meat and seafood market by 2030, driven also by the introduction of new ingredients and the development of improved products.[455] However, scaling of ingredient supply and production capacity will still require substantial investments to reach this volume.[456] While sales continue to increase in various developed and emerging markets globally,[457] current market evidence suggests that a more substantial shift towards plant-based alternatives may not be achieved in the short term, as many consumers view plant proteins and plant-based meats as complements, rather than replacements, of meat.[458]

4.2.3 How demand may put pressure on tropical rainforests

The global food system is marked by a highly unequal distribution of both benefits and burdens. As highlighted by the 2025 EAT-*Lancet* Commission report, the diets of the richest 30% of the global population account for more than 70% of the environmental pressures associated with food systems. These inequalities also mean that nearly half the world's population does not meet human rights related to food systems, such as the rights to food, a healthy environment, and decent work.[459]

The global food system's heavy and increasing reliance on animal proteins is linked to two primary drivers of deforestation: cattle ranching and feed production for industrial livestock, particularly soybeans. Among tropical rainforest countries, these impacts are most pronounced in Brazil.

The impact of food system dynamics on tropical rainforests is linked to a diverse set of factors. Rising incomes and urbanisation have historically been accompanied by increased demand for meat, dairy, and eggs.[460] Cheap retail prices, often shaped by subsidies, externalised costs, and aggressive marketing, expand consumption of animal proteins beyond nutritional needs.[461] At the same time, the production of animal protein is significantly more resource-intensive than that of plant proteins. Considering the protein content per food unit, beef from free-range cattle herds requires, on average, 163.6 m^2 of land to produce 100 g of protein, compared to 10.7 m^2 for pork and 7.1 m^2 for poultry meat.[r] In comparison, pulses are linked to an average of 7.3 m^2, peas 3.4 m^2, and tofu to 2.2 m^2.[462]

Pasture and feed crop expansion tends to occur where agronomic conditions are favourable, but is also attracted by cheap land, tenure gaps (including unclear land rights), and weak enforcement.[463] In livestock, by-products like leather and tallow can support additional industries (biodiesel, oleochemicals, tanning and downstream processing), reinforcing herd economics (→ section 3.3.5).

While domestic markets can play a key role in livestock demand, global supply chains linked to animal products also connect ('telecouple') distant consumers to forest frontiers as import demand encourages deforestation incentives in producing countries.[464] Land conversion is supported by infrastructure development, including roads, ports, slaughterhouses, and crushing

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r Beef from the dairy herd has a smaller footprint as part of it is assigned to the milk production.

capacity, as well as enabling credit flows.[465] Once herds, slaughter capacity, feed mills, and trade routes scale up, falling costs lock regions like the Amazon into protein-heavy supply chains.[466]

4.2.4 Outlook for the Amazon rainforest

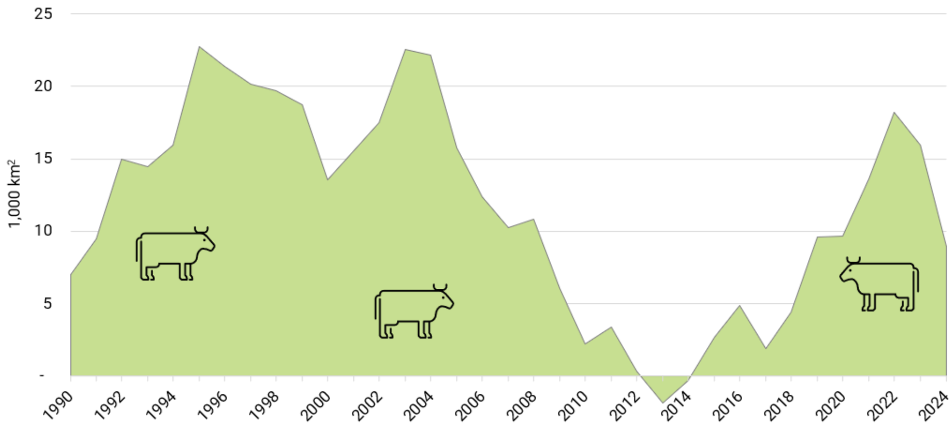
Taking overlaps between the data into account, crops and pasture combined cover an estimated 1.16 million km^2, equivalent to 19% of the overall Amazon area.[467]

Brazil

Beef

According to MapBiomas data for 2024, ~560,000 km^2 of pasture are in the Brazilian Amazon alone, accounting for 36% of the country's total pasture and covering 13% of the biome's land area. This area has experienced a significant increase from ~335,000 km^2 in 2000. Pasture area expansion peaked in the early 2000s (Figure 19).[468]

Figure 19 Pasture area added in the Brazilian Amazon, 1990 to 2024



Source: Own elaboration, based on: MapBiomas (2025, August), *Project MapBiomas - Collection 10 of Brazilian Land Cover & Use Map Series,* online: https://brasil.mapbiomas.org/estatisticas/.

The oscillation in cattle-driven deforestation is due to a complex interplay of factors, including but not limited to:

- Historically high deforestation rates between 2002 and 2004 were, among others, driven by international market developments, including bovine spongiform encephalopathy (BSE) outbreaks in Europe and China's economic growth, increasing demand for Brazilian beef and soy in distant markets.[469] Temporary deforestation spikes were linked to an increasing number of municipalities becoming free of foot-and-mouth disease, enabling producers from these municipalities to gain access to external markets.[470]
- From 2004 onwards, the roll-out of Brazil's near-real-time satellite alerts (DETER) and stepped-up law enforcement by the environmental authority, IBAMA, contributed to decreasing deforestation rates in the Amazon.[471]
- The expansion of protected areas, including indigenous lands, played a major role in reducing Amazon deforestation in the so-called 'arc of deforestation' in the eastern, southern, and southwestern Amazon (~37% of the total 2004–06 decrease).[472]
- Targeted economic levers contributed to a reduction in Amazon deforestation rates. These included Central Bank Resolution 3,545 of 2008, which tied rural credit to environmental compliance, and the blacklisting of municipalities with high rates of illegal deforestation.[473]
- Following the 2006 Amazon Soy Moratorium, major meatpackers signed so-called Terms of Adjustments with the Federal Prosecutors' Office (MPF) in 2009, pledging not to buy cattle from farms that deforested without environmental licenses or raised on Indigenous lands or in protected areas. However, because meatpackers largely failed to monitor the important indirect suppliers, the agreement reduced cattle-driven deforestation but did not stop it.[474]

- The rapid increase in cattle pasture in the Amazon from 2019 onwards reflects the weakening of environmental protection and Indigenous land rights, alongside a sense of impunity under the Bolsonaro government.[475]

The data does not allow for distinguishing displacement effects, where pastures are taken over by other agricultural uses and cattle move further along the deforestation frontier.[476]

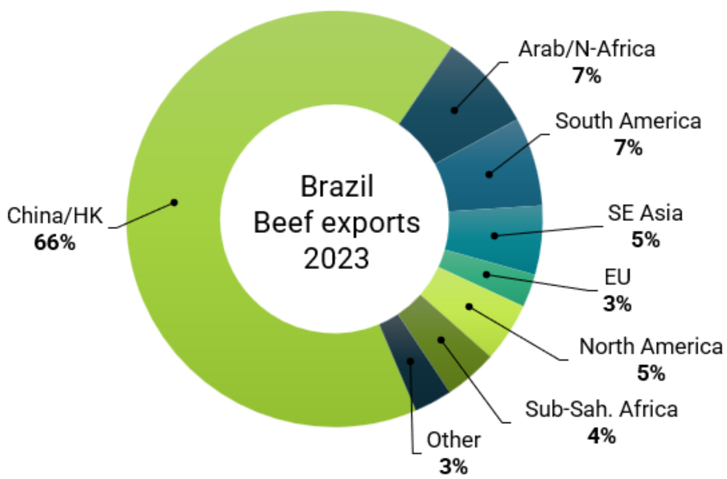
Government policies have strongly promoted the Brazilian cattle industry during the last decades. Support included foot-and-mouth disease control in the 2000s and subsidies that spurred growth in the meatpacking industry and beef exports from the Amazon. The sector benefited from millions of dollars annually through tax exemptions, amnesties, and debt forgiveness.[477] In the meantime, some instruments have evolved, while others are increasingly tied to sustainability criteria. However, cattle and meatpacking operations can still benefit from tax incentives, rural credits, and other support programmes.[478]

Cattle are predominantly raised for meat production. Yet, valuable co-products, especially leather and increasingly collagen, contribute to the economic viability of the sector. With the largest commercial bovine herd globally, Brazil is also a leading exporter of bovine hides to world markets.[479] There is also a growing global market for bovine collagen as an ingredient in health supplements, and for beef tallow use in biodiesel production (→ section 3.3.5). Similar to beef, these co-products have been repeatedly linked to deforestation in the Amazon.[480] While the high value and high demand for beef will remain the primary economic driver of rising cattle numbers, strong market demand for these products makes cattle ranching economically more attractive.

Pasture expansion in the Amazon is also linked to low productivity and rapid degradation, driven by abundant and cheap land, as well as weak incentives to sustainably maintain the land while improving productivity.[481] As of 2021, 57% of the pasture in the Amazon was subject to some level of degradation and would require regeneration.[482] Higher stocking rates are more commonly observed near federally inspected slaughterhouses and in areas with active conservation policies.[483] The relative ease of regularising illegally occupied public land, combined with weak enforcement of restoration, encourages speculative deforestation.[484]

Domestic consumption remains the largest market for Brazilian beef, though its share has decreased from 83% to 70% in the last decade, while production increased by 25% during the same period.[485] Growing export demand has been a key driver for the expansion of cattle ranching. Accounting for two-thirds of exports in 2023, China (including Hong Kong and Macao) was the top destination by far, with increasing trade volumes during the last ten years.[486]

Figure 20 Export destinations for Brazilian beef, 2023



Source: Own elaboration, based on: UN Comtrade Database (2025), online: https://comtradeplus.un.org/.

Importantly, the beef-linked deforestation risk is higher for beef sold on the Brazilian domestic market than that reaching export markets. From 2015 to 2017, the domestic market consumed 80.9-82.4% of Brazil's beef, which was linked to 85.8-86.8% of the deforestation risk each year. In contrast, export markets purchased 17.9-19.1% of Brazil's beef, incurring 13.2-14.2% of the deforestation risk. Exports are more likely to originate from municipalities with more mature agricultural sectors, contributing to this difference.[487]

In its latest agricultural projections, the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) expects beef production in the country to grow by 10.2% from 2024 to 2034, almost exclusively to serve export markets.[488]

Impact scenarios

Under a business-as-usual (BAU) scenario, based on the current cattle pasture area in the Amazon of ~560,000 km^2, and a stable stocking intensity,[489] we estimate that the 10.2% increase in beef production expected by MAPA could lead to the deforestation of ~57,000 km^2 by 2034. Deforestation would be even greater if cattle raising continued to shift to the Amazon from other parts of the country, and if no gains in productivity are achieved.[s,490]

Global estimates for the land footprint of different protein sources (→ section 4.2.2) illustrate the outsized land requirement of pasture-fed cattle. Producing the same volume of protein from poultry, peas, or soy-based tofu instead could decrease the required land by a factor of 23 to 74, with plant proteins providing the most significant potential decrease.[491]

A shift away from cattle ranching to alternative, nature-positive income opportunities for farmers could be one of the most impactful strategies to ease cattle-driven pressure on the Brazilian Amazon while ensuring farmers' income. Such a comprehensive shift would require investments and support for farmers, which could be provided from different government finance mechanisms, including, importantly, repurposing agricultural subsidies that currently benefit and incentivise cattle ranching.[492]

The Amazon-focused 'sociobioeconomy' is a community-led economic model that centres around Indigenous Peoples and Local Communities (IP and LCs) and socio-biodiversity value chains—for example, açaí, Brazil nuts, babassu, community forestry, pirarucu fisheries.[493] Unlike a generic, profit-maximising bioeconomy or land- and volume-intensive ventures like cattle ranching and single-crop plantations, the sociobioeconomy model prioritises territorial rights and governance, fair benefit-sharing, community ownership, diversified forest-compatible production, and traceability, aiming to keep the forest standing while generating income locally. FPIC, rights-based territorial governance, and adapted credit and market access stand at the centre of the approach.[494]

To make sociobioeconomy and non-timber forest products viable alternatives in the Brazilian Amazon, public support must be paired with simplified access for IPs and LCs to existing public instruments, at levels comparable to those in conventional agriculture. Examples include PRONAF rural credit lines, PGPAF price guarantee bonuses, PGPM-Bio minimum prices for sociobiodiversity products via Conab, and marketing support.[495] The National Bioeconomy Strategy was launched in 2024. A National Plan for Bioeconomy (PNDBio) is currently under development with participation from government, businesses, and CSOs, representatives of Indigenous Peoples, Traditional Peoples and Communities, and family farmers.[496]

A less ambitious approach to addressing cattle-driven deforestation in the Amazon is sustainable intensification. This approach aims to protect the economic role of livestock ranching and is often described in the literature as a critical pathway to reducing deforestation pressure and carbon emissions while maintaining household income.[497] An increase in stocking rate to a value close to

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s The North region of Brazil experienced a 50% increase in pasture area (plus 104,000 km^2), and a 287% increase in cattle herds (plus 25.8 million heads) between 1985 and 2017. Moreover, the Amazonian pasture area as a percentage of the total pasture area of Brazil increased from 11.86% to 29.16% in the period 1985 to 2018.

pasture carrying capacity in Brazil's Northern region, of just above two heads per hectare or 200 heads per km^2,[498] could decrease the pressure from pasture expansion on forests. Utilising the large areas of degraded pastures in Brazil[499] and mainstreaming improved production methods could also help to reduce deforestation pressure from cattle.[500]

Another intensification approach involves a reduced time to slaughter, where shifts in production practices could enable a significant increase in productivity.[501] In a 2022 study, Skidmore et al. found that properties selling younger animals were connected to less deforestation and linked to zero-deforestation slaughterhouses. However, the higher start-up and operational costs for these strategies can form a barrier to slaughter age reduction for smallholders and cash-constrained ranchers working in traditional, pasture-based systems.[502] The leather market prefers a younger slaughter age due to the better quality leather that would result from the younger slaughter age described above. However, leather is considered undervalued in Brazil anyway, and as the global price of leather has fallen in recent years, driven in part by shifting consumer preferences toward synthetics and vegan products, it is unlikely that leather will become a driver of lower slaughter ages.[503]

Importantly, regulatory developments aimed at enhancing traceability could help mitigate the deforestation pressure from cattle in the Amazon in the coming years. Full cattle traceability is of particular importance due to the multiple layers of indirect suppliers commonly observed between birth and slaughter, as well as a significantly higher likelihood of deforestation among higher-tier suppliers.[504]

- Brazil's **National Traceability Plan** ('Plano Nacional de Rastreabilidade') envisages using electronic ear tags capable of electronic identification to track animals' location and movements, and is aimed at improving animal health issues, controlling epizootic outbreaks, and meeting international traceability requirements, including EUDR. The plan, however, has a six-year phasing-in period. Therefore, considerable areas can potentially still be deforested before the entire 238-million cattle herd is fully traceable.[505]
- The **state-level traceability initiative in Pará** will require tagging of all cattle transported through the state from December 2025, and the permanent herd by December 2026.[506] Pará is the Amazon state with the largest cattle herd in Brazil, counting ~24 million heads on almost 300,000 farms. The first programme of its kind in Brazil is supported by a coalition of public and private sector actors, including industry associations, producers, and CSOs. Considering estimates that at least 50% of cattle in Pará are reared on illegally deforested land, the initiative could have a sizeable impact.[507]
- The **Beef on Track** initiative by Imaflora, in partnership with the Public Ministry of Brazil, aims to provide support in implementing commitments for a cattle supply chain free of environmental and social irregularities. It seeks to bring all actors in the cattle supply chain, as well as investors, public actors and CSOs, on the same page by promoting good practices through monitoring, auditing and reporting processes and tools.[508]

Such supply chain initiatives will provide an important incentive in facilitating compliance with legislation in downstream markets, such as the EUDR (→ section 6.3). While the EU is only a small market for Brazilian beef exports, traceability answers, for example, also to animal health monitoring requirements by China.[509]

Soy

As explained in relation to biodiesel (→ section 3.3.5), the Amazon Soy Moratorium has effectively reduced the role of soy cultivation as a driver of Amazon deforestation over the past 20 years, but this situation can no longer be taken for granted in light of recent developments. In the industrial grains-oilseeds-livestock-feed complex, feed demand closely follows meat production, and soy is a key feed ingredient for the modern livestock industry. Under current conditions, global soy demand increases in line with meat consumption.

The majority of the global soy harvest is crushed into soybean meal (~78.5%) and oil (~18.5%); the meal serves as a source of high-quality protein in livestock production globally, with Brazil as the top exporter. In a scenario where the Soy Moratorium is dismantled, the risk of soy cultivation again becoming a driver of deforestation in the Brazilian Amazon could significantly increase. A rise in meat demand in line with OECD/FAO projections would further exacerbate this risk, creating a cumulative effect. The main destinations for Brazilian soy are the large domestic meat market (~25%), and exports to China (~30%), and to the EU (~10%).[510] Therefore, demand-side regulations and requirements in jurisdictions worldwide are important determinants of the deforestation outcomes. While the EU's Deforestation Regulation (EUDR) is expected to enter into force in December 2025 or 2026 (→ section 6.3.4), no similar legislation is in place in the other key markets for Brazilian soy as of October 2025.

The industrial grains-oilseed-livestock-feed complex

Coined by Tony Weis in the early 2000s, he referred to the concept of the industrial grains-oilseed-livestock-feed complex as the dominant system of agriculture, initially across the temperate world, but then also expanding to the tropics.[511] This system unfolds through the 'meatification' process observed across many countries, marked by a growing dominance of meat in diets, food systems, and economies. At the core of this process stands industrial feed production, with soy as a key source of high-quality protein.[512] The resulting landscapes are characterised by islands of concentrated populations of a few livestock species within seas of grain and oilseed monocultures.

The Chinese market is crucial in global soy trade and its forest footprint. Soy supply from Brazil is fundamental to feeding China's large livestock sector; its demand for feed cannot be met by domestic production at its current size.[t] However, the 'Three-Year Action Plan for Reducing and Substituting Soybean Meal for Feed', as presented by the Ministry for Agriculture and Rural Affairs in April 2023, foresees a reduction in the average soymeal content in feed from 14.5% to 13%. Full implementation could reduce soybean imports by 8.7 Mt, assuming the livestock sector does not continue to grow.[513] However, China's self-reliance policy is expected to drive domestic meat production increases and, consequently, higher feed demand in the coming years.[514]

Colombia

In Colombia, cattle ranching is also a sizeable deforestation driver, utilised by territorial armed groups operating in weakened governance and leading to land grabs and deforestation.[515] Land grabbing to secure land rights after clearing and pasture creation to level the land are closely entwined. These activities also do not stop from encroaching on protected areas and are often connected to illegal road networks (→ section 6.6.1). Between 2013 and 2023, ~1,250 km^2 of deforestation in national parks was documented, and large numbers of cattle were found grazing within the parks.[516] Illegal agriculture linked to cattle ranching was the primary cause of the 35% increase in deforestation observed in Colombia in 2024, closely tied to armed groups and their economic interests.[517]

Despite this complex situation, zero-deforestation agreements involving the major actors in the domestic beef and dairy sector could reach 41% of the country's forests if effectively implemented. The inclusion of the widespread indirect suppliers will be crucial, requiring monitoring and traceability systems.[518]

In the meantime, Colombia is considering its fourth attempt at a cattle traceability law, which would require ear tags, GPS chips, and real-time digital tracking across supply chains. With an estimated 30 million head of cattle, the sector remains a major driver of forest clearance. The bill,

[t] In 2024, China imported around 105 Mt of soybeans, out of which around 71% from Brazil, 21% from the US, and 4% from Argentina.

passed in the Senate's second debate as of October 2025, would unite existing systems, create "high-surveillance zones," mandate environmental certification for market access, and offer smallholders phased compliance support, aiming to curb land-grabbing and illegal ranching linked to environmental crime.[519] However, the future law's efficiency will also largely depend on effective enforcement.

4.3 Processed foods as a driver of palm oil consumption

4.3.1 Global market landscape

Palm oil is the world's most significant vegetable oil, with food manufacturing using ~70% of production.[520] The market for processed and ultra-processed foods (UPFs, broadly defined as foods that contain ingredients not typically found in a kitchen cupboard) has become a key market for palm oil, alongside maize, wheat, and soy. Products such as French fries, fried chicken, instant noodles, and snack foods are commonly prepared with palm oil and palm olein today, and fast-food establishments often use palm oil for frying.[521] Driven by the industrialisation of food systems and powerful commercial interests, UPFs today contribute more than 50% of all caloric intake in some high-income countries.[522] In addition to driving the demand for palm oil, the increasing market size of packaged foods also boosts the wood pulp market, as increasing volumes of paperboard are used for food packaging (→ section 5.2.1).

In this context, it is essential to consider that corporate power in the modern food system is highly concentrated, meaning that a small group of companies has the power to shape food systems for profit maximisation. As described in the recent report by the UN's Special Rapporteur on the Right to Food, UPFs are a case in point, as corporations not only drive the homogenisation of diets, but also specifically target lower-income countries with unhealthy products, while wealthier countries receive healthier choices.[523]

4.3.2 Demand trends

Further growth in the market for UPFs is expected worldwide, from US$2.18 trillion (€1.86 trillion) in 2025 to ~US$3.23 trillion (€2.75 trillion) by 2034, at a CAGR of 4.48%. An important driver for this increase is the growing demand for convenience food and fast food products,[524] which in turn is facilitated by the transformation of food systems due to increasing urbanisation.[525] Their role in the diets of both upper- and lower-middle income countries in Asia, the Middle East and Africa is rapidly growing as well.[526] This trend is expected to persist in the years to come, driven by the transformation of food systems due to urbanisation, rising incomes leading to shifts in diets away from traditional staples, and the expansion of fast-food chains and modern retailing, among other factors.[527]

In sub-Saharan Africa, a growing market for processed foods is accompanied by rapidly growing imports of non-staple ingredients for domestic processing and UPFs. Among ingredient imports, cheap palm oil from Asia has seen particularly strong growth, despite palm oil being traditionally produced in the region.[528] In South and Southeast Asia, several large, price-sensitive markets, including India, the Philippines, and Vietnam, are also experiencing robust growth in packaged food and food service markets.[529] Many of these products include palm oil as a cheap ingredient, as has been observed, for example, in packaged and street food in India.[530] Processed foods, including UPFs, experience strong growth rates in the two largest Asian markets, India and China. In India, the total processed foods volume has grown at a CAGR of 7.2% between 2011 and 2021.[531] During the same time, palm oil imports increased from 5.4 Mt to 8.2 Mt (CAGR 3.2%).[532] In China, instant noodles are an important driver of palm oil consumption in the food sector, with total annual consumption exceeding 40 billion servings and a palm oil content of ~20%.[533]

4.3.3 How demand may put pressure on tropical rainforests

Due to its versatility in processed foods, global food demand for palm oil is expected to further increase in the coming years, though the size of the effect will vary depending on relative prices compared to other vegetable oils, nutrition regulations in relation to HPFs, and biofuel policies (→ section 3.3).

Despite palm oil's favourable characteristics for the food industry, price competition among oils (soy, sunflower, palm) is known to reallocate demand by market and year. For example, India saw soybean oil imports surging in 2025 (typically from Argentina and Brazil) as palm oil traded at a premium for several months.[534] Future developments may also hinge on consumers' increasing health consciousness. The impacts of health policies can be significant. The risks of trans-fat historically pushed formulators toward palm oil as a cheap alternative; however, it has become clear that rules are also needed to moderate the intake of saturated fats, which would put palm oil at a disadvantage.[535]

There is a credible case that growing consumption of highly processed foods will support higher food-use demand for vegetable oils, particularly in low- and middle-income economies. Palm oil is likely to capture a sizable share of this demand, owing to its functionality and cost-effectiveness.

4.3.4 Outlook for the Amazon rainforest

Palm oil expansion has occurred in the eastern part of the Brazilian Amazon, mainly in Pará, and to a lesser extent in northern Colombia; in both countries, the focus is on biodiesel production (→ section 3.3.5).

Peru

Palm oil production has also expanded in central Peru, where it largely overlaps with the Amazon rainforest. Here, the market is more closely linked to food consumption as palm oil is the most widely used vegetable oil in the country.[536] In the ten years to 2024, the harvested area increased from 4,600 km^2 to 11,500 km^2.[537] Among the Amazon rainforest countries, Peru has experienced the most primary forest loss driven by oil palm expansion. This trend is expected to continue in the coming years, alongside acute adverse effects on indigenous rights.[538] Most oil palm is grown in the regions of San Martin and Ucayali, with the latter seeing higher deforestation rates and land-use conflicts, driven by weaker governance.[539] Research from 2023 revealed an additional 130 km^2 of deforestation in Loreto and Ucayali provinces, driven by palm oil and cocoa between 2012 and 2021, with supply chain links to international consumer goods companies like Kellogg's, Nestlé and Colgate.[540]

In March 2025, Peru's Ministry of Agrarian Development and Irrigation presented a new regulation to boost oil palm production, Policy Framework for the Sustainable Development of Oil Palm in Peru (2025–2034). The regulation was drafted without consulting Indigenous organisations. Critics also fear that it could lead to further palm oil-driven deforestation in the years to come.[541]

4.3.5 Outlook for the Congo Basin rainforest

Palm oil is traditionally produced by smallholder farmers in Western and Central African countries, but yields remain comparatively low. Even the larger producers in the region, like Cameroon, the DRC, and Gabon, still need to import palm oil to meet demand for food.[542] The Congo Basin has been identified as being at risk of becoming a new frontier for oil palm expansion since the late 2000s, with agro-industrial companies with foreign and/or mixed capital searching for suitable land. This risk is connected to rising land pressures in the top palm oil-producing countries in Southeast Asia, as well as increasing local and international demand, creating attractive market opportunities. Moreover, with more than 2.8 million km^2 of suitable land—mostly in the DRC, Cameroon, and the Republic of the Congo (RoC)—the region offers ample space for plantations, and national policies favour increased production.[543]

In the late 2000s, a surge in land deals for palm oil development sparked concerns about large-scale deforestation and land grabbing. In the Congo Basin countries, concession areas exceeded 10,000 km^2, including 5,000 km^2 in the RoC and just above 2,000 km^2 in Cameroon and DRC, often overlapping with community lands.[544] However, only a fraction of the original concessions were eventually developed, while others were abandoned, largely due to the resistance of local communities.[545] Inadequate mitigation of social, cultural and environmental risks, as well as resulting complaints and conflicts, exposes investors to considerable market access and stranded assets risk.[546] In recent years, no new large-scale oil palm plantation plans have been announced, and oil palm has not developed into an export commodity for the producer countries in the Congo Basin.

However, in light of growing demand for vegetable oil for processed food production and recent supply constraints or price spikes observed for Indonesian palm oil, existing undeveloped concessions could quickly become a risk to large tracts of forest, as demonstrated by a 600 km^2 palm oil concession in Cameroon, where a local company started clear-cutting the first 50 km^2 of coastal rainforest overlapping with ancestral lands in 2022.[547]

4.3.6 Outlook for the Southeast Asia-Oceania rainforest

Increasing demand could encourage new palm oil development, consequently increasing the risks for further rainforest conversion in Southeast Asia (→ section 3.3.4). The region is the main supplier of palm oil to international markets and has experienced high domestic growth rates in vegetable oil consumption, both for food and as a fuel. However, market and policy caveats mean that the magnitude of this risk will hinge on relative prices and policy in each market.

4.4 Possible scenarios

Transforming food systems can reduce or reallocate pressure on tropical forests. Today, most tropical deforestation is tied (directly or indirectly) to agriculture. The dominant commodity systems driving deforestation are cattle, oil palm, soy, and cereals, commodities closely linked to the grains-oilseeds-livestock-feed complex and affected by powerful telecoupled effects via trade and urban, income-driven demand. Deforestation for pasture or feed production is incompatible with achieving both human and environmental goals.[548] A smaller livestock sector, particularly for beef, seems inevitable to cut deforestation while achieving other environmental outcomes, alongside benefiting animal and human health.

Processed food markets are expanding rapidly in many low- and middle-income countries, driving demand for vegetable oils, notably palm oil. Meanwhile, a lack of regulation, coupled with the concentration of power among a small number of corporate actors who shape the food that is produced, traded, and available, enables business as usual. Without strong safeguards, the expansion of domestic demand and trade trends risks amplifying resource-intensive production and forest loss in the rainforest basins.

What will determine outcomes?

To what extent these conditions in the global food system will result in further deforestation in the coming decade depends on many different factors. Important ones include:

- **Global demand trajectory**: Current projections, like the OECD/FAO Outlook, expect continued growth in food demand to 2034/2050, driven by population and income. Under these forecasts, meat demand increases, particularly in upper-middle-income economies, and cross-border calorie trade intensifies. Rising meat demand has a direct impact on tropical rainforests through cattle ranching and an indirect impact through the expansion of soy production. Sales of processed and ultra-processed foods (UPF) are increasing, linked to palm oil demand due to its versatility and cost-effectiveness. High growth rates are observed in emerging markets and driven by corporate marketing efforts. These trends can determine the scale of land pressure and leakage risks in tropical rainforests.
- **Production-side measures**: Land-use planning, tenure clarity, enforcement, traceability, and DCF policies determine the level of protection of forest areas from commodity expansion. Examples include the (contested) Amazon Soy Moratorium, cattle traceability efforts, and regionally distinct roles of small- versus large-scale farming. In the Congo Basin, historical

interest in palm expansion and 'suitable land' narratives require strong tenure and biodiversity safeguards to avert commodity-driven deforestation. In Southeast Asia, the growth of processed food, price-sensitive vegetable oil substitution, and competition from the biofuel market all contribute to shaping the risk of oil palm expansion. Improved cultivation techniques and timely replanting of oil palms at the end of their productive life could help alleviate land pressure despite increasing demand.[549] Supporting agroecological systems in forest biomes could offer opportunities to mitigate the impacts of livestock while potentially improving the productivity of land that is typically managed separately for pasture or trees.[550] An important role across the three basins is played by supposedly 'agriculture-driven' land clearing that never results in productive farmland, reflecting speculation, tenure issues, short-lived uses and fire spillovers.

- **Demand-side measures**: Diet shifts toward plant-rich foods and other alternative proteins, reduced food waste, and healthier food-environment policies (including on UPFs) could materially lower land demand; without them, rising meat and processed-food consumption sustains feed, pasture and palm-oil pressures. However, the discussion of dietary shifts is sensitive as it is closely linked to cultural norms and values, as well as socio-economic disparities. The implementation and enforcement of robust supply chain and due diligence legislation have the potential to encourage deforestation-free production systems. Such initiatives would be particularly effective in key markets, like China and the EU. However, landmark EU legislation is currently facing weakening and delays.
- **Intensification with caveats**: Better yields could help to reduce pressure on forests, but outcomes are dependent on where and how: near frontiers and under weak governance, yield gains can induce a rebound of expansion and risk negative effects on local populations and biodiversity from intensifying agro-chemical use.

Scenario pathways

Taking these different factors into account, we have defined three potential scenarios for how the impact of key food system trends on tropical deforestation risks may develop in the coming decade:

- **Pressured Expansion**: This scenario assumes robust global food and feed demand, with meat growth in line with BAU projections. The policy environment is characterised by weak or uneven due diligence and traceability requirements, including further weakening and delays in the implementation of the EU Deforestation Regulation (EUDR) and other due diligence legislation. Leakage markets persist because China and other key markets for beef, soy and palm oil do not adequately consider material deforestation risks in their sourcing requirements. The attack on the Amazon Soy Moratorium is successful, eroding its impact. Due to a lack of supportive public policies and price incentives, progress in dietary shifts away from animal proteins in high-consumption markets stalls or remains slow, while consumption in emerging markets continues to increase. Similarly, food waste reduction is only slowly and partially succeeding. UPFs see increased expansion in emerging markets and sustained demand in established markets.

  Likely rainforest outcomes:

  - Amazon: The Amazon sees continued deforestation pressure from cattle pasture. Soy-driven deforestation, particularly in Brazil, increases as safeguards are weakened. In Colombia, land-grabbing and illegal ranching remain salient, while non-productive, speculative clearing persists.
  - Southeast Asia–Oceania: UPF-linked palm-oil demand growth and domestic consumption add pressure on rainforest frontiers. Expansion risk is highest where governance is weak. High-risk palm oil finds leakage markets.
  - Congo Basin: Renewed investor interest in industrial oil-palm appears where 'suitable land' and pro-expansion policies coincide with rising regional demand.

- **Managed Transition**: This scenario assumes solid demand but stricter producer-side rules in the form of zoning, tenure improvement, and law enforcement, with the Soy Moratorium staying in place, mandatory FPIC, and strengthened land tenure systems increasing accountability for land grabbing cases and recognising customary rights. Scaled traceability and DCF commitments, the implementation of EU legislation without further weakening and delay, and EUDR-style due diligence with strict cut-off dates appearing in other markets contribute to decreasing forest pressure from cattle, soy, and palm oil. Targeted and considered intensification and timely replanting of trees at the end of their maturity reduce the pressure to convert new land. Community-led economic production models, as alternative production systems, receive increasing support, particularly those with IP and LC leadership and involvement. Subsidies for meat production are scaled down and strategically diverted to low-impact production. Demand measures, such as reducing food waste and implementing healthier food policies, are gaining momentum, contributing to a decline in meat consumption.

  Likely rainforest outcomes:

  - Deforestation for cattle pasture, soy, and palm oil production decreases overall, but impacts are uneven across rainforest basins and supply chains. Leakage of deforestation-linked commodities to markets with weaker legislation is reduced but not eliminated.
  - Cattle, soy, and palm oil risks are moderated by geolocation-based screening, cattle traceability, and maintaining and expanding moratoria-type instruments beyond narrow geographies.
  - Community-led models that work with the forest increasingly gain structural support.

- **Resource-Light Shift**: This scenario builds further on a ‘managed transition’, assuming an accelerated diet change in high-consumption markets toward more plant proteins and a selective substitution within meats toward lower-footprint species. Investment in scaling alternative proteins is increasing while support for meat production is being cut. This is supported by public policies that prioritise and support the transition to lower-impact and healthier diets. The outsized influence of a small number of multinational food corporations is reduced, for example, through stricter competition laws and lobbying restrictions. In combination with systemic food-waste reduction and broader circularity approaches in food systems, the dependencies of the industrial grains-oilseed-livestock-feed complex are significantly reduced.

  Likely rainforest outcomes:

  - Pasture and feed-crop expansion pressures fall. Land savings in the order of millions of square kilometres become plausible under partial meat-substitution scenarios, particularly in high-consuming countries.
  - As advanced policies in high-demand as well as emerging UPF markets promote healthier diets, decreasing market shares for these processed foods also reduces the associated palm oil consumption.

Conclusions

Food system choices will fundamentally influence forest outcomes. It is clear that the rainforest basins will face sustained conversion pressure in a situation where demand, trade, and corporate power continue under a business-as-usual scenario, which currently largely overlaps with the ‘pressured expansion’ track in which global food and feed production growth is not influenced by due diligence and traceability requirements. A ‘managed transition’ based on stricter producer-side rules, such as zoning, tenure improvement, and law enforcement, can bend the curve, but importantly requires action by policymakers to implement ambitious legislation and advocate for policy convergence across markets.

Developments are currently diverging; for example, cattle traceability systems are advancing in Brazil, but the Amazon Soy Moratorium is under severe threat; the EU may further weaken and delay its initially ambitious deforestation and due diligence legislation, but takes steps to reduce food waste, while the important Chinese market shows initial signs of strengthened deforestation requirements (→ section 6.3).

Transitioning to a ‘resource-light’ diet shift that reduces land demand at the source by switching from animal protein consumption to plant protein consumption would be far more effective in protecting forests, as the potential gains in terms of land requirements are enormous. However, such a transition seems currently unrealistic in the short term as it would require broad international policy alignment and action, while this topic is closely linked to cultural norms and values, and socio-economic disparities.

5

Fast-turnover products and emerging forest-risk trends

Increasing consumerism and fast-turnover of products contribute to pressure on tropical rainforests, as commodity production expands to meet rising demand. In parallel, global demand for forest-risk products for longer-term use also increases, including, for example, gold for investment, jewellery, and technology, as well as timber for furniture or construction. Three examples are used to highlight these concerns and the need for a trend change: expanding wood pulp production, timber extraction, and the growing demand for gold.

Key findings

- **Consumerism** linked to fast fashion, other fast-turnover goods, and e-commerce packaging is boosting demand for wood pulp and timber, increasing pressure on tropical forests via plantation expansion. In recent years, pulpwood conversion in Indonesia has rebounded, with a high near-term deforestation risk of thousands of square kilometres of tropical rainforest.
- **Illegality in logging** remains widespread, with laundering via weak documentation and exports to foreign markets observed across the Amazon. PNG is a hotspot in Southeast Asia-Oceania, with large concessions in natural forests and important trade links to China. In the Congo Basin, criminal networks and weak enforcement undermine safeguards, resulting in devastating consequences for the forests.
- The **gold** price is reaching new heights, and demand is surging while traceability remains low. Mining-related deforestation and mercury pollution are rampant in the Amazon and Southeast Asia. Stricter regulation in Brazil suggests that the laundering of illicit gold may become more difficult. Yet, driven by the gold price, a further ~375 km^2 of gold mining area may expand in the Brazilian Amazon by 2028, while the Madre de Dios region in Peru could see ~530 km^2 of gold mining-driven conversion by 2029.

5.1 Why is it relevant?

As has been observed for energy (→ section 3.1), broader global raw material footprints are marked by a high level of inequality.[551] Consumerism in wealthy countries and among wealthy segments of populations is based on the resources and labour of lower-income countries in the so-called 'Global South. This situation is marked by patterns of exploitation and extractive economies, driven by companies' overproduction, the efficient marketing of products on consumer markets to maximise economic gains, and a lack of action by policymakers. These dynamics disregard external costs to the environment, health, and labour rights.[552]

Three important forest-risk commodities linked to globalised consumer markets are highlighted in this chapter, though their roles differ. Wood pulp demand is increasingly driven by packaging material, as a replacement for plastic, as well as packaging used in the booming e-commerce market. Wood pulp also has a growing role as a feedstock in the rapidly growing textile market. Demand for tropical timber is projected to continue increasing, with markets including cheaper flatpack and fast-turnover furniture, as well as more expensive, longer-term applications of higher-value species in higher-end furniture, construction, and shipbuilding. Gold demand tends to be linked to longer-term investments and finance sector gold reserves, but also follows market trends and is strongly influenced by price developments.

5.2 Wood pulp demand for packaging and fashion

5.2.1 Demand trends

The global pulp sector is divided into chemical wood pulp (CWP), used for paper production, and dissolving wood pulp (DWP), which has important and growing applications in the textile industry. Historically, the paper packaging market has seen average annual growth rates of 2.5–3.5%. While global oversupply was a trailing consequence of the COVID-19 pandemic, a return to similar growth rates was observed in 2024.[553] Based on its value of US$13.0 billion (€11 billion) in 2025, the paper pulp market is projected to reach US$17.8 billion (€15.1 billion) by 2033.[554] As mentioned in relation to processed foods (→ section 4.3), their growing market is one driver of demand for paperboard made from pulp due to growing food packaging volumes and the increasing use of paper packaging to replace plastic. The rapidly growing e-commerce sector drives demand for pulp and paper as shipping volumes increase.[555]

Textiles and fast fashion are another driver. Owing to rapidly increasing fashion cycles, the textile industry is linked to deforestation on various levels: it is an important and growing customer for fossil fuels used to produce synthetics (→ section 3.4.2), cotton production has been linked to deforestation, land grabbing, and violence,[556] leather is linked to cattle-driven deforestation in the Amazon, and it is another driver of wood pulp demand. Viscose, rayon, and other cellulose materials, referred to as man-made cellulosic fibres (MMCF), are obtained from dissolving wood pulp (DWP).[u,557] According to estimates, more than 300 million trees are processed to produce fabrics annually, an unknown share of which comes from primary forests.[558] In plantations, fast-growing eucalyptus and acacia are typical pulpwood species in tropical countries.[559] With increasingly short fashion cycles, the so-called 'fast fashion' phenomenon is an important factor in driving demand for textile fibres.[560]

Global fibre demand is forecasted to experience annual growth of ~2-3% through 2030, with ~1-2% attributed to growth in per capita consumption and ~1% linked to population growth. Driven by its properties and alleged superior sustainability credentials compared to cotton or synthetic materials,[561] viscose production is expected to grow stronger, with global demand forecasted to grow at a CAGR of 8.4% from 2025 to 2032, from US$21 billion to US$40 billion (€18 billion to €34 billion). The Asia-Pacific region is the dominant supplier of viscose staple fibre, with a market share of ~80% in 2024.[562]

Regulations to tackle the large volumes of textile waste are not yet widely implemented. An important development is the revision to the EU Waste Framework Directive, which was agreed upon in September 2025. It introduces extended producer responsibility (EPR), which applies to e-commerce operators regardless of their location. Producers will be required to cover the collection, sorting, and recycling of textiles they have put on the market, and manage textile waste in line with the waste hierarchy, including provisions to halt exports of textile waste disguised as clothing for reuse. Upon publication of the directive, EU member states will have 30 months to transpose it into national law. Member states should also address ultra-fast fashion and fast fashion practices when determining their financial contributions to the EPR schemes.[563]

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u DWP is bleached chemical pulp with low hemicellulose content that is processed into viscose fibers.

The waste hierarchy

The waste hierarchy refers to a ranking of waste management options from most to least preferred. It emphasises waste prevention by reducing material use and avoiding unnecessary materials during design and manufacturing.

1-Prevention: Avoid creating waste in the first place.
2-Reuse: Use items again for the same or new purposes by checking, cleaning, or repairing them.
3-Recycling: Process materials into new products with the same or different purposes.
4-Recovery: Extract energy or other resources from waste.
5-Disposal: Landfill or incineration as the least preferred option.[564]

5.2.2 Outlook for the Amazon rainforest

Brazil

Although Brazil is the world's second-largest pulp producer and at the centre of the industry's growth, the link between wood pulp sourcing and deforestation in the Amazon is less direct than in Indonesia. Pulp mills require large volumes of timber and must be located within 200–300 km of plantations to be economically viable. Establishing a pulp mill near active deforestation fronts is usually unviable due to the need for access to roads, power grids, and extensive land for plantations. However, cattle ranches commonly expand along deforestation fronts, with infrastructure following to support transport and trade. As land values rise, pastures may be sold to a pulp company at a premium while the cattle operations shift to frontier areas, perpetuating forest loss.[565] It is likely that the increasing demand for wood pulp will contribute to such displacement mechanisms and, in turn, indirectly drive deforestation in the Brazilian Amazon; however, this is difficult to quantify.

5.2.3 Outlook for the Southeast Asia-Oceania rainforest

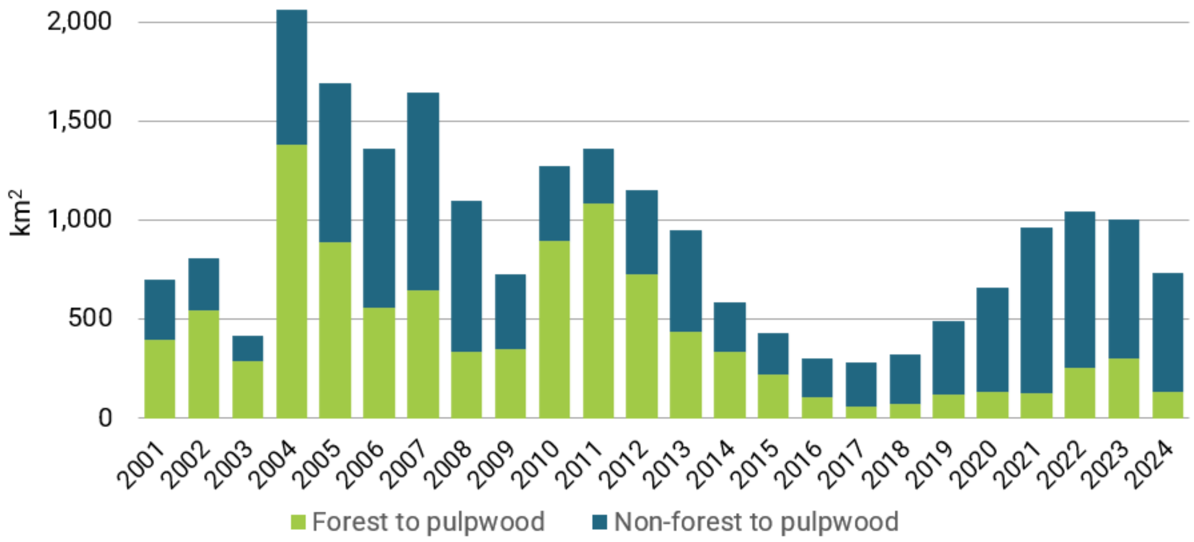
Indonesia

Indonesia's wood pulp production has experienced significant growth over the past years. Output of dissolving wood pulp (DWP) increased more than eightfold in the period from 2018 to 2023, from ~140 Kt to 1.2 Mt. The increase in chemical wood pulp (CWP) was more moderate but involved a substantially higher volume, from ~8 Mt in 2018 to ~10 Mt in 2023. Indonesia contributed ~5.4% of global CWP and ~12% of global DWP production in 2023.[566]

Indonesia's growing pulp mill capacity threatens to accelerate deforestation directly, through forest clearance for wood supply, and indirectly, by incentivising logging in already vulnerable areas impacted by other extractive industries.[567] Even if the share of recycled contents in paper or viscose increases, these two markets will likely contribute to the growing global demand for wood pulp in the coming years, and with this to the expansion of fast-growing monoculture pulpwood plantations in Indonesia, mostly consisting of Acacia sp. or Eucalyptus sp.[568] The industry controls an estimated 100,000 km^2 of land in the country. The expansion of plantations was also facilitated by state support and national and multinational funding,[569] including the Japanese JBIC, China Development Bank, and ICBC.[570] However, due to the growing adoption of DCF policies among companies as a result of public campaigning, pulpwood was an example of an industry that experienced a decreasing deforestation impact for several years, with primary forest loss dropping since 2012.[571]

Yet, forest conversion for pulpwood plantations has increased again since 2018 (Figure 21), with particularly high rates in 2022 and 2023, concentrated in Kalimantan. Pulp and paper producers are building and operating new mills to meet the growing global demand for wood pulp products. Indonesia's total pulp exports (including wood, waste and scrap) doubled between 2012 and 2023.[572] According to 2022 data, just over half of Indonesia's pulp production was exported, while the remainder was processed domestically into paper, tissue, viscose, and other products for domestic and export markets. Almost three-quarters of exports go to China, with smaller shares accounted for by India, South Korea, Bangladesh, Vietnam, and Turkey.[573]

Figure 21 Pulpwood expansion in Indonesia, 2001-2024



Source: Republished from Nusantara Atlas (2025); The TreeMap (2025, April 11), "Industrial wood pulp deforestation in Indonesia slows in 2024", Nusantara Atlas, online: https://nusantara-atlas.org/industrial-wood-pulp-deforestation-in-indonesia-slows-in-2024/.

Data published by Nusantara Atlas based on satellite imagery showed that in 2023 alone, more than 300 km^2 of forest were converted to pulpwood plantations. In 2024, the conversion of primary forests to pulpwood plantations slowed compared to 2023 but still reached almost 140 km^2.[574] Part of the deforested area in recent years, which was linked to just a handful of companies, overlapped with prime orangutan habitat.[575]

Indonesia's pulpwood sector is poised for substantial growth as global demand for wood pulp and its derivatives is expected to continue rising. Major increases in mill capacity are planned in Sumatra, while a new large-scale pulp mill is already under construction on the island of Tarakan in North Kalimantan. Expected to become operational in stages by 2028, this facility will require at least 3.9 million m^3 of wood annually, equivalent to ~100,000 truckloads. The surge in capacity will likely intensify pressure on primary forests, particularly those located within pulpwood concessions.[576] According to Trase analysis, as of 2022, more than 28,000 km^2 of natural forest remained within concessions across Indonesia, with 14,000 km^2 in Kalimantan, 7,400 km^2 in Tanah Papua, and 6,800 km^2 in Sumatra. Much of it lies within licensed concessions that are not yet supplying wood to mills. These areas have experienced high rates of deforestation during recent years, illustrating the fast pace of conversion from natural forests to pulpwood plantations.[577]

Impact scenario

The new Tarakan mill is expected to become a significant contributor to forest loss due to its high capacity. A 2023 report by an NGO coalition identified more than 6,000 km^2 of tropical rainforest across seven timber and plantation concessions at risk of being cleared to supply this mill.[578] There are concerns that the mill may also source wood from Sulawesi and Maluku, islands already facing environmental degradation due to the expansion of nickel mining operations. As deforestation continues for mining infrastructure, the resulting timber could be diverted to meet the pulp industry's growing demand, further linking industrial expansion with forest degradation.[579]

5.3 Logging

5.3.1 Demand trends

Global industrial roundwood, excluding energy uses but including pulpwood and considering plantation and logged wood, reached 1.9 billion m^3 in 2023. Important market segments included sawnwood with 445 million m^3 and wood-based panels (including particleboard and fibreboard) with 84 million m^3. Engineered wood products reached over 12 million m^3.[580] Overall, timber demand for construction, furniture, packaging, and other purposes is expected to increase significantly in the coming years.[581] Projections to 2030 indicate continued growth in global roundwood demand under different climate scenarios, from 1.9 billion m^3 in 2023 to ~2.25 billion m^3 in 2030.[582] These projections focus on existing markets and do not incorporate future demand for new products or products in early development stages, including those resulting from the transition to a bio-based economy and an increasing market share of bio-based construction, as well as the demand for engineered wood.[583]

The ready-to-assemble (RTA) furniture market is a key downstream market showing ongoing growth. RTA furniture, also known as flatpack furniture, includes items such as desks, tables, wardrobes, and beds. Wood remains the primary material used (~47% in 2023). This market is expected to see a CAGR of 5.4% between 2024 and 2033, from US$15.1 billion (€14.9 billion) to US$25.5 billion (€24.5 billion).[584] Overall, a strong trend towards 'fast furniture' is observed, which combines fast production, low costs, and short product life cycles with higher unit sales and faster replacement, resulting in increased resource demand.[585] Using the French market as an example, the number of furniture items placed on the market between 2017 and 2022 increased by 88%, from 269 million to 505 million items,[586] illustrating the rise in bulk-produced low-cost furniture and home decorations that has become one important driver of global timber demand and an increasingly important contribution to waste volumes.

China has emerged as a major player in the tropical timber sector over recent decades. Among others, its share in global tropical plywood production increased from 0.5% in 1990 to 57% of global production by 2021. This unusual expansion was driven by a rapid growth in domestic plywood demand in China's downstream industries, including building construction, furniture, and shipbuilding. Beyond the domestic market, the country has become an important supplier to international markets, partly due to its strongly competitive wooden furniture supply to price-sensitive, emerging markets with growing consumer demand.[587] In 2024, for example, there were reports of cheap Chinese furniture flooding the Indonesian market.[588]

Higher-value species are utilised for products such as flooring, outdoor decking, yacht and recreational vehicle interiors, and other applications.[589]

Demand for tropical timber is driven by a market for high-value and rare species, often linked to illicit activities.[590] If strong governance cannot be guaranteed, direct and indirect pressure on tropical rainforests and biodiversity hotspots may increase due to logging and the expansion of timber plantations to meet rising demand, as well as competition for land resources.[591] Timber extraction typically does not result in complete forest loss, but it is an important driver of degradation and fragmentation.[592] Illegality is a widespread phenomenon in the logging sector that affects 15-30% of timber traded worldwide, also and importantly in tropical rainforests, with heavy impacts on the environment and local communities (→ section 6.5).[593]

5.3.2 Outlook for the Amazon rainforest

Brazil

Logging is an important contributor to forest degradation and eventual loss in the Amazon. In its Brazilian part, areas affected by logging each year are much larger than those that are deforested. Annual logging rates have seen little reduction over the years, while timber illegality remains a serious concern in Brazilian Amazon timber (→ section 6.5).

In the Brazilian Amazon, a growing percentage of illegal wood has been observed in recent years, leading to increased degradation and openings in the forest. In the 2022-23 period, 35% of the tropical wood felled in the Amazon was sourced illegally. Approximately 8% of Brazil's Amazonian timber is exported, with the majority of the market (48%) in Europe and a significant portion (20%) in the US.[594] These findings highlight the ongoing nature of these illicit activities, which potentially open vast tracts of as-yet-unexplored forest areas.

Timber merchants have several ways of circumventing the authorisations and controls required by federal or state authorities, at the centre of which stands the 'Forest Origin Document' (Documento de Origem Florestal (DOF)).[595] It is difficult to quantify the areas affected by such practices, as logging is more likely to lead to degradation rather than clear-cutting. Investigations by the Environmental Investigation Agency published in April 2025 documented substantial timber exports from illegal operations between 2021 and 2024, some of which were linked to embargoed sites or the scene of illegal logging for gold mining.[596]

Colombia

The trade value of Colombian timber (in the rough, sawn, particle board etc.) shows volatility but no significant increase during the last five years.[597] Around 80% of the extracted timber originates from natural forests, with the Amazon being the main source. Meanwhile, large areas suitable for commercial plantations would be available.[598]

Illegality is widespread in the Colombian timber sector. An investigation by the Environmental Investigation Agency tracking timber exports concluded that ~94% of wood flooring and decking exports from Colombia between 2020 and 2023 lacked the mandatory certification, and importers in the US, the EU, and Canada failed to conduct due diligence. It documented cases of abusive working arrangements akin to modern slavery, where local Afro-Colombian and Indigenous communities in northwestern Colombia were exploited by timber companies and armed groups to log their own forests.[599]

Peru

Illegal logging is also a widespread and systematic phenomenon in Peru,[600] where fraud and corruption are drivers of illegal timber laundering.[601] According to estimates, 70-90% of all timber harvested in Peru is illegal. Peru became the main source of mahogany when Brazil banned its exports in 2001. Upon tighter protections on mahogany trade, the timber industry shifted to species like cumaru, Spanish cedar, and cumala. Downstream markets include construction, flooring, and high-end furniture.[602] Recent efforts by Peru's forestry commission to combat illegal logging have included satellite monitoring, which reportedly identified up to 37% of all reported illegal logging across 18,000 km^2 of the country's rainforests and facilitated the seizure of more than 41,000 m^3 of illegal wood in 2023/24.[603] Main export destinations for Peruvian timber in 2024 were the EU, China, the Dominican Republic, Mexico, and the US. Export values in recent years have been volatile, with a strong rebound post-COVID but contracting again in 2023/24.[604]

5.3.3 Outlook for the Congo Basin rainforest

Legal and illegal logging have long been and continue to be difficult to tackle as drivers of forest loss in the Congo Basin. Plagued by insufficient policies and enforcement challenges, up to 90% of logging has been found to be illegal for years.[605]

Multiple conflicts in the northeast part of the DRC allow the trafficking of protected hardwoods. During the past twenty years, hundreds of millions of dollars' worth of protected hardwoods have been looted from the DRC and smuggled into surrounding countries.[606] A 2018 Global Witness report asserted that a European timber business, with the largest holding of concessions in the DRC, spanning 40,000 km^2, was operating illegally on 90% of those concessions.[607]

In Cameroon, an international network of criminal groups, potentially benefiting terrorist groups like Boko Haram, was found to facilitate the illegal movement of timber from remote forests to illicit markets in Nigeria, Vietnam and China.[608]

In the DRC, a 2022 government report confirmed that many logging areas known as concessions had in fact been assigned in breach of the country's own laws. However, an attempt by the government to halt logging concessions linked to illegality was reversed again briefly afterwards due to legal appeals,[609] and a government communication from January 2024 even considered lifting the 2022 moratorium and issuing new industrial forest concessions.[610] Meanwhile, a multi-year investigation published in 2024 of two Chinese logging companies with control over 3 million hectares of forest concession in the DRC found that the companies systematically disregarded the country's forest laws in what was found to be "*part of a larger business model*".[611] These two forest concession contracts were cancelled in early 2024, following inspection missions that revealed multiple cases of illegality and human rights violations. However, the companies continue to operate on the ground.[612]

These are examples of persistent illegal and unregulated logging activities that erode the livelihoods of millions of forest-dependent households across the region. Weak forest governance, characterised by corruption, complicit officials, and a lack of enforcement, empowers organised crime syndicates and militant groups operating at the nexus of timber, mining, and wildlife trade.[613] It is currently unlikely that these patterns will be effectively broken in the near future. In fact, due to a lack of efficient forest management and monitoring plans, they may be further facilitated and exacerbated by the opening of remote forest areas through infrastructure projects (→ section 6.6.2). Currently, the Congo River is a vital transportation route for logs, used by both industrial loggers and local communities seeking to sell their logs.[614]

Cameroon (2011), Central African Republic (2012), and the Republic of the Congo (2013) have obtained Voluntary Partnership Agreements (VPA) under the EU FLEGT regulation, while the DRC is still under negotiation.[615] However, none of them have successfully issued FLEGT licences yet,[616] and most traceability systems remain non-functional or stalled. Despite strong legal frameworks, weak regulatory governance continues to undermine implementation, as evidenced by limited institutional capacity and a lack of political will to effectively regulate illegal logging. At the same time, concerns exist that VPAs may not address power imbalances but consolidate power among large, internationally financed logging firms while excluding small-scale domestic operators, raising concerns over equity and the viability of linking forest governance with poverty reduction and inclusive economic development.[617]

Export-driven pressure on high-value species incentivises logging. Europe was once a key trading partner. However, driven by stricter EU regulations, the export value of unprocessed tropical wood in the rough from Congo Basin countries decreased from US$388 million (€328 million) to US$42 million (€35 million) annually between 2012 and 2023. The decline in European imports is also due to Central African countries' struggle to process timber beyond the primary or secondary stages because of limited infrastructure, high costs, and skills gaps.[618] Simultaneously, exports to China and other Asian markets with weaker or non-existent sustainability requirements have soared.[619] According to the United Nations Office on Drugs and Crime, Africa's share of rosewood exports to China rose from 40% in 2008 to 90% in 2018, with a considerable share of that suspected to be illegal. Asian importers are less stringent in their processing requirements, making these markets more accessible compared to those in Europe. At the same time, soaring demand from Asian markets in an environment with weak oversight and enforcement threatens to speed up the replacement of selective logging confined to concessions with unregulated and larger-scale timber harvesting.[620] China supplies the world market with timber products, requiring large volumes of raw materials as inputs. The products are mostly developed from imported timber, often from countries with weak forest governance. While the industry supplies a large domestic market, it is also an important supplier internationally, with export destinations of wood furniture including the US, the EU, Japan and Australia, among many others.[621]

As timber demand is forecast to continue growing strongly in the coming years, while key consumer markets have few sustainability and traceability requirements in place, and a comprehensive crackdown on illegal logging seems unrealistic in the short term, the mix of market opportunity and impunity will likely continue to drive forest loss through illegal logging for the coming years.

5.3.4 Outlook for the Southeast Asia-Oceanic rainforest

Indonesia

Indonesia sources timber from plantation forests, including teak on Java, as well as acacia and eucalyptus for pulp wood on Sumatra. Additionally, it obtains timber from selective logging in natural production forests on Sumatra, Kalimantan, and Papua.[622] The country is a leading global supplier to regulated markets, primarily due to its mandatory timber legality system[623] and its status as the first country to have a Forest Law Enforcement, Governance and Trade (FLEGT) licensing agreement with the EU.[624] In recent years, Japan, the US, China, South Korea, and the EU have been the main export destinations, collectively accounting for more than two-thirds of the total export value in 2024.[625] However, when the EU Deforestation Regulation (EUDR) enters into force (→ section 6.3.4), FLEGT will evidence legality but no longer guarantee deforestation-free status. Consequently, EU buyers will need to implement geolocation-based due diligence to ensure compliance.[626]

Recent monitoring highlights rising pulpwood-plantation expansion and the fact that much of the 2024 forest loss occurred within legal concessions (→ section 2.3).[627] Research by Earthsight and Auriga Nusantara recently traced meranti, a principal species for tropical plywood production, from large clearings for timber plantations on a 280 km^2 concession in East Kalimantan. The US recreational vehicle industry is one of the important consumers of this product.[628] These findings underscore the need to pair legality with robust no-conversion safeguards across both plantations and natural-forest management.

The Ministry of Trade and the Coordinating Ministry for Economic Affairs plan to deregulate hundreds of trade codes in the Indonesian forestry sector. These plans would make legality documents optional for markets outside the EU and the UK, and revoke the mandatory due diligence declarations. The proposal is framed as a response to US tariffs and an effort to increase export competitiveness. However, in a joint statement in May 2025, CSOs warned of increasing compliance costs, a loss of export opportunities and market trust, and a growing risk of illegal logging.[629]

Forest crime has been significantly reduced since a peak in the early 2000s,[630] but illegal logging, particularly of highly valuable and often rare species, remains a widespread issue.[631] Only a small share of illegal logging cases are effectively prosecuted.[632]

Papua New Guinea

Commercial logging is a significant contributor to the economy of PNG. Logging and agricultural land clearance primarily occur in intact natural forests, rather than plantations. As of 2023, logging concessions covered almost 110,000 km^2, or ~25% of the country's land area.[633]

Unlawful logging continues to be rampant; it has been documented for years that most timber production in PNG is likely illegal in some way.[634] Most often associated are corruption, money laundering, and financial crimes (tax evasion). Widespread governance failures and corruption in the forestry sector have been documented by official inquiries and independent studies. Legality controls are weak: the log export monitoring system does not verify timber legality, and a national Timber Legality Standard, which has been under development since 2010, remains incomplete and lacks critical safeguards.[635]

Illegality in the PNG forestry sector entails breaching the Forestry Act 1991 when harvesting, processing, and exporting timber. Other relevant laws include The Forestry (Amendment) Act 2000, The Forestry (Amendment) Act 2007, The Environment Act 2000 and the Conservation and Environment Protection Act 2014 (→ section 6.3.3). Although most logging operations are authorised by the PNG Forest Authority (PNGFA), CSOs have observed an almost universal failure by the PNGFA to issue timber harvesting licences that comply with the legal requirements.[636] Lack of law enforcement is a significant enabler of illegal activity in the sector.[637] Permits are frequently issued illegally, bypassing required procedures and violating customary land rights.[638] The latter is of high importance in PNG, where ~97% of the land area is under customary tenure. The government leases land from customary rights holders and transfers these to private companies for mining or logging concessions.[639]

Since the 2000s, Special Agricultural Business Leases (SABL) involving clearance permits have been misused by foreign firms as a legal pretext for timber extraction.[640] Companies promised palm oil, rubber, or other land uses under agricultural land clearing permits, but only razed the forests for roundwood, while agricultural developments never materialised.[641] The procedural steps foreseen in the Forest Act are often not followed, and monitoring of harvesting operations to ensure compliance with the terms and conditions of licenses is lacking. Nonetheless, the PNGAF uses the fact that harvesting is occurring in licensed projects as an argument to claim that the requirements of the EU and the International Tropical Timber Organisation (ITTO), as well as the EU definitions of legal timber, are met, both of which require legality according to local laws.[642]

The PNG forestry sector is highly export-oriented. While the country has announced a ban on exports of raw logs for 2025, with the goal of shifting to domestic value-added production, this has not yet been implemented.[643] PNG has been a leading supplier of tropical roundlogs[v] to world markets in recent years. Exports of logs had a value of US$508 million (€430 million) in 2023. Most of the timber exports go to Asian markets, with China receiving more than 90% by volume and value (Figure 22). Timber products, typically including furniture, plywood, as well as roofs, walls, and floors, then enter global markets from China.[644] Smaller volumes are shipped to other Asian markets like India, South Korea, and Japan.[645] The EU and US do not import directly, but are likely exposed to PNG timber indirectly through imports of Chinese-manufactured products, considering PNG's important role as a supplier of tropical timber to the Chinese manufacturing industry.[646]

Figure 22 Roundlog export destinations from Papua New Guinea, 2023

Source: Own elaboration, based on: UN Comtrade (2025), online: https://comtradeplus.un.org/.

Given that timber product demand is expected to grow in the coming years, it is likely that this trend will continue or even intensify. The outcome largely depends on improvements in local law enforcement and the effective implementation of due diligence measures in export markets. While logging is more likely to cause fragmentation than complete forest loss, a continuation of this trend could cause considerable damage to PNG's standing tropical rainforests.

5.4 Gold

5.4.1 Demand trends

In 2024, around half of global gold demand was driven by jewellery (43%) and technology (7%), mostly electronics, while the remaining 50% was accounted for by investment and central bank

v Domestic processing capacity is limited.

demand.[647] Digital technology is an important demand driver. Although only used in small volumes, gold is a vital component in microprocessors and communication devices, among others.[648]

In this total, recycled gold contributed around one-fourth of the volume,[649] a share that has remained stable for many years. Meanwhile, overall gold supply from both recycled and newly mined gold increased by ~10% during the last decade.[650] It is also important to note that there is significant concern around the mixing of smuggled gold from high-risk areas with recycled sources, where the absence of traceability allows these flows to enter international supply chains.[651] Gold prices reached record highs in the first half of 2025 and are expected to remain high, driven by an increasingly volatile global economy and the high demand for 'safe investment havens'.[652]

Consumer demand for jewellery and a fast-growing electronics sector drive price signals and investments that ultimately risk incentivising the opening of new frontiers in tropical rainforests. Gold and coal have been the main drivers of mining-related deforestation in the past, accounting for more than 70% of deforestation from 2001 to 2019.[653] The gold mining boom started shortly after the 2008 global financial crisis and continues to date, amid high gold prices.[654] In the first quarter of 2025 alone, global demand increased by 3% year-on-year. Demand for gold bars increased by 21%, while global gold jewellery consumption decreased 14% to its lowest level since the COVID-19 pandemic.[655] The drop in jewellery demand was largely attributed to weakened demand from India and China due to high gold prices; however, the sector remains important, and if prices stabilise and inflation declines, jewellery demand is expected to rise again.[656]

5.4.2 Outlook for the Amazon rainforest

Open-pit gold mining is estimated to cover 1.9 million hectares (0.23% of the Amazon biome).[657] It is connected to direct deforestation for mining, as well as much larger indirect impacts in the surrounding areas, ranging from agricultural clearing to the establishment of settlements, illegal mining roads, and airstrips.[658] Next to official mining activities in the Amazon, informal or illegal gold mining is a localised but highly impactful business, particularly prevalent in parts of the Brazilian Amazon as well as the Madre de Dios department in the Amazon of southeastern Peru. It causes widespread mercury pollution due to poor mining practices and has destroyed thousands of hectares of forests.[659] Mercury is severely polluting water and fish in areas of illegal mining, putting the health of local communities at risk as it builds up in the body.[660] Illegal gold mining in the Amazon is often linked to well-organised criminal networks, using environmentally harmful extraction methods and invading Indigenous lands and conservation zones.[661]

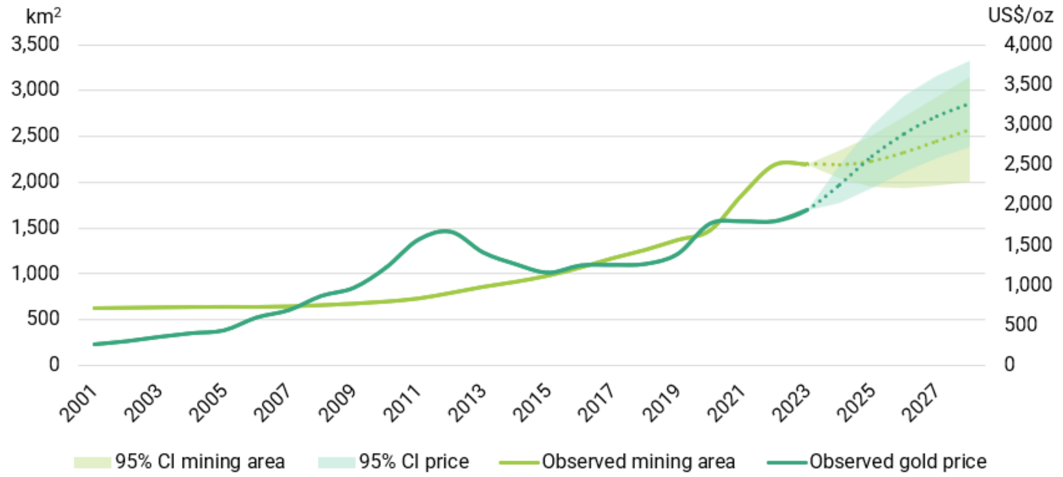
Brazil

Many actors stand to benefit from illegal gold mining activities in the Brazilian Amazon, a highly profitable business facilitated by corrupt civil servants, logistics providers, police officers and military personnel. Research has shown that a significant portion of Brazil's gold exports lack appropriate documentation, origin records, or extraction permits.[662] Government measures, which introduced mandatory electronic invoices for gold transactions in 2023, have led to a 45% drop in recorded wildcat gold production, equivalent to 17 tons in 2023 compared to 2022. A further decline was observed in the first half of 2024, suggesting that the 'laundering' of wildcat gold to enter legal streams has been impeded.[663] However, the record-high gold prices are likely to encourage illicit gold mining activities despite the government's efforts, including in remote forest areas and Indigenous territories. A Greenpeace report documented 42 km^2 of rainforest destruction for illegal gold mining in 2022 and 2023 across four Indigenous territories in the Amazon. Discrepancies in gold trade figures, where Brazil's recorded exports are significantly lower than imported volumes recorded in destination countries, confirm a lack of oversight and transparency in gold flows.[664]

Impact scenario

To analyse how the projected gold price development may impact the gold mining area in the Amazon, we have mapped the evolution of the gold price (left axis) and the area associated with gold mining in the Brazilian Amazon between 2001 and 2023 (Figure 23). Using a vector error correction (VEC) model to analyse the expected joint evolution of these two variables, we find that both will continue their cointegrated development by growing at a similar rate as they did in the past twenty years. This could lead to an additional expansion of gold mining on ~375 km^2 in the Brazilian Amazon by 2028.[w] The volatility of the analysed data explains the relatively broad confidence interval.

Figure 23 Forecast: Gold price and gold mining area Brazilian Amazon, 2024 to 2028



Note: CI=Confidence Interval.

Source: Own calculations, based on: MapBiomas (2025), "Mining statistics - MapBiomas Brasil Collection 9", online: https://doi.org/10.58053/MapBiomas/VC507; World Bank (2025), "Commodity markets – Gold"; JP Morgan (2025, June 10), "Will gold prices break $4,000/oz in 2026?".

Peru

Peru's total gold mining-related deforestation footprint from 2018 to 2024 accumulated to ~1,400 km^2, with a hotspot in the Madre de Dios region in the Peruvian Amazon.[665] Alluvial gold mining is spreading in Peru, driving widespread mercury contamination of water and the food chain, which affects various rivers, particularly in Loreto and Amazonas.[666] Peru's Operation Mercury (2019–2020) temporarily halted illegal gold mining in La Pampa, near a major national park, forcing miners into legal concessions. While some forest regeneration followed, deforestation has since worsened in these legal mining zones. Outside the La Pampa region, the illegal mining business continued as usual.[667]

Peru has made efforts to formalise artisanal mining for years. Delays and postponements in the process have opened the door to illegal mining. The Comprehensive Registry of Mining Formalisation (Reinfo), a controversial scheme that provides informal miners with temporary permits, has been extended multiple times since its creation in 2016, once more in December 2024.[668] Continuous delays to full formalisation under the Reinfo registration process allow illegal miners to avoid inspection and sanctions, and consequently facilitate impunity for illegal miners for years.[669]

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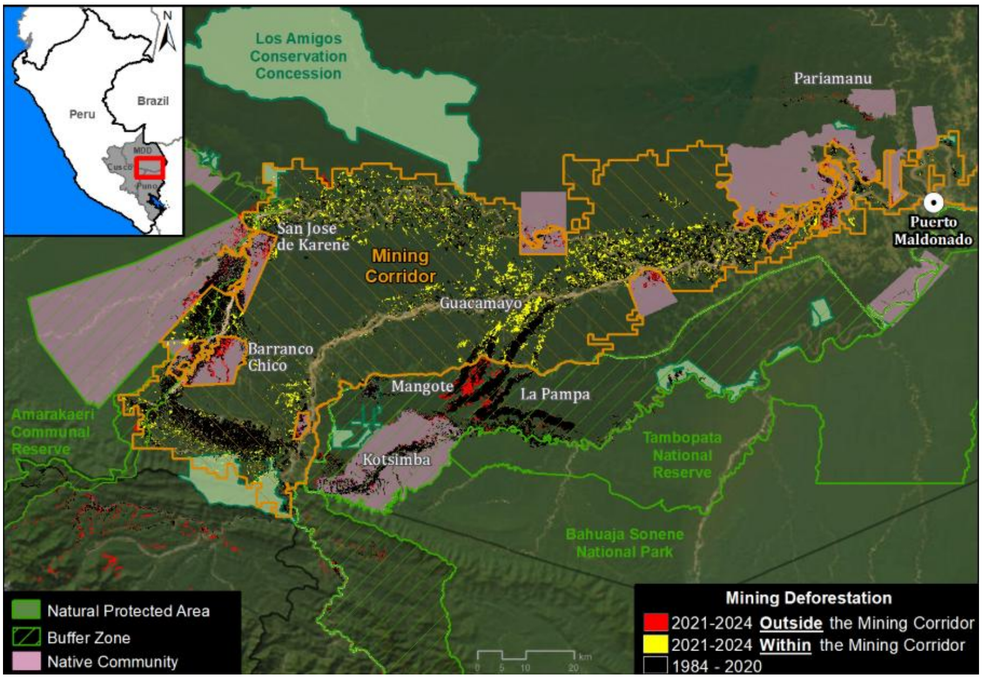
[w] The forecasts in Figure 23 and Figure 25 were generated using ARIMA, a model that predicts future values based solely on past patterns of the variable itself. The accuracy depends on the data's consistency: if the variable shows a clear trend or seasonal rhythm, the forecast will be precise with a narrow confidence interval. Conversely, if the data is erratic without a clear pattern, the forecast will be broader to reflect this uncertainty.

Figure 24 Deforestation inside and outside the Madre de Dios mining corridor, 2021-2024

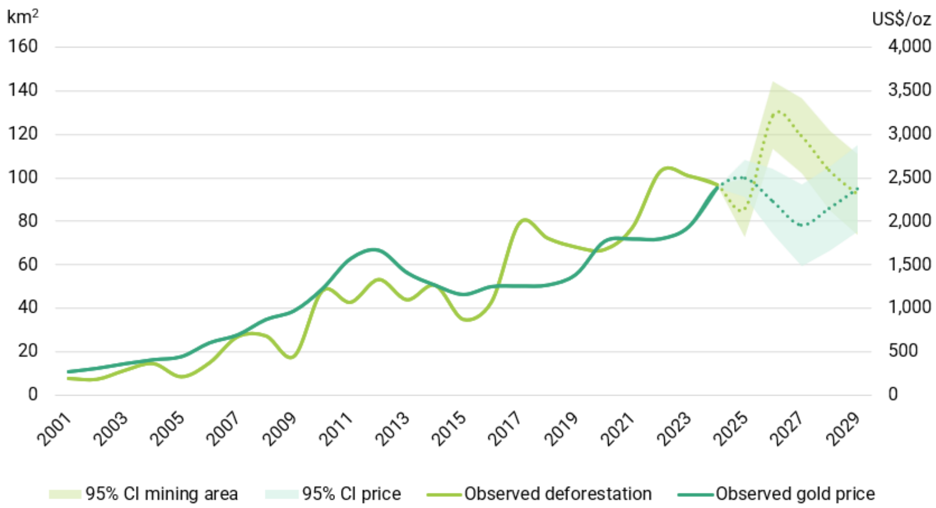


Source: Amazon Conservation's MAAP (Monitoring of the Andes Amazon Program) Initiative (2024, May 8), "Gold mining in the Southern Peruvian Amazon, summary 2021-2024", online: https://www.maaprogram.org/maap-208-gold-mining-in-the-southern-peruvian-amazon-summary-2021-2024/.

Impact scenario

The deforestation levels associated with gold mining in the Madre de Dios region in Peru have been increasing significantly since 2001, showing a high level of volatility (Figure 25). Volatility may indicate the presence of other factors influencing gold mining in a cyclical manner. We applied a VEC model to cointegrate gold mining-driven deforestation and gold prices, in order to forecast the evolution of deforested areas in Madre de Dios. It suggests an additional deforestation footprint of ~530 km^2 for gold mining in the region until 2029. The erratic data pattern in past years is reflected in the forecast and confidence intervals.

Figure 25 Forecast: Gold price and mining deforestation in Madre de Dios, 2024 to 2029



Note: CI=Confidence Interval.

Source: Own calculations, based on: Global Forest Watch (2025), "Peru", online: https://www.globalforestwatch.org/dashboards/country/PER/; World Bank (2025), "Commodity markets – Gold"; JP Morgan (2025, June 10), "Will gold prices break $4,000/oz in 2026?".

Although illegal gold mining in remote parts of the Amazon is a complex issue to solve, the fact that illicit gold eventually enters official supply chains creates opportunities for interventions. Strengthening controls and traceability, through tools like blockchain or physical marking, could be important levers to counter illegal gold mining in the Amazon. In addition to improving coordination among local authorities, consumer markets should demand strict environmental and social safeguards for gold sourcing and mining.[670]

5.4.3 Outlook for the Southeast Asia-Oceania rainforest

Most gold mined in Indonesia comes from licensed and industrial operations. Yet, ASM is also widespread and has seen a surge in the last two decades, providing significant income for an estimated 300,000 to 500,000 people.[671] Indonesian ASM gold mining has a comparatively small deforestation footprint as miners use rudimentary technologies rather than large machinery, but it is also encroaching into protected areas. The gold mining activities are also concerning due to the contamination of soil, water, and food chains, as well as adverse health impacts from the widespread use of mercury, despite efforts to reduce and eliminate its use.[672] Given the economic importance of the sector and government efforts to formalise it,[673] it is likely that rising demand and prices will sustain or increase incentives for gold mining in Indonesia in the coming years.

5.5 Possible scenarios

Demand pressures from the sectors and markets described in this chapter are likely to impact tropical forests, together with pressures from energy systems (→ chapter 3) and food systems (→ chapter 4). Rising consumerism (fast-turnover products, e-commerce) and robust gold demand illustrate how value chains add pressure on tropical forests, through rising demand for wood pulp (paper/packaging; dissolving pulp for textiles), timber products (plywood, furniture, millwork), and gold (jewellery, investments, electronics). These drivers affect forests directly (through plantations, logging and mining) and indirectly (through roads, mills and settlements), and have different risk profiles in the three rainforest basins.

What will determine outcomes?

The extent to which the discussed forest-risk commodities will result in further deforestation in the coming decade depends on a complex set of factors. Important ones include:

- **Global demand trajectory:** The shaping of forest outcomes in the wood pulp sector depends importantly on whether e-commerce and fast-turnover industries remain largely unregulated, as well as on the progress made in implementing effective safeguards against deforestation and robust socio-environmental governance across sectors. Logging pressure for timber demand is driven by both rapid product cycles, such as flatpack furniture, and the demand for longer-term use, like in the construction industry. Gold prices are influenced by a complex interplay of macroeconomic indicators, supply and demand dynamics, and geopolitical factors. High prices are a significant incentive for mining expansion, which heightens risks for tropical rainforests, particularly due to illicit gold mining.
- **Production side governance**: The legal expansion of wood pulp plantations at the cost of natural forests remains a high risk in Southeast Asia-Oceania. Efforts to counter illegality and, in the case of timber and gold, organised crime, through effective concession control and national and international law enforcement and cooperation, are essential. The formalisation and traceability of ASM gold, as well as effective support in building alternative livelihoods, are all factors shaping frontiers. Safeguarding IP and LC territories and conservation areas from logging and gold mining activities significantly reduces risks.
- **Demand-side measures:** Implementing strong DCF supply chain standards is crucial in promoting deforestation-free production. Addressing overproduction and waste in the fashion and furniture industries, along with strict standards for durability and repair, can reduce pressure on forests. Regulating e-commerce would also contribute to reducing packaging volumes. Requiring transparency on volumes and supply chain links provides policymakers and

consumers with essential information to make informed decisions. Robust human rights and environmental due diligence, gold traceability, monitored recycling, and market oversight of Chinese processing hubs serve as effective tools on the demand side. Central banks can play a key role in the gold sector by introducing strict environmental and social due diligence, given their growing gold reserves.

Scenario pathways

Taking these different factors into account, we have defined three potential scenarios for how risks of tropical deforestation related to these key trends for fast-turnover products and emerging forest-risk markets may unfold over the coming decade:

- **Pressured expansion:** This scenario assumes strong growth in packaging demand from processed food and e-commerce. Fast fashion cycles, which contribute to wood pulp demand, continue to accelerate despite overproduction. Timber demand for fast-turnover wood products as well as longer-term applications increases due to growing demand from emerging markets and no slowdown in mature markets. Continually high gold prices drive investment demand, while robust due diligence remains the exception. In producer countries, a lack of progress on socio-environmental legislation and land-use governance, or permissive policies and enforcement gaps, enable further forest conversion. Illegality remains a serious concern for forests and the livelihoods of IPs and LCs exposed to timber and gold supply chains. Demand-side reforms to enhance due diligence in forest-risk commodity supply chains remain limited, including further delays and weakening in the implementation of EUDR and other due diligence legislation.

  Likely rainforest outcomes:

  - Wood pulp: Indonesia experiences an accelerated expansion of pulpwood plantations and new mill capacity, with Kalimantan as a conversion hotspot and remaining natural forest inside concessions at risk. Spillovers from other extractive industries (particularly nickel mining and processing) intensify clearing.
  - Timber products: Higher throughput of low-cost furniture and other timber sectors drives degradation and illegal logging in the Amazon, PNG and the Congo Basin. Chinese processing channels remain the main transmission routes for PNG and Congo Basin wood into Asian, EU, US, and other markets via finished goods.
  - Gold: The price-driven expansion of mining footprints and indirect mining halos remains most severe in the Brazilian and Peruvian Amazon but also plays a role in Indonesia, with continued mercury pollution and exposure to organised crime as additional threats to IPs and LCs.

- **Managed transition**: This scenario assumes solid demand from consumer markets but tighter supply-side safeguards, with enforcement of no-go zones and concession auditing. Mandatory FPIC and strengthened land tenure systems are being increasingly implemented in producer countries, which increases accountability for land grabbing cases, recognises customary rights, and contributes to forest protection. Illegal gold mining and logging are targeted with improved policy frameworks and enforcement; however, the success will likely be uneven, considering the difficulties in tackling illegality. Support to establish alternative livelihoods and sociobioeconomy is extended to people engaged in the ASM of gold. On the demand side, strengthened DCF policies linked to wood pulp and timber, as well as EUDR and EU due diligence legislation, are implemented without further weakening or delays. China, as a key downstream market, is improving its requirements for no deforestation and legality. The end-of-life responsibility for producers is extended, and higher recycled content requirements are in place, impacting wood pulp, timber, and gold. Gold traceability measures are introduced as a means to verify the origin of gold, identify recycled flows, and prevent laundering of illegal gold.

Likely rainforest outcomes:

- Primary rainforest conversion for pulpwood in Southeast Asia-Oceania slows somewhat as some plantation expansion projects are cancelled.
- Illegal logging leakage and gold mining are reduced where law enforcement is tightened, IP & LC rights are strengthened, and buyer rules apply; however, impacts are uneven across rainforest basins and supply chains. Conversion pressure from timber and gold also sees decreasing intensity as downstream markets more seriously tackle illegal output and support the growth of recycled sources.
- Leakage of deforestation-linked commodities to markets with weaker legislation is reduced but not eliminated.

- **Resource-light shift**: This scenario builds further on the managed transition, assuming the strict implementation of no-deforestation and legality policies in producer countries. International cooperation to address organised crime in relation to timber and gold is intensified and follows UN Office on Drugs and Crime (UNODC) guidance.[674] Mandatory FPIC is enshrined in the laws of producer countries across the rainforest basins. In key consumer markets, comprehensive sufficiency and durability norms combined with true-price levies on fast-moving consumer goods are implemented to reduce resource consumption in high-consumption markets and populations. This includes strict rules for the recyclability, recycling rates, and circularity of textiles, paper and cardboard, wood products, and gold. Man-made cellulosic fibre (MMCF) and timber sourcing are confined to verified DCF supply, and producers must disclose production volumes and material origins. Regulations to limit the placing on the market of cheap, high-turnover products are increasingly implemented, including slower and more durable fashion cycles with higher recycled fibre content, a take-back obligation for producers, and a wider uptake of taxes on fast-turnover products; however, progress will likely remain uneven across geographies. Gold products are accompanied by comprehensive traceability and origin information. Gold investments are bound to strict, mandatory sourcing and transparency regulations.

  Likely rainforest outcomes:

  - The conversion of tropical rainforests to new wood pulp plantations sees a significant decrease. The markets for illegal timber are shrinking, reducing forest fragmentation. The gold frontier expansion moderates, and pollution and land conflicts linked to ASM and illicit mining are decreasing. Forest restoration in previously mined areas is growing.

Conclusions

The increasing spread of fast-paced consumption and low-quality products will likely continue for the coming years, as companies target new markets and policymakers struggle to address and regulate international e-commerce markets and powerful commercial actors that disregard socioenvironmental standards. Current forecasts for wood pulp and timber consumption trends, combined with the lack of broad and targeted policy action to address consumerism and the growing international e-commerce, suggest a continuation of the current overproduction of unnecessary and short-lived products. Some progress is being made in reducing the impact of gold mining in the Amazon, but it remains slow. As gold prices surge and law enforcement and international cooperation remain limited, the risk of illegal gold entering supply chains through other channels remains high.

A determined shift towards a ‘resource-light’ model will be necessary to avoid further socioenvironmental impacts and exacerbating the dynamic where high-income countries and their demand trajectories shift the burden of pollution, human rights infringements, labour rights breaches and overproduction onto tropical rainforest regions and populations. Moving towards a ‘resource-light’ future depends on ambitious policies in demand markets, strong production-side governance and policies, international collaboration, industry buy-in, as well as consumer willingness to change behaviour.

However, compared to energy and food systems, the opportunities to transition to a 'resource-light' scenario may be somewhat better for addressing these consumption pressures. This is true for gold, where economic incentives on the demand side promote increased recycling, as efficiency improvements make so-called 'urban mining' increasingly cost-effective and more environmentally friendly than extracting new gold.[675] In the case of fast-turnover products, such a development is less evident. Some positive developments can be observed in the EU, such as the mandatory Extended Producer Responsibility (EPR) entering into force in October 2025, the proposal of a handling fee for low-value e-commerce imports to the EU, or the French tax on fast-fashion garments, which was introduced in June 2025.[676] However, governments are generally slow to act despite the clear waste of resources, rising landfill volumes, and environmental consequences.

6

Key underlying factors and cross-cutting issues

Direct drivers of deforestation are not working in isolation, but are closely connected to several indirect, underlying factors. Indirect drivers can cause an, at times significant, increase in the deforestation footprint of economic activities, but can also have a dampening impact, for example, when they improve supply chain transparency and traceability. The following sections look at indirect drivers that are highly relevant to the commodity sectors discussed above.

6.1 Socioeconomic factors and food security concerns

Local and global market dynamics and evolving consumption patterns are powerful forces shaping land use in tropical rainforest regions. Global, regional, and domestic demand for forest commodities, as well as the resulting international trade, have proven to be important accelerators of deforestation. It is, therefore, important to understand how different dimensions of societal systems—consumption-demand, production-supply, and trade-distribution—are shaped by underlying drivers. Population growth and rising prosperity can be drivers of deforestation if they lead to growing demand for commodities.[677] At the same time, a growing population, poverty, and lack of alternative livelihoods could lead to forest exploitation through increasing land pressure, as the prospect of finding new livelihoods may attract new settlers into as yet undeveloped forested areas.[678] In the future, these pressures will likely not be evenly distributed, but rather follow distinct patterns depending on natural conditions, available infrastructure or regulatory conditions. Deforestation trajectories across different forest biomes reflect a range of different and complex socioeconomic influences, with market-driven forces interacting with local contexts and trends.

Population growth and lack of arable land are directly linked to food security concerns of countries like China, whose large market is important for forest-risk commodity demand and related deforestation.[679] Other countries with scarce farmland and resulting supply shortages include Japan and Middle Eastern nations.[x, 680] These issues are fostering increased foreign direct investment growth in agricultural commodity supply chains, especially in Asia and Latin America, which also impacts deforestation trends.[681] For example, various Asian commodity traders have expanded their presence in Brazil over the last 20 years, illustrating the country's role as a global agricultural powerhouse and strategic trade partner. The aim of this expansion is to secure reliable commodity flows, at times alongside establishing their own production investments in the country.[682]

6.2 Land tenure and land speculation

Land speculation often exacerbates the impact of expanding economic activities into forested areas.[683] This indirect driver is closely linked to governance issues, as it is often observed in regions with unclear or contested land tenure and limited government presence, where forest is

[x] For example, the Saudi Agricultural and Livestock Investment Company (SALIC) acquired a stake in commodity trader Olam Agri (Olam Group) in 2022. The Singapore Sovereign Wealth Fund holds stakes in two commodity traders, Cofco International (China), and Olam Group (Singapore).

cleared in anticipation of future agricultural value. The price of forested land is influenced by expectations of economic gain from converting forests into agriculture or pastures, enabled, for example, by planned infrastructure development.[684] Planned road projects or improvements, unclear or permissive conservation policies, and tracts of undesignated public lands contribute to speculative clearing.[685] Conversely, clear land rights and responsibilities for forest preservation contribute to protecting forests and the communities that depend on them.[686]

Legal incentives can also link land rights to clearing, reinforcing deforestation in tenure-conflict zones. In settings where deforestation is a means to secure land claims, land grabbing and speculation may be linked to high levels of deforestation.[687]

Using Indonesia as an example, of the 284,000 km^2 of deforestation between 1991 and 2020, more than half were either initially left idle or experienced crop failure before a land use could be identified, and 44% remained unused for at least 5 years. Where lands were eventually cultivated, oil palm plantations were the most common use. The deliberate creation of idle land and later use for oil palm plantations suggests that speculation is an important driver of forest clearing.[688]

Meanwhile, the designation of protected areas, Indigenous lands, and community-managed forests plays a critical role in avoiding deforestation. Such arrangements can both conserve forests and support local livelihoods and rights.[689] Data on forest cover trends shows that deforestation is generally lower inside protected areas and Indigenous Peoples' territories, though enforcement gaps can undermine their effectiveness.[690] Their success depends on consistent implementation and long-term support.[691] While showing varied outcomes overall, REDD+ projects and community-based forest management have slowed forest loss in some regions, particularly where economic incentives and safeguards are well-aligned.[692] Still, Indigenous and community lands continue to face threats from encroachment and weak legal protection or implementation in all three rainforest basins.[693]

Protection of Environmental and Human Rights Defenders (EHRDs)

In 2024, at least 146 EHRDs were killed or disappeared globally. A report by Global Witness documents that Colombia was by far the most dangerous country, with 48 defenders killed or disappeared, followed by Guatemala (20) and Mexico (19). Indonesia experienced five cases, while Peru and the DRC each reported four. Mining and extractives were by far the most dangerous industry, accounting for 29 cases, followed by logging (8), and agribusiness (4). One-third of the defenders killed or disappeared in 2024 were Indigenous people. To protect defenders, urgent action must be taken by states and businesses, including the establishment of strong and legally binding policy frameworks, as well as full and transparent investigations of attacks. Businesses should, inter alia, commit to respecting and upholding the rights of IPs and LCs and strengthen human rights due diligence in their business conduct. While the EU Corporate Sustainability Due Diligence Directive (CSDDD) could significantly enhance corporate accountability, critical provisions are under threat of being substantially weakened as of October 2025.[694]

6.3 National and regional policies, governance and enforcement

The regulatory and policy environment at the national and regional level significantly impacts the state of forests, either halting or contributing to tropical deforestation. Political decisions influence forest conservation or exploitation, and the effectiveness of law enforcement has a crucial impact on curbing illegal activities. The following sections add to the policy analysis and recommendations made in the previous chapters, describing developments in deforestation-related legislation and initiatives in key countries.

6.3.1 Amazon

Brazil

Brazil is an interesting example of dynamics pulling in different directions. The quality of deforestation regulation and the robustness of its implementation considerably fluctuated in recent years, depending on the political debate and administration in power. The **Código Florestal (Forest Code) (2012)** is a key piece of legislation, as it aims to limit deforestation while requiring restoration in areas that have been illegally deforested.[695] The Code requires landowners to maintain a portion of their land as a forest reserve. Under the Bolsonaro administration, the Code experienced weakened enforcement, and funding to combat deforestation and fires underwent severe cuts, resulting in a surge in forest loss.[696]

Brazil's Senate, the upper house of the country's Parliament, has played a controversial role in rainforest protection for years. On the one hand, it has all the tools to enact legislation that promotes forest conservation, Indigenous rights, and sustainable land-use practices. In practice, the Senate is often dominated by large business interests and lobbying, with members closely linked to agribusiness.[697] Agribusiness is, in fact, a powerful force in the Brazilian Senate and the Chamber of Deputies, where the Frente Parlamentar da Agropecuária (FPA), also referred to as the 'Bancada Ruralista', forms a multi-party congressional bloc to fight for large landowners' property rights. Lately, this bloc has also supported a strong development agenda, including opening protected areas for industrial mining or the construction of road infrastructure.[698]

Most recently, **PL 2159/2021** (also known as the '**Devastation Bill**') was passed by the Senate, essentially dismantling the environmental licensing system for farming, mining and energy, and increasing the risk of widespread deforestation and forest degradation.[699] President Lula signed it into law in August 2025, though he vetoed a set of key articles to avoid a dismantling of Brazil's environmental legislation. The question now is whether Congress will overturn the vetoes.[700] Other examples of proposed legislation that undermine forest protection include:

- **PL 364/2019**: Seeks to eliminate protections for native grasslands and other non-forest vegetation, allowing extensive conversion of 480,000 km^2 in areas such as the Pantanal, Pampa, Cerrado, and the Amazon. It is currently a proposed law (Projeto de Lei) in the Brazilian Chamber of Deputies that would amend the Forest Code.[701] It was approved by the Chamber's Constitution and Justice Committee (CCJC) in March 2024; however, as no vote has taken place in the full Chamber as of October 2025, it has not been sent to the Senate.[702]
- **PL 3334/2023**: Proposes reducing the required preservation of native vegetation (Reserva Legal) in the Amazon from 80% to 50%, increasing the risk of extensive deforestation. The bill, introduced in July 2023, is in the Constitution and Justice Committee as of October 2025.[703]
- **PL 2374/2020**: Would extend amnesty to those responsible for illegal deforestation up to May 2012, weakening enforcement against environmental crimes. As of October 2025, it is in the Senate's Agriculture and Agrarian Reform Committee (CRA); the last recorded status (July 2, 2025) marked it as ready for the committee agenda.[704]
- **PL 510/2021** and **PL 2633/2020** ('**Land Grabbing Bill**'): Facilitates the regularisation of land acquired through illegal deforestation, incentivising further land grabbing and environmental degradation. As of October 2025, the bill is being discussed in the Senate's Agriculture and Agrarian Reform Committee and Environment Committee and has not been voted on yet.[705]
- There is an ongoing discussion around the so-called '**Marco Temporal**', a legal thesis defended by the Brazilian agroindustry. It proposes that only territories occupied by indigenous peoples on October 5, 1988, the date of the Brazilian Constitution's enactment, may be legally acknowledged and demarcated. This attack on Indigenous rights would ignore the fact that many Indigenous people were expelled from their territories over the years.[706] As of October 2025, the issue is being fought in the courts. The UN Special Rapporteur on the rights of Indigenous Peoples in June 2025 expressed grave concern about Brazil's ongoing use of the controversial legal interpretation to repeal the legal foundation for indigenous land demarcation.[707]

While deforestation in the Brazilian Amazon surged during the Bolsonaro government, the current Lula government is expected to better control the implementation of the Forest Code,[708] owing to its track record during previous terms.[709] However, the stated aim to achieve 'desmatamento zero' – zero deforestation by 2030[710] seems challenging to achieve, given current deforestation trends and political constellations.

Various other policies from recent years are linked to the prioritisation of 'critical' mineral mining development (→ section 3.3.5).

Land grabbing in undesignated public lands (UPLs) is a major contributor to forest loss in the Brazilian Amazon. Nearly 570,000 km^2 of this forest area is undesignated. In 2020, 32% of illegal deforestation occurred in UPLs, often facilitated by fraudulent entries in the Rural Environmental Registry (CAR). Land tenure insecurity, combined with weakened enforcement during the Bolsonaro administration, allowed illegal activities to flourish.[711] The effectiveness of the Forest Code is undermined by amnesties for pre-2008 deforestation, encouraging a sense of impunity, and inconsistent enforcement.[712] Research also found widespread non-compliance with the Forest Code's legal reserve provision. A particularly large deficit of legal reserves is observed among large-scale cattle ranchers,[713] but non-compliance is also frequently observed on Amazon soy farms.[714]

Illegality is also widespread in logging activities in the Brazilian Amazon. Recent enforcement efforts signal renewed attention. In one of the largest operations of this size in years, the Brazilian Environmental Agency (IBAMA) seized the equivalent of more than 5,000 truckloads of illegal timber. Much of it was taken from protected areas. Ibama closed sawmills and imposed fines totalling US$2.7 million (€2.3 million) during a two-week raid in Amazonas, Pará and Rondônia in early 2025. The operation will continue for the remainder of the year.[715]

Experts warn that without sustained investment in enforcement and governance, criminal networks will continue driving forest loss, linked to drug trafficking, illegal mining, and land speculation. Recent research confirms that municipalities with stronger regulatory enforcement show both lower deforestation and higher economic development.[716]

Colombia

Colombia's key regulations to tackle deforestation include the **1993 Environmental Statute**,[717] which laid the foundation for environmental protection and enabled stricter regulations around forests and protected zones, **CONPES 2020** (National Policy for the Control of Deforestation and Forest Management), a comprehensive roadmap with goals like zero net deforestation by 2030, prevention and control of illegal land use, and strengthening of institutional capacities.[718] The **2018 Supreme Court Ruling (CST-4360)** recognises the Amazon Rainforest as a 'subject of rights' and empowers communities to demand compliance. Yet, the overall forest loss trend has not been decisively reversed, largely due to armed-group activity, land grabbing, and illegal cattle ranching, which are enabled by a lack of state presence and effective law enforcement.[719]

Illegal deforestation is a widespread problem across the Amazon, driven by a combination of weak governance, poverty, land tenure insecurity, and organised crime. In Colombia, a complex interplay of armed conflict, institutional corruption, and global demand for illicit crops fuels forest loss and violence against Indigenous and local communities.[720]

Peru

Peru faces similar challenges to Colombia. Illegality and informality are large and widespread problems, driven by political instability, a lack of accountability, and rising poverty.[721] Changes to the country's **Forestry and Wildlife Law** threaten to legalise and encourage the dispossession of Indigenous Peoples from their ancestral lands.[722] Enacted in March 2025, the amendment removed the obligation for landowners or companies to get official authorisation before converting forested land for other uses. While supporters of the change stated that it will support economic development, critics point to grave risks for Indigenous Peoples and forests.[723]

The ongoing process around **Reinfo** in the mining sector is another cause of concern (→ section 5.4.2). In general, serious concerns exist within civil society about the ongoing dismantling of civic space, accountability, and human rights protection in Peru.[724]

6.3.2 Congo Basin

Democratic Republic of the Congo

In the DRC, the government implemented a ban on new industrial logging concessions under its **2002 Forest Code**, aiming to curtail corruption. The Code establishes the legal framework for the sustainable management, conservation, and exploitation of the country's vast forest resources. Key requirements include classifying forests into three categories (classified forests, protected forests, and permanent production forests) and mandating forest concession contracts through public tender processes. It emphasises community rights by requiring consultation with local and Indigenous populations and providing for benefit-sharing mechanisms. Environmental protection is a core principle, with provisions for forest inventories, management plans, and impact assessments. The code also prohibits logging in certain areas to preserve biodiversity and ecological balance.[725]

However, scores of illegal and corrupt logging concession allocations were documented right from the start, and the Forest Code only slowed but did not stop the awarding of concessions. While conservation groups oppose the government's 2021 suggestion to lift the moratorium, they emphasise the need for stronger safeguards and effective law enforcement.[726] The Code also envisions Government-approved **Forest Management Plans (FMPs)** for concessions; however, according to CIFOR/ICRAF, despite requiring FMPs and community-sharing measures, these requirements are largely unenforced and produce no measurable reduction in forest loss.[727]

A systemic lack of law enforcement continues to contribute to deforestation in the DRC. According to Global Witness, the Ministry for the Environment and Sustainable Development (MEDD) has provisionally suspended 12 illegally granted concessions covering over 200,000 km^2 of land–a decree that, after 2,5 years, is still not enforced.[728] Even the most progressive legislation will likely fail to reduce deforestation without strong institutions to enforce it. Effective implementation requires a robust judiciary, anti-corruption measures, and the capacity for nationwide enforcement.

6.3.3 Southeast Asia-Oceania

Indonesia

In Indonesia, a **moratorium** on issuing new permits to clear primary and peat forests and law enforcement against illegal deforestation is in place. Nonetheless, deforestation rates have shown an upward trend in recent years.[729] The predominantly legal nature of conversion activities points to a lack of effective regulation to halt the further conversion of forested areas. The moratorium also excludes secondary forests and does not revoke existing concessions.[730] An important driver is speculative clearing: firms obtain forestry or plantation permits, log valuable timber, and then leave areas idle, often due to limited capital or deliberate land-banking. This pattern has been observed since the 1990s, reflecting regulatory failures and the uncontrolled issuance of permits. With few penalties for clearing and abandonment, concession holders face little accountability, perpetuating a cycle of forest loss.[731]

National Strategic Projects (Proyek Strategis Nasional / PSN) are large-scale infrastructure and economic development initiatives designated by the Indonesian government as critical to national interests. They are governed by **Presidential Regulation No. 109/2020** and updated through sector-specific decrees such as Presidential Regulation No. 40/2023 (Perpres 40/2023 concerning bioethanol) and Coordinating Minister's Regulation No. 8/2023 (Permenko Perekonomian No. 8 Tahun 2023), and reinforced by the **Omnibus Law on job creation** (No. 11/2020). These regulations enable fast-tracking of licensing, land acquisition, and investment procedures for projects in sectors like energy, mining, food estates, and transportation. PSNs are often exempt from key environmental and social safeguards, including full Environmental Impact Assessments (AMDAL), spatial planning alignment, and public consultation requirements.[732]

CSOs have criticised PSNs for undermining Indigenous land rights and accelerating deforestation, especially in frontier regions.[733] This is already resulting in deforestation and will likely cause much more forest loss in the short and medium terms, as illustrated by the mega-project in Merauke (→ section 3.3.4). Independent oversight bodies and CSOs have documented violations: no FPIC, military presence, and blatant clashes with human rights and environmental laws, potentially, as a result of the PSN framework bypassing normally required safeguards.[734]

In Tanah Papua, agricultural and infrastructure expansion projects, driven by national-level policies, increasingly undermine the region's commitment under the **2018 Manokwari Declaration**, as illustrated by the large-scale developments in Merauke. The Declaration was initiated by provincial and local stakeholders to promote indigenous-led conservation and is committed to conserving 70% of land area.[735]

Concerns have also been raised about the human rights situation in Tanah Papua. In light of rising encroachment into forests, Indigenous communities are faced with human rights abuses and violence from an oppressive police and military presence when claiming their land rights or expressing basic political freedoms. Independent investigations are hampered by restricted media access.[736]

Papua New Guinea

PNG has generally weak law enforcement, despite an array of environmental protection laws and regulations covering key issues like timber exports and FPIC for land acquisition, including the **Land Act of 1996**, the **Environment Act (2000)**, **Forestry Act (1991)**, **Mining Act (1992)**, and **the Oil and Gas Act (1998)**.[737]

Moratoria and spatial plans exist but face implementation gaps. In 2024, Papua New Guinea's National Forest Board extended the moratorium on new **Forest Clearance Authorities (FCAs)** for another year.[738] This move, accompanied by a planned audit of existing FCAs, aims to curb illegal logging under the guise of agricultural development. However, more than two years after coming into force, the forest authority had not published FCA audit findings.[739] Other legislative progress in 2024 included the passage of the **Protected Areas Act**,[740] enhancing support for community-led conservation initiatives. If effectively implemented, it could significantly enhance the protection of forest areas under traditional stewardship. The Act pledges to protect 30% of national territory by 2030 by establishing a national system of protected areas; the Act has been praised for providing a legal framework to protect the country's ecosystems. Yet, effective implementation, particularly concerning the customary land rights prevailing in the country and securing sustainable funding, remains challenging.[741]

Additionally, the revised **Environment Act** strengthened the authority of PNG's Conservation and Environment Protection Authority, introduced broader environmental auditing provisions, and emphasised inter-agency collaboration to improve monitoring and compliance. However, the suspension of the government's log export monitoring program throughout 2024 raised concerns about transparency and accountability, with no clear data confirming a reduction in log exports.[742]

Concerns also persist regarding large-scale 'impact projects' and **Special Economic Zones (SEZs)**,[743] which could threaten increased deforestation, community displacement, and environmental degradation. The 'Connect PNG' road projects (→ section 6.6) further exacerbate risks, conflicting with the objectives of PNG's National Biodiversity Strategy and Action Plan.[744]

Despite legal improvements, in the short and medium terms, weak law enforcement and widespread corruption, combined with ambitious economic development projects and infrastructure expansions, will likely drive high deforestation rates in PNG for the coming years.

6.3.4 European Union

The **EU Timber Regulation (EUTR)**, which entered into force in 2013, aims to counter the trade in illegally harvested timber and timber products, covering both domestic and imported production. It requires operators placing timber on the market to exercise due diligence and require additional information and verification to mitigate risk; traders must keep records of their suppliers and customers. Member State authorities enforce compliance, conduct checks, and impose penalties. Enforcement disparities across Member States have been found to limit effectiveness.[745] The EUTR will be superseded by the **EU Deforestation Regulation (EUDR)** once it enters into force. Based on the current timeline for the EUDR implementation by December 30, 2025 (see below), the EUTR will be repealed by that date for large-/medium-sized firms and by June 30, 2026, for micro-/small-sized firms. Transitional rules will apply for 'old-harvest timber': the EUTR will still apply until December 31, 2028, for timber harvested before June 29, 2023 and placed on the market after the above repeal dates. After December 2028, old-harvest timber placed on the market must comply with EUDR Article 3 (deforestation-free, degradation-free, legal). Timber stocks already placed on the EU market before the repeal dates remain under the EUTR.[746]

The **EU Forest Law Enforcement, Governance and Trade (FLEGT)** Regulation (2173/2005) entered into force in 2005.[747] It aims to regulate the control of EU timber imports through bilateral Voluntary Partnership Agreements (VPAs). A 2021 fitness check of the FLEGT concluded that it had improved stakeholder engagement but failed its key objective of tackling illegal logging.[748] After almost two decades, only two out of 15 countries engaged in the VPA process have implemented an operating licensing system as of September 2025.[749]

In 2023, the **EU Regulation on Deforestation-Free Products (EUDR)** was adopted in the EU. Its scope includes palm oil, soy, coffee, cocoa, timber, cattle, and rubber–commodities that are of high relevance in the focus geographies of this research. The regulation will make it illegal for operators or traders to place EUDR-covered commodities and products on the EU market, unless it can be proven that these commodities comply with the legislation of the production country, are deforestation-free, traceable to the plot and accompanied by a due diligence statement confirming there are only negligible risks of non-compliance. An important gap that has been widely discussed is the scope, limited to the FAO definition of 'forest'. This means that crucial ecosystems like the Brazilian Cerrado, a highly biodiverse forested savannah experiencing exceedingly fast conversion rates, are not covered,[750] risking displacement effects.

In response to political pressure, the compliance deadlines have been postponed, initially by one year to December 30, 2025. In April 2025, the European Commission (EC) introduced simplifications to the EUDR, reacting to pressure by certain political parties to reduce administrative burdens.[751] Key changes criticised by many CSOs[752] include a reduced frequency of due diligence statements (DDS), allowing annual submissions rather than for each shipment or batch. This change delays potential mitigation and compensation measures and makes it virtually impossible to prevent further deforestation, given the possible one-year lag before EU authorities take action. Large downstream operators were initially obliged to ascertain deforestation-free supply chains up to the production point, but may now only have a minimal obligation to collect and cite DDS reference numbers from the direct suppliers.[753]

Similarly, the EUDR's country benchmarking system, which classifies countries as low, standard, or high risk, has drawn criticism. Some of the countries object to their 'standard' status, while CSOs argue that many jurisdictions known for their high deforestation rates and human rights abuses are unjustifiably labelled as low or standard risk. Only four countries—Belarus, Myanmar, North Korea, and Russia—are deemed high risk, likely due to limited or absent information exchange, and have a minimal impact due to their low trade relevance, especially in light of trade sanctions against Russia. NGOs also argue that the classification focuses on the quality of laws rather than their enforcement, which can potentially lead to misclassification. For example, Brazil, the DRC, Indonesia, and PNG were categorised as 'low' or 'standard risk'.[754]

As of October 2, 2025, the EU Commission announced that it is considering a further one-year delay to December 2026, pointing to concerns over the IT platform for compliance data.[755] If a 'stop the clock' proposal is approved by the EU Council and Parliament, a further delay also raises concerns over additional simplification attempts within the scope of the EU Commission's environmental omnibus simplification proposal.[756]

The postponements and dilution of the EUDR are undermining its initial ambitious objectives. While it will likely remain an important lever, its role in halting global deforestation will probably be diminished. Such a weakening is particularly concerning when considering the impact the EUDR could have. According to estimates by Global Witness, based on projected deforestation rates and past trade patterns, the EUDR could help save more than 80,000 km^2 of forest over the next decade, an area roughly the size of Austria.[757] At the same time, some experts raise concerns that unless other high-consuming countries, especially China and the US, enact comparable regulations, the effect on global deforestation dynamics will be limited, as potentially non-compliant supplies may be diverted to non-European markets.[758]

The 'Brussels Effect' and factors influencing policy convergence

Various research papers have analysed whether the EUDR will be effective in reducing tropical forest loss, and whether the so-called 'Brussels Effect'[759] will achieve the externalisation of EU standards beyond its own jurisdiction.[760] Muradian et al. concluded that, despite the potentially positive symbolic effect in mobilising a global agenda for combating deforestation, the regulation faces several downsides and risks, mainly linked to its demand-side orientation and high degree of unilateralism. To be effective in curbing tropical deforestation, the EUDR would need to be complemented with international cooperation aiming to strengthen national policies with a territorial approach, combined with social movements to address the underlying causes of forest loss and human rights violations in production regions.[761] This is also a precondition to avoid market leakage, where deforestation-linked products may 'leak' to non-EU markets.[762] Coenen et al. identified the EU's share in world trade as a key condition affecting the EUDR's success. Leverage is expected to be stronger for forest-risk commodities with large EU market shares (for example, for cocoa and coffee), while influence on commodities where the EU has a lower market share (such as soy and palm oil) carry substantial spillover risks. To achieve substantially lower deforestation, the narrow EU focus needs to be broadened to a collaboration with producer and influential consumer countries.[763]

The **EU Battery Regulation** (2023/1542), which entered into force in August 2023, aims to minimise the environmental impact of the exponential growth in battery demand driven, among others, by technological developments and market shifts. It aims to achieve a safe, circular and sustainable battery value chain, including for EVs.[764] The regulation applies to all new batteries placed on the market or put into service, regardless of their origin and the economic operators involved. Key obligations include more ambitious collection targets for spent batteries, stricter recycling duties with higher recovery rates for minerals like copper, cobalt, lithium and nickel, and restrictions on the use of harmful substances (mercury, cadmium, lead). The Battery Passport is intended to improve transparency and traceability, as well as support due diligence by providing publicly accessible information on origin and composition.[765]

The **Corporate Sustainability Reporting Directive (CSRD**, **2022/2464)**[766] and the **Corporate Sustainability Due Diligence Directive (CSDDD, 2024/1760)**[767] introduce wider-reaching due diligence and reporting requirements in the EU. The **CSRD**, in force since January 5, 2023, introduce a double materiality concept, whereby firms must report on both how sustainability issues can affect their performance (financial materiality) and how their activities impact people and the environment. The Directive also broadens the scope of material environmental, social and governance topics to be disclosed.[768] Originally supposed to be phased in via three waves from 2025 (reporting on financial year 2025) for large undertakings to 2027 for small entities, the new European Commission's Omnibus proposal (COM 2025/80) from February 2025 seeks a two-year delay for wave 2 and 3 companies and a narrower scope.[769] The delay has already been agreed upon by the EU Parliament.[770] If adopted, the Omnibus proposal would remove around 80% of companies from the scope of the CSRD, limiting it to entities with more than 1,000 employees and a turnover above €50 million or more than €25 million in total assets.[771] In response to the Omnibus proposal, the European Parliament and member states have put forward additional changes to the scope of the CSRD. The 'Stop the Clock' Directive was adopted in April 2025 and must be transposed into the national legislation by December 31, 2025.[772]

The **CSDDD**, in force since July 25, 2024, aims to address the social and environmental impacts of major companies, both within and outside the EU. Its scope includes large EU limited liability companies and partnerships with more than 1,000 employees and a turnover of more than €450 million worldwide, as well as large non-EU companies with a turnover of more than € 450 million in the EU. Obligations involve identifying and addressing potential and actual negative impacts on the environment and human rights within the firm's own operations, its subsidiaries, and, when relevant, its supply chain partners. The Directive also requires large companies to develop and implement Paris- and EU Climate Law-aligned climate transition plans. Member States are expected to ensure that victims are compensated for damages resulting from an intentional or negligent failure to perform due diligence. The Directive was initially intended to be transposed into national law by July 26, 2026, with rules applying one year later in three waves until 2029. The proposed one-year extension for transposition and application under the Commission's Omnibus Package and the "Stop-the-clock" Directive has already been agreed by the Parliament.[773] In October 2025, the EU Parliament agreed on a deal to reduce the scope of the CSDDD to avoid 'over-burdening' of companies.[774] The final CSRD and CSDDD scopes will depend on ongoing negotiations on the Omnibus Proposal.

6.3.5 United Kingdom

Currently, the UK is the only major market with a regulation similar to the EUDR, though its scope is somewhat narrower. The **UK Forest Risk Commodity Regulation** (UKFRC), part of the Environment Act 2021, has been formally adopted;[775] however, as of October 2025, it has not been implemented due to the absence of secondary legislation necessary for its practical implementation. The law was criticised by CSOs and forest scientists for its focus on illegal deforestation, which does not cover deforestation that is legal under local regulations but can account for a significant share of forest loss, and for its limited scope of high-risk commodities, which currently excludes coffee, rubber and timber.[776] However, timber and timber-derived products fall within the scope of the UK Timber Regulation. It bans the placing on the market of illegally harvested timber and requires UK operators to carry out due diligence on timber products in their supply chains to ensure they are produced legally.[777]

Owed to implementation delays and the limited scope of the UKFRC, Global Witness estimates that the UK's direct imports of key forest-risk commodities–cattle products, palm oil, soy, cocoa, coffee and natural rubber– were responsible for the loss of an estimated 393 km^2 of forests between November 2021 and December 2024, a conservative estimate due to the disregard of indirect imports.[778]

Impact scenario

If the deforestation rates linked to direct UK commodity consumption persist, a simple extrapolation based on an annual average of ~10.3 km^2, as suggested by Global Witness (393 km^2 divided by 38 months), leads us to the estimate that an additional ~745 km^2 of forest loss may be linked to UK imports between 2025 and 2030.

6.3.6 China

In the last twenty years, China has been the country most significantly exposed to deforestation in tropical rainforests through its imports from Brazil, Indonesia, and other parts of the world. Forest Trends estimates that China's agricultural and timber imports between 2013 and 2022 were linked to ~40,000 km^2 of tropical deforestation,[779] an area almost the size of Denmark. Despite this high exposure, the country has not yet enacted specific legislation targeting deforestation linked to imports.

However, there are signs of increasing attention to the issue, along with preliminary actions. For example, China signalled last year that it would soon enforce a traceability requirement across the beef supply chain from Brazil.[780] The impact and eventual evolution of such an initiative will depend on various economic and political considerations, notably food security concerns and the country's non-interference principle.[781] The real effectiveness will likely hinge on the eventual quality of monitoring, traceability and enforcement.

In the 2019 revision of the **Forest Law**, Chinese authorities prohibited the purchase, processing, and transportation of timber known to be from illegal sources. The law also requires timber operators to maintain records of raw materials and products, aiming to ensure the traceability of timber to a legal source. However, according to ClientEarth, this legislation concerns only domestically produced timber and lacks clarity on the obligation it may place on importers, a major concern given the large volume of China's timber imports.[782] Other research claims that imported timber is at least partially in scope, citing that administrative penalties on imported illegal timber are already being imposed based on the law.[783] It remains to be seen how strictly the Forest Law is enforced, and to what extent it covers imported timber. As it only applies to timber and not to agricultural forest-risk commodities like soy, palm oil, and rubber, its impacts on tackling China's deforestation footprint abroad may remain limited.

Other, broader regulatory developments that could reduce China's exposure to tropical rainforest loss include the **Green Finance Guidelines for the Banking and Insurance Industry**, issued by the China Banking and Insurance Regulatory Commission (CBIRC) in 2022. Banking and insurance institutions are required, among other things, to establish a green-finance governance and coordination mechanism; promote carbon peaking and neutrality by financing energy-saving, pollution- and carbon-reduction, resilience, and other green upgrades; and support the greening of Belt and Road Initiative (BRI) projects.[784] The **Guidelines for Ecological Environmental Protection of Foreign Investment Cooperation and Construction Projects** by the Ministry of Environment and Ecology and the Ministry of Commerce were first presented in 2021[y] and updated in 2022. They encourage Chinese companies operating abroad to apply international standards or China's stricter rules throughout the entire project lifecycle, especially where environmental governance is weak, and to systematically reduce risks across three dimensions: pollution, climate, and biodiversity. Some guidance is provided for mining projects, where companies should focus on pollution control measures and waste disposal, and transportation projects, where infrastructure should be designed to avoid nature reserves and important wildlife habitats.[785] Leading Chinese corporations are also beginning to introduce sourcing guidelines for deforestation-free commodities.[786]

While China's role in driving the global consumption of agricultural commodities is expected to slow down in the coming years, emerging Asian countries, particularly India and Southeast Asian countries, are expected to grow in influence,[787] as has discussed in previous chapters. Without comprehensive legislative frameworks to ensure deforestation-free supply chains, the coming years may see vast areas of additional deforestation linked to these trends, as there are currently no indications of no-deforestation and due diligence legislation in these Asian countries.

6.3.7 United States

The **US Lacey Act** was amended in 2008 to cover timber. It makes the import and retailing of timber and timber-derived products illegal if procured in violation of source-country laws. Importers must submit declarations that detail the species and origin. The Lacey Act is a reactive law where violations must be proven. Various cases of prosecution under the Act have been

[y] The 2021 Guidelines were called "Green Development Guidelines for Foreign Investment and Cooperation".

documented in recent years.[788] Yet, in Brazil, deficiencies in the control of timber origin regarding legality have been observed, especially in verifying the legitimacy of authorisations.[789]

Given the current Trump administration's ongoing dismantling of environmental regulations, it seems unlikely that the six-point anti-deforestation policy framework presented by the previous Biden administration will be implemented anytime soon.[790]

The **FOREST Act of 2023**, short for the Fostering Overseas Rule of Law and Environmentally Sound Trade Act of 2023, is currently pending in Congress but unlikely to pass. The Act is proactive, seeking to prevent products linked to illegal deforestation from entering the US. To achieve this, it proposes a system where importers must trace and verify the origin of high-risk commodities (palm oil, soybeans, cocoa, rubber, and cattle – but not timber and coffee), and confirm they were not produced on illegally deforested land. The Act also authorises Federal Agencies to offer a 10% price preference in government contracts to companies that can certify their commodities are sustainably and legally sourced, thereby using federal procurement power to reward ethical business practices.[791]

6.4 International trade policies

Global **trade tensions and policies** can also impact the flow of forest-risk commodities. Analysts predicted that 2025 would be dominated by global trade tensions following Donald Trump's return to the White House, his erratic trade policies and threats of imposing wide-ranging tariffs.[792] The resulting volatility is likely to prevail for several years to come.

Trade agreements represent a powerful tool for encouraging resource-rich producer countries to adopt stronger sustainability regulations, market norms and production methods by incentivising compliant producers and restricting or even banning unsustainable products. The EU uses its trade policy to advance this agenda by incorporating Trade and Sustainable Development (TSD) chapters into all modern agreements. Since 2018, a 15-Point Action Plan has guided their enforcement. In 2021, the EC launched a review to strengthen the way how trade agreements support sustainable trade, aligning them more closely with broader EU policies like the Green Deal.[793] The European Economic and Social Committee (EESC), an advisory body to the European Parliament, the Council and the EC, consisting of employers, trade unionists and representatives of social, occupational, economic and cultural organisations, issued an Opinion on trade and sustainability. In this document, it "*[…] emphasises the need for clearer and more detailed TSD provisions to better define roadmaps and help both trade partners to better understand what is expected of them [and] regrets that Just Transition is not made an overarching concept*."[794]

Recent research shows that in practice, deforestation can increase due to the higher demand for agricultural commodities linked to **free trade agreements (FTAs),**[z] as deforestation peaks have been observed during and after agreements are signed.[795] Ex-ante modelling projects additional forest loss in the Brazilian Amazon under the EU-Mercosur agreement due to a lack of strong safeguards.[796] Conversely, including environmental provisions and making tariff reductions contingent on maintaining or improving forest cover could mitigate forest risks.[797]

However, as demonstrated in a recent OECD report, measures such as conditional market access or conditional tariffs linked to meeting specific environmental criteria are largely absent from **international trade policies**.[798] Out of a total of 130 identified provisions, 116 were not commodity-specific, while the remaining 14 covered forest-risk products, including palm oil, soy, biofuels, coffee, cocoa, and cattle. Most of the 'hard' market measures (requiring sustainability conditions for market access) were part of national/jurisdictional legislation, like the EUDR, rather than

[z] Like the EU-Mercosur Partnership Agreement (as of October 3, 2025, submitted by the EU Commission to the Council for conclusion), EFTA-Mercosur FTA (signed on September 16, 2025, entry into force pending ratifications; the European Free Trade Association (EFTA) consists of Iceland, Liechtenstein, Norway, and Switzerland), or the Indonesia-EU Comprehensive Economic Partnership Agreement (EU-CEPA, signed on September 23, 2025, implementation expected by 2027).

regional trade agreements. Very few FTAs contained provisions on environmental trade preferences (conditional preferential tariffs and conditional tariff rate quota (TRQ)), with one notable exception: the EFTA-Indonesia Regional Trade Agreement, which has been in force since 2021. At the same time, the authors conclude that most environmental provisions in trade agreements and national legislation regulating market access have been implemented over the last four years. It is, therefore, difficult to assess how efficient they have been in reaching the on-the-ground conservation goals at this point.

Trade wars appear to have a severe impact on natural landscapes. During the US-China trade war in 2018/19, growing demand for Brazilian soybeans and bovine meat by China was not connected to a substitution effect in Brazilian exports to other regions. Instead, exports of both commodities showed sustained growth, inevitably suggesting increased demand for production land.[799]

Already in 2019, scientists pointed out that "*[t]he Amazon rainforest could become the greatest casualty of the US-China trade war*."[800] Using scenario analysis, they demonstrated that China's demand shift to South America may result in additional land needs and incentivise expansion, even under the most favourable conditions. If all 94 major soy-producing countries increased production to replace US soy in China's imports, Brazil would need 57,000 km^2 and Argentina 20,000 km^2 to 33,000 km^2 (at current yields) of additional land under soy, equivalent to a ~10-15% increase based on the countries' cultivation areas at the time.[801] Although this scenario did not consider the potential cultivation of soy on land used for other crops, it was noted that substituting one crop for another had technical and political limits, so expansion into savannas and tropical rainforests was likely.[802]

Unlike trade wars, **trade agreements** are likely to have a more ambiguous impact on future deforestation trends. They may increase deforestation due to the higher demand for agricultural commodities, with previously demonstrated peaks in deforestation occurring during and after the signing of regional trade agreements. On the other hand, these agreements can serve as a tool to ensure that forest-risk commodity trade is subject to strict sustainability requirements, including those related to no deforestation and no conversion. However, to achieve such conditions, more major importing countries (including China and the US) must include TSD-like provisions in their trade policies, while the EU TSD clauses must be made stricter, at least in line with what is already required under the EUDR.

In relation to due diligence for corporations, the non-binding **OECD Guidelines for Multinational Enterprises** set a high standard for responsible business conduct and serve as a benchmark for national and international laws and directives. The recommendations help enterprises identify, prevent, and mitigate adverse impacts related to workers, human rights, the environment, bribery, consumers and corporate governance that may be associated with their operations, supply chains and other business relationships.[803]

6.5 Corruption and illicit activities

Systemic illegalities in forest risk sectors are closely linked to the quality of regulation, governance, enforcement and related resource availability. Illicit activities like illegal logging and illegal mining are major drivers of forest loss and can severely undermine progress in environmental protection.[804]

Illegal logging is a widespread contributor to global deforestation. According to estimates, illegal timber makes up 15-30% of all timber traded worldwide, contributing to deforestation and biodiversity loss, and threatening the livelihoods of Indigenous peoples and local communities. Proceeds from illicit logging may also fund conflicts.[805] Commonly observed practices include timber extraction in protected areas and of protected species, as well as logging without a permit.[806]

Forest crimes have profound impacts on protected areas and Indigenous peoples, threatening their livelihoods, cultural practices, and territorial rights.[807] Criminal activities often involve violence, displacement, and the destruction of sacred sites.[808]

An international coalition led by INTERPOL and the United Nations Office on Drugs and Crime (UNODC) has launched the next phase of a global programme to tackle forestry crime, illustrating the scale of the problem. Codenamed LEAP II, the programme will offer support to countries across Latin America and Southeast Asia to address forestry crime and illegal tropical deforestation.[809]

Nature crime is also a significant driver of forest fires. Reinforced by the impacts of climate change, the role of fire in forest loss in the region surged in 2024.[810] As put by Barber, "*[…] recent fires in tropical primary forests are by no means a "natural" disaster. Rather, the conflagration represents a perfect storm of climate change-induced environmental conditions, governance failures and unchecked, organized criminality.*"[811] For the Brazilian Amazon, government data suggests that 91% of forest loss is linked to illegal activity, including land clearing for agriculture and small-scale mining, which is often controlled by international criminal networks.[812] The rise in global timber demand is another driver for illegal timber extraction, as explained in chapter 5.[813] In particular, illegal timber trade and drug trafficking are increasingly linked in the tri-border area of the Amazon between Brazil, Colombia, and Peru, creating a 'criminal economy of scale'.[814]

6.6 Infrastructure development

Infrastructure development is booming, driven by goals to support economic growth and the living standards of local populations. Governments and institutions, such as national, regional, and international development banks, view investments in regions with an infrastructure deficit as a key driver of progress, a means to increase the competitiveness of industries, and a contribution to poverty reduction.[815] Across the three basins, multiple large projects are planned or underway. Without robust governance and monitoring, these projects raise serious environmental and social concerns. Roads, ports, airports, and other forms of transport infrastructure can make significant contributions to social and economic development by facilitating access to supplies and markets, easing the transportation of people and goods, and lowering production costs and crop losses.[816] However, they are also a direct driver of highly impactful environmental changes.[817] In the Amazon, research has shown that roads often cause a net economic loss for society, as construction and maintenance costs outweigh the gains, and the loss increases even further when environmental impacts are factored in.[818]

Implementing new transport infrastructure projects, or expanding or improving existing ones, is not only linked to direct forest conversion and fragmentation, but more importantly, may act as an indirect driver by creating accessibility that, in turn, attracts new settlers and intensifies deforestation by facilitating commodity production and trade.[819] Transport infrastructure is a fundamental enabler of all large-scale commercial activities in tropical rainforests by creating accessibility.[820] The improved access to as-yet remote forested areas can threaten forests and the livelihoods of Indigenous Peoples, particularly those living in voluntary isolation. Improved accessibility also increases the risk of dangerous encounters with loggers, missionaries, and criminal organisations engaged in illicit activities.[821]

Research has shown that initial, first-cut road infrastructure attracts unofficial road networks, which often branch off the initial road in a typical fishbone pattern, a dynamic that can significantly increase forest and biodiversity losses.[822] Much of this road construction is happening under the radar. Networks of unmapped, unregulated and often illegal roads are insidiously spreading into fragile ecosystems. Temporary roads for selective logging, which initially have a comparatively small impact, are often reopened and then facilitate activities with a broader impact in remote areas.[823] Road density has been identified as by far the strongest correlate of deforestation, out of 38 potential biophysical and socioeconomic covariates, whereby deforestation peaks soon after roads penetrate a landscape and then drops as roads multiply and remaining accessible forests largely disappear.[824]

According to recent research, for every kilometre of first-cut road, 49.1 km of secondary roads were formed in the Brazilian Amazon, 9.8 km on the island of New Guinea, and 4.8 km in the Congo Basin. The forest loss and degradation rates linked to secondary roads were 31.5 times greater than those connected to first-cut roads in the Congo Basin, 22.2 times greater on New Guinea, and 305.2 times greater in the Brazilian Amazon. Meanwhile, total human impact footprints of first-cut roads reached up to 19.2 km^2 per km in the Brazilian Amazon, 2.7 km^2 on New Guinea, and 1.9 km^2 in the Congo Basin.[825]

An important effect of road expansion in tropical rainforests is that it increases the forests' vulnerability to fires, with fragmentation and easier human access as key contributing factors. It is particularly alarming that the frequency of fire incidents has been found to be significantly higher in the proximity of roads and other transport infrastructure, such as navigable rivers,[826] considering the significant jump in fire-induced forest loss in recent years.

Similar to transport infrastructure, other infrastructure projects (like hydropower dams or oil and gas pipelines) also carry the risk of severe direct and indirect impacts. Direct impacts concern the project itself, including clearing for pipelines, the vast areas of forest flooded during dam construction, and the cutting of electrical transmission lines through forests. Indirect or cumulative impacts relate to the increased accessibility into forested areas created by project-related infrastructure. This is often connected to significant increases in clearing for farmland, illegal logging, and poaching, including in formally protected areas.[827]

6.6.1 Amazon

Road infrastructure plays a crucial role in facilitating access to and land speculation in the Amazon. Several studies have confirmed the important role of roads as a crucial underlying driver in the Amazon by creating accessibility to markets.[828] However, the construction of new roads and multimodal corridors across remote Amazon areas threatens to accelerate deforestation, attract land-grabbers, and encroach on Indigenous people's lands, some of whom live in voluntary isolation.[829] According to estimates, more than 70% of the cleared forests were located within 50 km on each side of roads, especially paved motorways that allow for the outflow of products like timber or cattle. Between 2012 and 2020, the density of roadways in the Amazon grew by 50%: from 12.4 to 18.7 km per km^2. In addition to official road networks, clandestine roads linked to logging and illicit coca plantations proliferate in the Amazon region, fuelled by demand from international markets.[830]

Brazil

Brazil is currently advancing plans to build a new transport infrastructure network through the Amazon to accelerate trade in grains, beef, and minerals with Asia, especially China, including the **Amazon Route** to connect Manaus to Pacific ports in Peru, Ecuador, and Colombia.[831] The project is supported by several development banks, including the Brazilian BNDES and the Inter-American Development Bank (IADB).[832] The plan is part of the broader **South American Integration and Development Routes Project**, which includes roads, riverways, ports, railways, and multimodal corridors connecting Brazil with its neighbours Peru, Ecuador, and Colombia.[833] Among others, it includes the China-backed **transcontinental railway** from Brazil to Peru.[834] In November 2024, Chinese President Xi Jinping already inaugurated the Chancay Port, a megaproject on the Peruvian Pacific coast.[835] The new roads, railways, and river routes linking Manaus and major agricultural production zones to Pacific ports will significantly reduce transit times and costs for exporting grains, beef, and iron ore to Asia, particularly China. These plans reflect a revival of development strategies dating back to Brazil's military era (1960s–70s), and connect with the broader Chinese Belt and Road Initiative.[836]

A comprehensive mapping of road infrastructure in 2022 found that 41% of the Brazilian Amazon is already cut by roads or lies within 10 km of one. The researchers identified 3.46 million km of roads, an estimated 86% of which were unofficially built and used by illegal loggers, gold miners, and settlers.[837] Earlier research found that 95% of deforestation occurs within 5.5 km of roads, and 85% of fires occur within 5 km.[838]

Impact scenario

Considering the finding that total human impact footprints of first-cut roads reach up to 1.9 km^2 per km in the Brazilian Amazon,[839] we estimate that the 230 km extension of the BR-364 highway, which would connect Juruá in western Acre with Pucallpa in Peru, may alone impact an estimated 440 km^2. The road would cut through the Serra do Divisor park, a highly biodiverse area and home to Indigenous Peoples living in voluntary isolation.[840]

The **BR-319 highway,** which connects Manaus in the central Amazon with Porto Velho in the southern part, is discussed as another critical infrastructure connector in the Brazilian part of the basin. Built in the 1970s, it was abandoned in the 80s until a maintenance programme made it passable again in the dry season since 2015.[841] The road is already recognised as a significant driver of deforestation, and its planned reconstruction, combined with its proximity to other road corridors, raises serious concerns about the potential uncontrollable impacts on surrounding forests.[842] In fact, the announcement of the reconstruction already caused an uptick in illegal deforestation and fires in the vicinity of the road.[843] Considering its economic unviability and more efficient transport routes with river barges, politicians in Manaus hoping for votes are seen as the main beneficiaries. A key concern is the planned branch highway AM-366, which would cross initial drilling blocks of the Solimões Sedimentary Basin oil and gas project—an area larger than the state of California. Illegal side roads are expected to flourish, with one already following the AM-366 and cutting through Indigenous territory and a national park.[844]

The Lula administration agreed in 2023 to incorporate the BR-319 into the Amazon development plan, meaning that one of the most preserved forest areas in the central Amazon would be linked to the so-called Amazonian arc of deforestation.[845] President Lula signed a contract for the paving of 52 km in September 2024, and promised to launch work on the most controversial section stretching 400 km through old-growth forest before the end of his term in 2026.[846]

Impact scenario

A study by Santos et al. concluded that, if the current status of the BR-319 is maintained without paving, deforestation would increase by ~200% until 2050, totalling 116,000 km^2 against a 2021 baseline. If paving were to start in 2025, the increase would reach 224% by 2050, or 129,000 km^2. Until 2100, these impacts would reach, respectively, 351,000 km^2 and 411,000 km^2.[847]

Another long-planned infrastructure project is the private sector-backed **Ferrogrão railway**, which is intended to connect Mato Grosso state with the port of Miritituba in Pará.[848] In a 2024 assessment, a panel of scientists highlighted flaws and gaps in the Environmental Feasibility Assessment, particularly in relation to cumulative impacts and projected deforestation.[849] Moreover, the Ferrogrão will affect six indigenous lands, 17 conservation units and three isolated peoples.[850]

Impact scenario

Currently in the planning stage,[851] the highly controversial Ferrogrão project in the Brazilian Amazon is estimated to result in 400 km^2 of deforestation during its first decade. Researchers further concluded that a 1% increase in market access would result in a roughly 0.5% increase in deforestation.[852]

Importantly, **protected areas** strongly mitigate the risk of deforestation from road infrastructure, whether legal or illegal.[853] Research in the Brazilian Amazon found that protected areas near roads and rivers had a deforestation rate of 10.9% while unprotected areas had a fourfold rate of 43.6%.[854]

Hundreds of existing hydroelectric plants and the resulting altered flow of more than 1,100 tributaries have an important direct and indirect impact on surrounding forests.[855] During the last ten years, no new bids for medium- or large-scale hydropower projects had been put forward in Brazil.[856] However, in 2024, energy company Eletrobras announced the revival of plans for a mega-project on the Tapajós River by asking the regulatory authority for a renewal of registration. The project had been removed from the Ten-Year-Energy Plan in 2016 due to its severe environmental and social impacts. The São Luiz do Tapajós reservoir would be formed in a pristine area of the forest and cover an area of 137,000 ha.[857]

Meanwhile, changing rainfall patterns induced by climate change, which is, in turn, accelerated by Amazon deforestation, have already had negative impacts on hydropower generation.[858]

Colombia

Illegal roads pose a major forest risk in the Colombian Amazon. Despite the government's public anti-deforestation pledges, operations to dismantle illegal roads largely stalled in 2024 amid security concerns and worries about undermining peace talks with rebels.[859]

Colombia's Inspector General's Office has identified more than 1,100 km of irregular roads. These are mostly dirt tracks that cut through seven deforestation hotspots. Between October 2024 and March 2025 alone, 888 km^2 of deforestation was identified. Several of the roads were found within or near national parks. A direct link was found between road expansion, deforestation, and illicit coca crops. The new road infrastructure connects illicit crop areas with strategic corridors leading to rivers, main roads, and, at times, the coast.[860]

Similarly, research by the Monitoring of the Andean Amazon Project (MAAP) and the Foundation for Conservation and Sustainable Development Colombia (FCDS) documented that between January 2024 and March 2025, more than 14 km^2 of forest were cleared in Chiribiquete National Park and the Llanos del Yarí-Yaguará II Indigenous Reserve due to the opening of more than 100 km of illegal roads within the areas. The road expansion is driven by the presence of armed guerrilla groups and cattle ranching interests, which in turn drives land-grabbing.[861]

Peru

In Peru, the indigenous peoples in the Kakataibo Territory are in conflict with invaders in search of land for cattle-raising, coca plantations and mining, which threatens the protected areas in the region (Kakataibo Indigenous Reserves, Protected Natural Areas and Kakataibo Native Communities). This pressure has been increased by road construction in the region, particularly **Interstate Federico Basadre (PE-18C/5N)**, which cuts through the ancestral territory. The planned highway to improve international transit connections between Pucallpa, Peru, and Cruzeiro do Sul, in the Brazilian state of Acre, will further increase the pressure on these territories.[862]

6.6.2 Congo Basin

While small-scale agriculture and fuelwood collection are widely recognised as major drivers of forest loss and degradation in the Congo Basin, the impact of infrastructure projects has received less attention. These projects are often linked to extractive industries, and could significantly impact the forests in the coming years. Built-up areas in the Congo Basin, consisting of infrastructure and settlements, increased from 1,400 km^2 in 1990 to 47,000 km^2 in 2020. Under three population and climate scenarios, Yuh et al. forecast a further expansion of built-up areas to 462,000 km^2 to 566,000 km^2 by 2050, largely at the expense of forest areas. This development is heavily influenced by expected population growth and growing urbanised areas, as well as transport infrastructure like roads, railroads, bridges, and ports.[863]

The Congo Basin countries are crisscrossed by various **development corridors.** These include infrastructure projects that have been partly realised already, with the highest density in the DRC, Cameroon and the RoC. The projects aim to increase agricultural and mining production, mineral exports, and broader economic integration.[864] There is broad recognition of the Congo Basin countries' need for development. However, new infrastructure projects in the Congo Basin receive little scrutiny by policymakers despite potentially major, irreversible impacts on the environment, biodiversity, ecosystem services, and the livelihoods of IPs and LCs. Current planning and development frameworks lack robustness to support rigorous impact assessment or comprehensive mitigation plans. These findings highlight the urgent need to integrate environmental, social and economic factors in forest conservation management planning.[865]

While the status of infrastructure projects in the Congo Basin is often unclear or progresses slowly, the development pace appears to be increasing.[866] The following sections can only describe some relevant developments, but it is very likely that these and other infrastructure projects will significantly impact the rainforest of the Congo Basin in the years to come. Research by Shapiro et al. found that ~80% of all deforestation in the Congo Basin was located within 3 km of the nearest road or settlement, while degradation commonly extends somewhat further, with 80% of degradation occurring within 4 km of the nearest road or settlement.[867]

Informal road networks play an important role in facilitating industrial selective logging, which is conducted in large parts of the Congo Basin. Under these specific local conditions, road development is typically associated with degradation rather than deforestation. Unpaved logging roads, especially those located within logging concessions, are typically abandoned after a few years, allowing the forest to regenerate. However, the recent expansion of logging roads raises concerns about more severe impacts on forests and biodiversity,[868] as the temporary roads can serve as catalysts for settlement, logging, agriculture, and mining in remote forest areas.

Research by Slagter et al. covering the period 2019 to 2022 found that, on average, 4.9 m of roads were developed annually per km^2 of forest, ranging from 0.5 m in the DRC to 17.6 m in Equatorial Guinea. Between 2019 and 2022, ~37,200 km of new roads were mapped, 78% of them inside logging concessions in the western Congo Basin. Over this period, annual road building increased from 7,846 km in 2019 to 10,196 km in 2022—an increase of about 30%.[869] The two years until 2024 added another 20,000 km to the network.[870]

Impact scenarios

Applying a five-year rolling average under a business-as-usual (BAU) scenario, we estimate that these trends may result in the development of ~60,000 km of additional roads throughout the Congo Basin by 2030. Under a conservative assumption of a static annual forest loss rate of 1% within 1 km of logging roads (based on 0.7% inside concessions and 1.3% outside concessions) as observed by Kleinschroth et al.,[871] this could lead to an estimated accumulated forest loss of 5% over an area of 120,000 km^2, or the equivalent of 6,000 km^2 by 2030.

Beyond extensive informal road networks, the Congo Basin is also crossed by two of the **Trans-African Highways** under development, passing through rainforests and several protected areas:

- *Tripoli – Windhoek (– Cape Town) Highway 3* crosses the Congo Basin in Cameroon, the Central African Republic, the RoC, and the DRC, with unpaved sections in Cameroon, the Central African Republic, and the Republic of Congo.
- *Lagos—Mombasa Highway 8* crosses the Congo Basin in Cameroon and the Central African Republic, with large unpaved sections in Cameroon, the Central African Republic, and the DRC.

Combined with the finding that 1 km of first-cut road in the Congo Basin on average attracts 4.8 km of secondary road,[872] the construction of missing links and the competition of unpaved highway sections could severely heighten the threat to the integrity of unique and biologically rich forests in the Congo Basin if sustainable forest management and effective monitoring systems are lacking.[873]

The US-EU-backed public-private partnership to develop the 1,300 km **Lobito Atlantic Railway Corridor** connecting the resource-rich DRC and Zambia with the Atlantic Coast in Angola could become another factor to consider in the region's deforestation dynamics.[874] It is anticipated to transport 1,700 Mt of freight per year by 2028, 3,000 Mt by 2033, and 5,000 Mt from 2043 onwards.[875] A trial run has taken place, but project competition is only expected for 2029.[876] The railway project is driven by the interest to bolster the export of 'critical' minerals (copper, cobalt) from the 'Copper Belt'.[877] While running along the edge of the Congo Basin Forest, it will likely link to the forest impacts of expanding mineral mining (→ section 3.2.4).[878] Minerals are currently predominantly transported by truck to ports in South Africa, Tanzania and Mozambique. The Lobito Corridor initiative aims to improve and expand the existing railway and supporting infrastructure to facilitate more time- and cost-efficient flows of 'critical' minerals to the port of Lobito in Angola and export destinations in the EU and the US.[879]

Funded by the US and the EU, alongside the African Development Bank and the African Finance Corporation,[880] project proponents praise its development for its potential economic benefits. Critics fear 'modern plundering'[881] with little local benefits.[882] The railroad necessitates land acquisition and community relocation,[883] raising concerns about fair compensation, FPIC, and the protection of marginalised peoples.[884] It may become a catalyst for growing settlements, logging, agricultural production and other economic activities in the catchment area of the transport corridor and into the Congo Basin rainforest.

The EU committed, among others, to supporting effective consultation of civil society, local communities and Indigenous peoples.[885] The EU's Memoranda of Understanding (MoU) with the DRC and Zambia on 'sustainable raw materials' refer to cooperation to achieve socially and environmentally responsible mining and sourcing.[886] However, poor human rights records in DRC cobalt mines raise doubts about the enforceability of sustainability and due diligence requirements, especially towards Chinese companies and artisanal miners.[887]

Similar expected impacts are connected to the **railway line** connecting the large cross-border iron ore deposits in **Cameroon** and the **RoC** to **Cameroon**'s new Kribi port. Construction through a China-linked consortium began in 2023.[888]

The Congo River is considered to have tremendous potential for hydropower.[889] At the same time, only a small share of the local population has access to electricity, estimated at one-fifth for the DRC. The DRC government aims to bring this share to 60% by 2030.[890] However, the energy needs of the mining industry seem at times to be more important drivers of hydropower development plans than tackling energy poverty among the local population. The **Grand Inga Dam** project is a series of seven proposed hydroelectric power stations at the Inga Falls in the DRC. At a projected output of 40 to 70 GW, it would generate more than twice the capacity of China's Three Gorges Dam, currently the world's largest hydropower facility. Grand Inga so far remains largely aspirational, facing a range of financial, institutional, and social challenges. Advocates argue it could bring the desperately needed improvement to Africa's energy security, create jobs and raise household incomes. Critics highlight severe social and environmental impacts and the previous failure of attempts to harness the power of the Congo River.[891] The first Inga dams from the 70s and 80s now run at less than half capacity, primarily serving cobalt and copper mines and export markets.[892] As part of the new project, the Bundi Valley would be flooded. Alterations in the Congo River's hydrology pose significant threats to local ecosystems and wildlife. Moreover, 30,000 to 60,000 people would face displacement, with impacts particularly affecting women.[893]

The estimated US$80 billion (€68 billion) cost has deterred investors, especially in a country with weak institutional oversight, widespread corruption, and conflict. Key backers, notably China's Three Gorges Corporation, exited the project in early 2025, citing poor return prospects and governance concerns.[894] While the project was long stalled, the World Bank resumed discussions in late 2024,[895] and a pan-African alliance of financial institutions aims to mobilise private investment.[896] In June 2025, the World Bank pledged US$1 billion to advance DRC hydropower projects, including US$250 million (€213 million) for Inga III under its *Mission 300* programme, which aims to connect 300 million Africans to electricity by 2030.[897] Beyond regional demand, interest comes from local mining companies[898] and countries like Germany, exploring options to produce low-cost green hydrogen in the DRC.[899]

In late 2024, the African Export-Import Bank (Afreximbank) announced the financing of the development of a 200 MW hydropower station on the **Lufira River**, also in the DRC. The dam's main aim is to provide electricity for mining companies, enabling the domestic processing of minerals such as copper and cobalt and fostering value retention.[900]

Other energy-related infrastructure includes the development of oil pipelines linked to the ongoing expansion of oil exploration in the Basin region. The **Pointe-Noire–Ouesso project**, owned by state-owned Société Nationale des Petroles du Congo, is expected to commence operations in 2029.[901] The proposed 1,200 km pipeline in the RoC would connect Pointe Noire in the South, via Brazzaville and Oyo, to Ouesso in the North.[902] In June 2025, the Russian government formally approved an agreement to partner in the project under a build-own-operate-transfer agreement.[903] The pipeline could significantly threaten the Cuvette peatlands, a globally critical carbon sink. The project's importance is growing as the country pursues oil development in the north, since any oil extracted would require a southbound export route (→ section 3.4.6). The pipeline would cross several already allocated oil blocks in the Cuvette region, threatening to accelerate the exploitation of sensitive peatland regions and including forest areas inhabited by Indigenous Peoples and local communities.[904]

6.6.3 Southeast Asia-Oceania

Asia is currently at the global forefront of infrastructure development, driven by China's **Belt and Road Initiative**, which spans 72 countries and affects many fragile habitats (→ section 3.2.2). The initiative is supported by ambitious national plans, such as road and hydropower development in Myanmar and Malaysia, and economic development plans in Indonesia.[905] It is expected to have far-reaching impacts on protected areas and key biodiversity areas in Southeast Asia. Infrastructure development is also a quickly developing sector in Indonesia and PNG.

Papua New Guinea

Although New Guinea is the world's biggest tropical island, it lacks a dependable road network. Currently, about a fifth of PNG's population has no access to roads at all. However, logging and mining roads have already facilitated access to resource frontiers and contributed to forest loss in the recent past.[906] In 2020, the government announced the **Connect PNG** programme, which revives plans for a massive extension of the country's road network. It is described as "*Papua New Guinea's most ambitious and transformative infrastructure initiative*".[907] The 20-year development initiative aims to spur economic development by connecting the most remote areas of the island through a network of national highways, bridges, provincial and district roads.[908] By bridging 'missing links'—priority projects to link the existing disjointed roads—and developing strategic corridors, the programme is meant to create positive impacts for communities through inclusive economic development and job creation.[909]

Throughout the twenty-year period, it aims to construct and maintain 16,000 km of roads. The government's Medium-Term Plan foresees the completion of 16 priority national highways, totalling over 4,200 km, and 1,800 km of 'Missing Link' roads by 2027, including the Trans-Island Highway connecting Lae to Port Moresby and the New Britain Highway linking Kimbe to Kokopo.[910]

While economic growth and access to markets, healthcare and education for remote communities would undoubtedly benefit from infrastructure development, the planned massive expansion is linked to serious environmental and broader societal risks if not accompanied by strict socio-environmental safeguards. According to a 2019 study,[aa] the proposed road network would dissect more than 50 critical biodiversity habitats, nine of which are protected, traversing highly biodiverse rainforests and carbon-rich peatlands.[911]

In line with commonly observed tropical deforestation patterns, local deforestation rates in PNG typically show strong spatial links with current road infrastructure. Therefore, new deforestation fronts are likely to develop in current forested areas near planned missing links and other proposed roads, as well as in areas adjacent to existing deforestation zones, attracting and

[aa] The intention at the time was still to double the national roadwork to 15,000 km until 2023; this plan was delayed and later adjusted to the current 2040 timeline with multiple milestones.

accelerating logging, plantations, mining, and other human activities that lead to intensified forest loss, degradation, and fragmentation.

Impact scenario

Based on a conservative estimate of 1 km spatial extent of the road impacts, Alamgir et al. project that ~6,800 km^2 (or ~3,740 km^2 of connectivity forests and ~3,080 km^2 of core forests) will be lost as a result of the road developments.[bb,912]

Using a less conservative approach, applying the estimate of total human impact footprints of first-cut roads of up to 2.7 km^2 in New Guinea as reported by Engert et al.,[913] we estimate that the plans of establishing 6,000 km of road network until 2027 may impact ~16,000 km^2 of forest, while the complete plans of 16,000 km could affect as much as ~44,000 km^2 or almost 10% of the country's surface area to be opened up for plantations, logging, mining, and other economic activities.

In addition to loss of biodiversity and ecological connectivity, other detrimental impacts include massive greenhouse gas emissions and disrupted water systems. Many of the roads traverse steep, high-rainfall terrain, increasing the risk of landslides and high infrastructure costs. Roads crossing rainforests and carbon-rich peatlands contradict PNG's climate goals and sustainable development ambitions.[914]

Indonesia

The forest of Tanah Papua is also increasingly threatened by infrastructure and plantation expansion. A major driver of deforestation is the Trans-Papua Highway, planned to span over 4,300 km from Sorong City in Southwest Papua to Merauke in South Papua. Although largely connected, many sections remain unpaved and incomplete due to security and logistical challenges.[915] It cuts through sensitive forest areas, including Lorentz National Park. As known from other studies, the risk of deforestation increases significantly near roads, with forest areas exposed to risk increasing by 30% compared to a no-expansion scenario. Lowland areas, especially near Dekai and Kenyam, were found to be particularly vulnerable.[916]

Positive correlations between highway and plantation expansion suggest that these processes are linked. The Indonesian government earmarked 26,200 km^2 of land for the development of industrial plantations (90% palm oil, 10% pulpwood), of which 74% (19,500 km^2) remained forest in 2019. Despite the 2018 Manokwari Declaration,[917] in which provincial governments pledged to conserve 70% of Papua's land, implementation has been weak. Ongoing land rights disputes, such as the Tanah Merah case,[918] highlight governance challenges and the vulnerability of Indigenous territories to large-scale concessions.[919]

Impact scenario

A spatial model by Gaveau et al. suggested that under a BAU scenario, where development trends, including road construction, continue along similar trajectories as observed in Kalimantan, 45,000 km^2 or ~13% of New Guinea's forests could be lost by 2036 versus 2019 due to the anticipated plantations, mining, food estates and associated influx of labour facilitated by roads.[920]

6.7 Financial flows

Financial institutions (FIs) play a critical role in enabling the expansion and daily operations of business activities. Financing through loans and credits, as well as investments in shares and bonds, can support the acquisition of land, concession areas, buildings, and equipment, and the development and maintenance of mills, refineries, silos, warehouses, and irrigation systems. It can

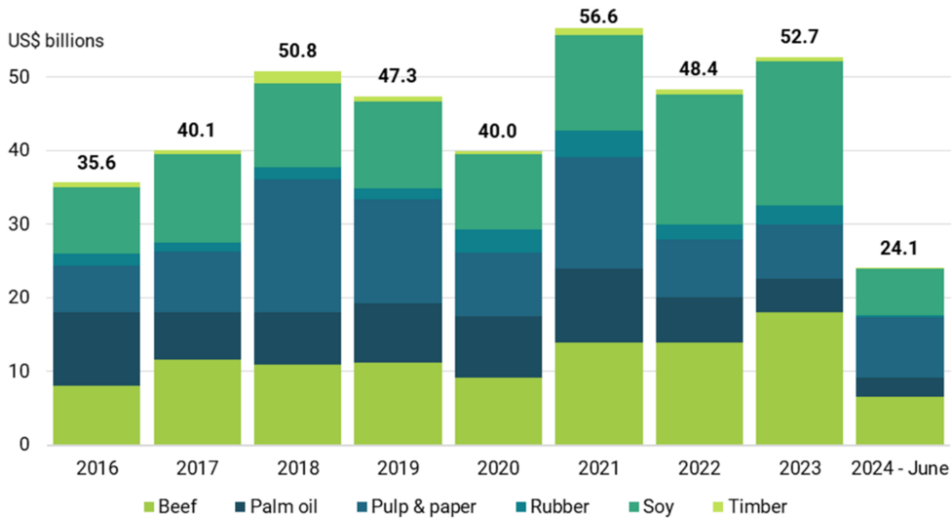
[bb] Connectivity forests are critical to maintain connectivity between different forest patches in a landscape; core forests maintain unique forested habitat for biodiversity in a landscape.

also be used to finance activities like land clearing, planting, and research and development, among others.

Future deforestation risks are significantly influenced by whether or not financing is tied to strict environmental and social safeguards. For example, if a company receives a loan to acquire a new concession area but the loan is not conditioned on zero-deforestation of primary forests, primary forests in the concession may be cleared for the development of its operations. Similarly, even indirect financing, such as a loan for mill construction, can contribute to deforestation if it is not conditioned on zero deforestation, including for third-party suppliers to the mill.

The Forests & Finance online data platform tracks financial flows to six forest-risk sectors (beef, palm oil, pulp & paper, rubber, soy and timber) in three forest-rich regions: Southeast Asia, South America (with a focus on the Amazon) and Central & West Africa (the Congo Basin in particular). Annual financial flows to these sectors, while fluctuating, have been gradually increasing since 2016 as demand for these commodities continues to grow (Figure 26). Average annual flows of US$44 billion (€37 billion) and a total of US$395 billion (€337 billion) in forest-risk credit between 2016 and June 2024 clearly demonstrate the critical role of the financial sector in supporting the development of forest-risk commodities.

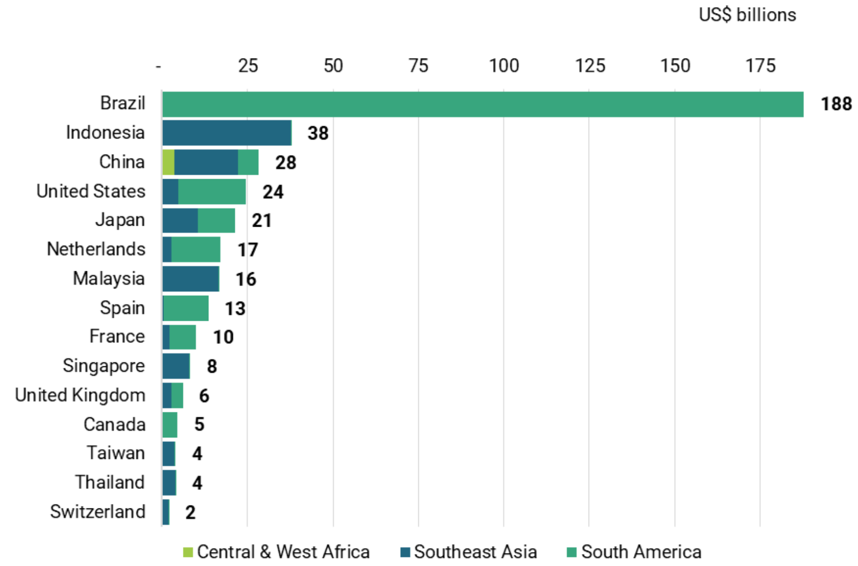
Figure 26 Loans & underwriting services to forest risk companies, 2016 to 2024 June



Source: Own elaboration, based on: *Forests & Finance* (n.d.), "Data deep dive", online: https://forestsandfinance.org/.

In the period 2016 to June 2024, ~69% of all identified forest-risk attributable credit flowed to South America, 30% to Southeast Asia, and 1% to Central & West Africa. Most identified forest-risk credit was provided by Brazilian FIs and went to companies active in the region (Figure 27). Indonesian FIs similarly directed their financing to the region. Chinese FIs provided loans and underwriting services to all three forest-rich biomes, and US-based FIs predominantly targeted South America and Southeast Asia.

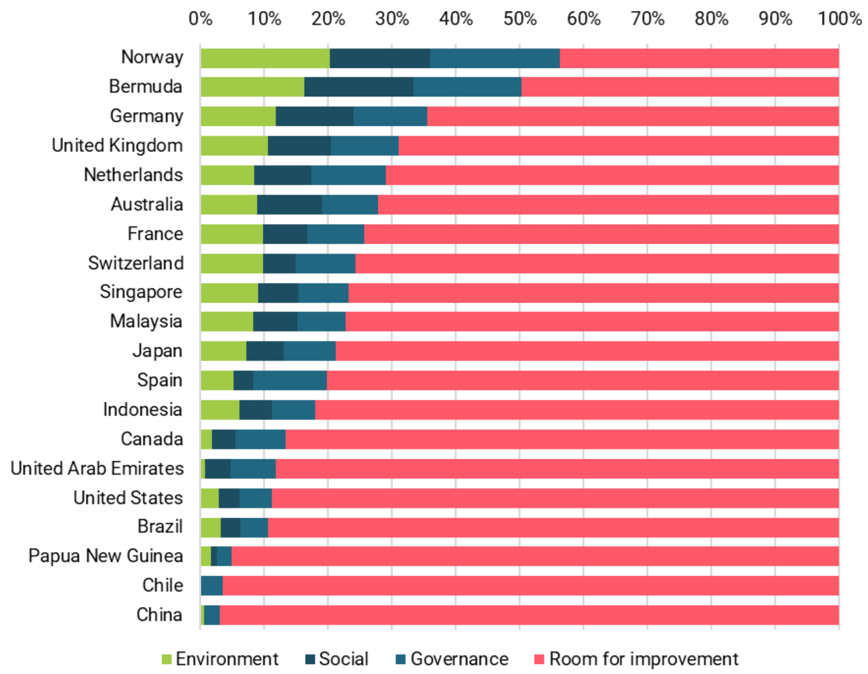
Figure 27 **Forest risk sector financier country of origin, 2016 to 2024 June**



Source: Own elaboration, based on *Forests & Finance* (n.d.), "Data deep dive", online: https://forestsandfinance.org/.

Efforts to prevent deforestation linked to finance rely on financial market regulation, voluntary institutional policies, and civil society pressure. The Forests & Finance coalition evaluates whether financial institutions incorporate 38 criteria, derived from international standards and best practices, into their lending and investment policies (Figure 28). Ensuring that clients and investees meet these criteria helps financial institutions avoid contributing to deforestation and related environmental, social, and governance (ESG) risks. The assessment finds that financial institutions from the largest forest-risk credit providers (Brazil, China, Indonesia, and the US) score the lowest, indicating significant room for improvement. Current forest-risk policies fall short in adequately addressing key risks in forest commodity supply chains.

Figure 28 **Average forest-risk policy scores per financial institution country (2023)**



Source: Own elaboration, based on *Forests & Finance* (n.d.), "Policy scores", online: https://forestsandfinance.org/.

Strong regulations are needed to address the absence of strong voluntary forest-risk policies among FIs financing forest-risk commodities, and thereby mitigate the risks of deforestation . However, an assessment of **financial sector regulations** in five key jurisdictions (Brazil, China, EU, Indonesia and the US) found that none had measures in place to mitigate deforestation or landscape conversions.[921] As such, both financial institutions' voluntary policies and the relevant financial sector regulations are falling short in preventing forest loss.

Companies engaged in the development of forest commodities can also receive funding from **national and international development banks**, as well as government subsidies. Financing from national development banks is often more targeted at socio-economic development objectives. As a result, environmental safeguards may receive less attention in the design of support programmes. International development banks may have stronger safeguards in place, and many will refer to the World Bank's International Finance Corporation's (IFC) Performance Standards on Environmental and Social Sustainability, which provide guidance on how to identify and mitigate risks and impacts when providing financing.[922] The proportion of international development bank financing provided to forest commodity development is much smaller than that provided by national development banks and national and international commercial banks.

In addition to loans and underwriting services attracted from commercial banks, (concessional) loans and grants attracted from national and international development banks, companies engaged in forest commodities can also receive **government subsidies** for their activities. These can vary from tax breaks and price support to direct payments and input support. While the intention of these subsidies is positive, namely to support agricultural producers in their socio-economic development, they can often lead to unintentional and sometimes unforeseen negative environmental consequences. These are known as Environmentally Harmful Subsidies (EHS). These subsidies can lead to the degradation of ecosystems, depletion of natural resources, distort the markets for agricultural products, and often misallocate resources.[923] For example, livestock subsidies in the US can lead to deforestation in Brazil through the increased demand for soy as feedstock. According to the IFC, an estimated 22,000 km^2 of deforestation annually is attributable to producer support, equivalent to ~14% of total and 37% of agriculture-driven deforestation.[924]

In a similar vein, even well-intentioned 'green' or 'sustainable' funds are sometimes at risk of causing deforestation when transparency and safeguards are lacking. For example, the Indonesian government has committed to reducing its reliance on coal. To this end, it has received investments from the United Nations Development Programme (UNDP) and the Norwegian government in its Indonesian Environment Fund (IEF). This fund has financed a biomass power plant in Papua. The company developing the project, Medco Group, has cleared primary forests to establish timber plantations for biomass feedstock.[925]

6.8 Sustainability initiatives and monitoring tools

Efforts to reduce deforestation linked to commodity production are advancing rapidly, driven by technological innovation, voluntary commitments, regulatory pressure, and civil society engagement. These initiatives aim to increase transparency, improve accountability, and shift production practices to limit forest loss.

6.8.1 Technology and monitoring tools

New tools are rapidly enhancing visibility into supply chains and forest risks, while supporting the assessment of risks of non-compliance with legality and corporate requirements. Platforms like Trase allow tracing commodity flows back to source regions, while systems such as Global Forest Watch (GFW) use satellite imagery and remote sensing to publish real-time deforestation alerts. Emerging applications of AI and machine learning use geospatial, socio-economic, and production data to predict emerging forest risk.[926] These innovations are gaining momentum alongside regulatory developments, such as the EUDR. It remains difficult to quantify the exact impact of these tools, but an evaluation of GFW suggests they have already contributed to reduced deforestation in monitored areas.[927]

6.8.2 Voluntary certification standards and audits on due diligence

Many companies have adopted voluntary sustainability commitments or use third-party certification schemes to demonstrate responsible sourcing. While voluntary initiatives can help drive improvements, their effectiveness is limited by the absence of enforcement mechanisms, insufficient independent auditing requirements, varying levels of assessment rigour and assurance, and other gaps.[928] Voluntary initiatives alone are inadequate to prevent deforestation, and rather signal a lack of adequate, mandatory due diligence legislation or of its enforcement.[929]

Legislative initiatives for human rights and environmental due diligence may also over-rely on questionable private-sector assurances, owing to successful industry framing. A recent study by Gustafsson et al. investigated businesses' approach to the EU's due diligence directive (→ section 6.3.4). They found that, particularly, the efforts by businesses to institutionalise voluntary standards and push for private assurances to indicate legal compliance are well presented in the CSDDD.[930]

6.9 Corporate strategies and lobbying

Across sectors with large environmental and social footprints, such as fossil fuels or cattle, many incumbents are still pursuing a "produce more, for longer" strategy and resisting a Paris-aligned transition plan as long as regulations and markets do not force them to stop.[931] Rather than changing their practices and business models, powerful firms and trade groups from agriculture and food, energy, or the car industry have lobbied hard to dilute rules and keep the status quo. Investigations found that ExxonMobil pushed to weaken or overturn the EU CSDDD (→ section 6.3.4), including lobbying the Trump administration,[932] while broader business coalitions worked to narrow the directive's scope.[933] Recent reports confirm that a majority group in the EU Parliament agreed to further weaken the law.[934]

6.10 Civil society action and political backlash

CSOs have played a crucial role in exposing deforestation drivers, increasing supply chain transparency, and advocating land tenure security for Indigenous Peoples and local communities. Their efforts in both producing and consuming countries have been instrumental in bringing deforestation to the forefront of public and political discourse.[935] However, CSOs often rely on public funding and grants that are vulnerable to political shifts. The rise of populist and conservative governments in many countries has led to funding cuts and political resistance, including in the US under the Trump administration, bringing long-running support to efforts to fight deforestation, habitat loss, and wildlife trafficking to an abrupt end.[936] Similarly, the discussions around freezing the European Union's EU Life Programme, pushed forward by conservative and right-wing politicians,[937] risks effectively shutting down the operations of several environmental NGOs.[938]

Meanwhile, companies and individuals profiting from commodities covered by the EUDR attempted to weaken the regulation behind the scenes[939] and have made sizable donations to EU political parties that are in favour of delaying and diluting the law.[940]

6.11 Climate change

Climate change is a cross-cutting issue, projected to interact with other drivers of land use change to substantially alter land use and land cover change in the long-term. It will likely affect socioeconomic variables such as wood extraction, cash crop prices, and agricultural and infrastructural expansions; soil erosion; and institutional factors related to forest policies and forest governance.[941]

In a so-called positive feedback loop, deforestation causes drought, which in turn worsens deforestation, intensifying the impacts.[942] Findings from the Brazilian Amazon indicate that its regional climate and rainfall patterns are more strongly influenced by forest loss than by changes in the global climate.[943] Changing climate patterns already influence agriculture, infrastructure, health, and migration in many parts of the world. For example, temperature increases are likely to shift coffee cultivation to higher altitudes, increasing the risk that high-altitude forests are converted.[944] Similarly, areas in West Africa become less suitable for cocoa cultivation, leading to a displacement to forested areas in Central African countries.[945]

The mix of climate change impacts and commodity-driven deforestation intensifies the impact of forest fires. Forest fires occur naturally, but are almost entirely human-induced in tropical rainforests, where they are often started to clear land for agriculture and spread out of control into nearby forests.[946] According to the World Resources Institute (WRI), in 2024, fires burned five times more tropical primary forest than in the year before. A mix of already active climate change impacts and the climate phenomenon El Niño made 2024 the hottest and driest year on record, with larger and more widespread fires. The impact was particularly strong in Latin America, ending the reduction in primary forest loss seen in Brazil and Colombia in 2023. While forests can recover from fires, the combined effects of climate change and the conversion of forests to other land uses like agriculture can make this recovery more difficult and increase the risk of future fires.[947]

7

Conclusions and recommendations

This research examined the expected role of commodities and market dynamics in driving tropical rainforest loss, focusing on the complex interplay between commodity production, demand trends, global trade dynamics, and shifting socioeconomic and policy priorities. This chapter draws conclusions and provides recommendations for key stakeholder groups.

7.1 Sectors and scenarios

Tropical deforestation remains a critical challenge, undermining biodiversity, water cycles, climate stability, and the livelihoods of millions. Forest-risk commodities from agriculture, forestry, and extractive industries drive both deforestation and related human-rights risks. Despite regulations, zero-deforestation pledges, and certification schemes, deforestation has not yet been halted. Outcomes continue to be shaped by volatile markets, economic interests, inequality, political shifts, and global demand trends that will influence commodity production, supply, and the state of rainforests in the years ahead.

The Amazon, the Congo Basin, and Southeast Asia-Oceania are home to the largest remaining primary tropical rainforests, as well as extensive secondary forests. Commodity markets have been a particularly large driver of recent deforestation; rising demand may intensify pressure on remaining intact forests in the years to come. It is therefore vital to ensure that commercial activity and markets do not lead to deforestation, ecosystem degradation, or rights violations.

Economic drivers can impact forests directly (through plantations, pastures, logging, mining, fossil fuel extraction) and indirectly (via transport and energy infrastructure, mills and refineries, settlements, speculative clearing), with varying risk profiles across the three basins.

Our forward-looking analysis maps where, how, and how much key commodities are likely to be produced, traded, and consumed, and how these trends pose risks to tropical rainforests. It focuses on three commercial complexes and related industry sectors, whose characteristics are expected to be highly relevant for markets and future pressures on the three rainforest basins. These are sectors linked to 1) energy systems, 2) food systems, and 3) consumerism and emerging forest-risk trends. Based on a mapping of medium-term trends and impacts at the intersection of global trade, technological development, and shifting socioeconomic and policy priorities, this report explores different pathways and their potential impacts on tropical forests. In this context, the report examines how policy and market trends could accelerate or slow forest loss, and develops recommendations to reduce forest risk and promote equity in global supply chains.

Global demand trajectories, production-side governance, and demand-side measures are crucial underlying factors that shape outcomes. For each economic complex, three scenarios are considered that help understand future threats and their mitigation:

- A **pressured expansion**, with a weak governance environment, continuous demand growth, and unrelenting expansion affecting tropical rainforests.
- A **managed transition**, with improved governance systems (for example, transparency in global supply chains) on the production and demand side, and controlled or flat expansion.

- A r**esource-light shift**, with strict governance on both ends of supply chains, sufficiency and durability norms, and equitable resource distribution that provides a decent living standard for all.

Pressured expansion pathways are undesirable for any commercial complex, as they could have devastating impacts on tropical rainforest basins, with wide-reaching effects on biodiversity, climate, and the livelihoods of Indigenous peoples and local communities (IPs and LCs). Facilitating a managed and just transition, and preferably an accelerated shift towards a resource-light system, would bring the best outcomes for forests, biodiversity, climate, and people.

The conclusions on how to achieve a managed transition and ultimately shift towards a resource-light system for each complex discussed in this report are partly sector-specific but also overlap. This is due to cross-commodity and underlying dynamics identified in the report, as well as the fact that, for example, agricultural production is relevant to both food and energy. Governance measures, such as increased supply chain transparency, oversight and traceability, in particular, have broad applicability across sectors.

7.1.1 Energy systems

Global energy demand is projected to keep rising. Markets are steered by policy, industrial strategy, geopolitics, trade, and innovation, and show a high degree of volatility. Paris-aligned decarbonisation is driving uptake of renewables and electrification, while power needs from industry, e-mobility, cooling, data centres, and AI surge despite efficiency gains. Renewables are scaling quickly, but face near-term uncertainty from policy swings, industry lobbying, and market volatility. Fossil fuels still dominate the global market, but face weakening and uneven prospects. Security concerns and efforts to limit import dependencies increasingly shape policies worldwide, with bioenergy seen by many countries as a means to promote energy self-sufficiency.

Rather than an overall transition, a layering of energy systems can be observed, with different forest-risk trends occurring simultaneously:

- Minerals for renewable technologies are in high and rising demand;
- Increasing volumes of vegetable oils, grains, and forest products are used for biofuels and biomass; and
- Fossil fuel companies frenetically keep developing new reserves to extend their existence.

Notwithstanding the importance of a just energy transition, these pathways are highly land- and resource-intensive, especially in the context of current cumulative development. This trajectory risks creating new dependencies and greater pressures on tropical rainforests and frontiers in the absence of strong governance, ambitious policies, and socioenvironmental safeguards.

'Critical' mineral mining

Regardless of the scenario, demand for 'critical' minerals for renewable energy technologies is expected to grow significantly in the coming decades. Mining is linked to direct deforestation and widespread, yet often underestimated, indirect forest loss. Tropical rainforests across the three basins show extensive overlap with 'critical' mineral reserves and concessions, especially in Brazil and Indonesia. In the Brazilian Amazon, Pará is a hotspot for 'critical' mineral mining applications. Indonesia's role as the world's largest nickel producer has already been linked to widespread forest loss, and current forecasts expect further demand increases for the mineral. For example, market developments in the global EV fleet until 2050 may be linked to estimated cumulative deforestation of ~1,500 km^2 to ~4,700 km^2 under a business-as-usual (BAU) scenario for transport patterns, depending on the dominant battery technology. Improved chemistries and sufficiency measures can significantly reduce the forest footprint of this industry, with gains from nickel-free battery chemistries particularly high for Indonesia. The direct footprint of five 'critical' mineral mining projects in planning, advanced permitting, or potential expansion phases in Papua New Guinea (PNG) is estimated to be ~580 km^2. All these estimates would increase significantly by incorporating the much larger indirect deforestation impact driven by supply chain and transportation infrastructure, energy supply and settlement expansion.

Bioenergy

Rising demand for and production of first-generation biofuels and wood pellets increase pressure on tropical rainforests in the Amazon and Southeast Asia-Oceania. The availability of sustainable waste feedstocks is limited, and markets are prone to fraud or leakage. In Indonesia, pellet co-firing policies could drive the conversion of tens of thousands of square kilometres of forest in the coming ten years. Rising biofuel mandates across various countries are reinforcing demand for palm oil, soy, and sugarcane.

The outlook for consumption increases in first-generation biofuels is particularly high for Brazil and Indonesia, driven by supportive domestic policy environments that facilitate increasing blending targets and require capacity expansions. Under a BAU scenario, the projected Brazilian biodiesel production increase by 38% by 2035 could translate into an additional soybean cultivation area of up to ~35,000 km^2. In addition to domestic forces, growing foreign and industry interest also contributes to increased demand. In combination, these demand drivers could increase existing pressure on Amazon deforestation frontiers. The pressure would be exacerbated by a suspension of the Amazon Soy Moratorium.

In Indonesia, the increasing domestic use of biomass for co-firing with coal, combined with growing foreign demand, is putting pressure on rainforests. Current government plans for power plant transformation could fuel annual deforestation rates of up to ~21,000 km^2, with the potential for total forest loss of up to ~100,000 km^2 by 2040. Ambitious biofuel targets set by the Indonesian government could also have severe impacts on forests. To meet blending targets for biodiesel, forecasts suggest a cumulative direct deforestation of up to ~9,970 km^2 in 2033 and up to ~15,000 km^2 in 2039. Considering indirect forest pressures would further increase these estimates.

Fossil fuels

Fossil fuel use in power generation and road transportation exhibits a declining trend; however, hard-to-abate sectors, such as shipping, aviation, and heavy industries, as well as increasing demand from petrochemicals, slow down the reduction. Green-field oil and gas projects in tropical rainforest countries are incentivised by industrialisation, mobility, urbanisation, and the strategy of oil & gas companies to extend their existence as long as possible, even while renewables are expanded. Energy and mining projects often overlap with IP and LC lands and protected areas: for example, rising conflict incidents are being observed in the Amazon rainforest. The extent to which potential oil and gas blocks will be developed in the tropical rainforest basins depends on political strategies and companies' willingness to deal with material risks and invest in the fossil fuel sector.

Possible scenarios

The growth of renewables, in parallel with continued fossil fuel production, will put heavy pressure on tropical rainforests under today's policies and expansion plans. A 'managed transition' with enforceable safeguards could curb losses, while it would be preferable to aim for a 'resource-light' pathway that prioritises sufficiency, circularity, efficiency and innovation over new extraction at the expense of forests and communities. Given current politics and markets, a hybrid path with part 'pressured expansion' and part 'managed transition' is the most likely near-term outcome. Clean-energy deployment is advancing, yet new fossil projects, continued demand for first-generation bioenergy, and mineral-intensive technologies without adequate safeguards will likely continue to impact tropical rainforests in the Amazon, Congo Basin, and Southeast Asia-Oceania.

7.1.2 Food systems

Agricultural expansion remains the primary direct driver of tropical deforestation and degradation. Several forest-risk agricultural commodities face competing demand for food and bioenergy, amplifying pressure on tropical rainforests.

Deforestation is driven by direct forest-to-farm conversion and indirect effects linked to globalised diets, trade, urbanisation, and growing incomes. These trends shift land use far from consuming markets ('telecoupling'), presenting particular governance challenges.[948] Globally, food commodity systems most closely linked to tropical deforestation are cattle ranching and the large-scale cultivation of oil palm, soybeans and cereals, with hotspots in the Amazon for cattle pasture and soybeans, and in Southeast Asia-Oceania for palm oil. In the Congo Basin, other drivers remain more salient for the time being.[949]

Animal proteins

Cattle pasture expansion has been the main driver of deforestation in the Amazon for years, with a particularly important role in Brazil. The government forecasts further growth in beef production over the next ten years, at 10.2% from 2024 to 2034, primarily to serve export markets, alongside domestic markets. Under a BAU scenario, this could result in the deforestation of ~57,000 km^2 in the Brazilian Amazon by 2034. Soy demand, driven by global feed markets and, to a lesser extent, food and biofuels, is putting additional pressure on the Amazon, particularly in Brazil. Demand for other cattle products also contributes to this pressure, such as for leather used in cars, furniture and fashion. Pressure on the Brazilian Amazon would likely increase further if the Amazon Soy Moratorium were to be lifted, as soy expansion may push the deforestation frontier into previously unexploited areas.

Compared to other protein sources, animal products have a much larger land footprint, particularly for pasture-fed cattle. A transition from the inefficient grains-oilseeds-livestock-feed system could significantly reduce forest pressure, while also providing additional health benefits. Reducing the meat produced and consumed in regions with exceedingly high animal protein intake by 30% and substituting it with a mix of alternative proteins could reduce global land requirements by more than 3 million km^2.

Ultra-processed foods

The market for ultra-processed foods (UPFs) is driven by convenience food and fast food products. While consumption in high-income countries is plateauing or declining, the role of UPFs in the diets of populations in upper- and lower-middle-income countries in Asia, the Middle East, and Africa is seeing high growth rates. These developments are accompanied by rapidly growing imports of non-staple ingredients for domestic processing and UPFs, with cheap palm oil from Asia seeing particularly strong growth in these markets. These developments must be viewed within the broader context of highly concentrated corporate power in modern global food systems, which empowers a small group of companies to shape and homogenise food systems for profit maximisation, specifically targeting lower-income countries with unhealthy, processed products.

Increasing palm oil demand poses particularly high risks for tropical rainforests in Southeast Asia and Oceania, and is also having an increasingly significant impact on the Amazon. Oil palm is traditionally cultivated in the Congo Basin, but it has not yet developed into an export commodity there. However, in light of growing demand for vegetable oil in processed food production and recent supply constraints or price spikes observed for Indonesian palm oil, existing undeveloped concessions in the Congo Basin could quickly become a risk to large tracts of rainforest.

Possible scenarios

Overall, targeting demand and trade is crucial in mitigating the impact of food systems on tropical rainforests, particularly given the anticipated rise in global food demand and the associated pressure on land. Meeting demand via area expansion risks major forest loss, and sustainable intensification has limits. With deforestation and climate implications as well as impacts on IPs and LCs mounting, supply-side gains alone will not suffice; policy-backed demand-side measures are pivotal, including fairer distribution, food-waste cuts, and shifts toward plant-rich, less resource-intensive diets–especially where consumption is exceedingly high.

Food-system choices will decisively shape forest outcomes. Even beyond the two drivers discussed, rainforest basins will face sustained conversion pressure if demand, trade, and corporate power continue on a business-as-usual path, which largely reflects the current 'pressured expansion' trajectory. A 'managed transition' could bend the curve, but it requires ambitious legislation and policy convergence across markets. Strong lobbies by companies active in the animal protein sector are successfully resisting this policy change.

Today, trajectories show diverging patterns: Brazil is advancing cattle traceability while the Amazon Soy Moratorium is under threat; the EU may weaken or delay deforestation and due diligence rules; and China is showing early signs of stronger deforestation requirements. A shift to 'resource light' diets that cut land demand at the source remains unlikely in the short term without broad international alignment and ambitious policies.

7.1.3 Fast-turnover consumer products and emerging forest-risk trends

Consumerism and the increasing volume of fast-turnover products flooding world markets, notably driven by the rapid growth of e-commerce, come with significant environmental impacts, both during their production and at the end of their lives. They contribute to resource depletion, pollution, and generate huge volumes of waste that are either burned, dumped in landfills, or released into the environment. Consumerism fosters a culture of disposability that runs counter to the principles of responsible resource use and social and environmental equality.[950] Producers make high profits, buyers benefit from convenience and low prices, but the outsized resource footprint and reliance on cheap labour in low- and middle-income countries reinforce existing inequalities.[951]

Global raw-material footprints are highly unequal: low-income countries often supply resources for fast-turnover products in wealthy markets, shaped by overproduction, aggressive marketing, weak policy environments, and the routine externalisation of environmental, health, and human rights impacts by corporations. High growth rates in packaging and fashion, both closely linked to booming e-commerce, are expected to continue driving demand for wood pulp. Timber demand is rising, linked to fast-turnover furniture as well as longer-term applications like flooring and construction. Gold demand is largely driven by investment and is highly price-sensitive, but it also plays a role in consumer markets.

Wood pulp

The global pulp sector serves the paper and cardboard industries, as well as the textile industry. Both are expecting continuous growth in the coming years under BAU scenarios. Demand is fueled, among other factors, by the growing processed foods market, the increasing adoption of paper-based packaging over plastic, and the rapidly expanding e-commerce sector. Due to ever-shorter fashion cycles, combined with a lack of repairability and low recycling rates, the fashion industry is linked to deforestation through the use of synthetics, cotton, and leather, as well as wood pulp for the production of man-made cellulosic fibres (MMCF). Global fibre demand is forecasted to experience ongoing growth in the coming years, driven by per capita consumption and population growth, with viscose showing particularly high growth rates.

The Asia-Pacific region is the dominant supplier of viscose staple fibre and an important supplier to the packaging industry. This translates to a risk of accelerating deforestation from Indonesia's growing pulp mill capacity. Major increases in mill capacity are planned, often requiring plantation development in forested areas; one pulp mill under construction is expected to process at least 100,000 truckloads of wood annually by 2028. Large areas of natural forest are found within concessions across Indonesia, putting them at risk from output increases. Pulp-related deforestation risk also exists in Brazil, but at a much lower level.

Logging

Timber demand for various purposes, ranging from the growing market for flatpack furniture to fibreboard and flooring to the construction sector, is expected to increase considerably in the coming years. Timber extraction typically does not result in complete forest loss, but rather acts as an important driver of degradation and fragmentation. Illegality is a widespread phenomenon in the logging sector across all tropical rainforest basins, with heavy impacts on the environment and IPs and LCs. Without strong governance, direct and indirect pressure on tropical rainforests and biodiversity hotspots may increase due to logging and the expansion of timber plantations to meet rising demand.

Gold

Investment and central bank interest, as well as jewellery markets, are the primary drivers of gold demand globally, with technology applications playing a smaller role. Recycled gold contributes around one-fourth of the total volume. Yet, there are significant concerns around the mixing of smuggled gold from high-risk areas with recycled sources, where the absence of traceability allows these flows to enter the international supply chain. Gold prices reached record highs in recent months and are expected to remain high, driven by an increasingly volatile global economy and the strong demand for 'safe investment havens'.

Surging gold prices and resulting investment interest, combined with consumer demand for jewellery, are contributing factors to price signals and investment that risk opening new frontiers in tropical rainforests as part of an ongoing gold mining boom. In addition to causing forest loss, Informal and illegal gold mining is linked to widespread mercury contamination, with severe impacts on the environment and the health of local populations. Our analysis indicates a correlation between gold price development and gold mining, which is accompanied by a high risk of deforestation in the Amazon. We expect the gold price and gold mining to continue their cointegrated evolution, potentially expanding gold mining by ~375 km^2 in the Brazilian Amazon by 2028. In Peru, deforestation levels associated with gold mining are particularly high in the Madre de Dios region, but are also spreading to other parts of the Amazon. For Madre de Dios, our analysis suggests an additional deforestation footprint of ~530 km^2 due to gold mining by 2029. While gold used for investment and jewellery remains a luxury accessible to only a few, its extraction has wide-reaching impacts on nature, IP and LC rights and health.

Possible scenarios

Fast-paced consumption and low-quality goods are likely to continue experiencing growth as companies target new markets, given current demand forecasts and weak policies to curb overproduction and address the issue overall. In producing regions, the strict implementation of robust deforestation- and conversion-free (DCF) and legality policies is needed, supported by intensified international cooperation to address organised crime related to timber and gold. A determined shift to a 'resource-light' model would help to prevent further burden-shifting onto tropical rainforest regions, which already face an outsized share of environmental impacts and human and labour rights abuses. Such a shift depends on ambitious policies and a change in consumer behaviour. In the Amazon, efforts to mitigate the impacts of gold mining are advancing, albeit slowly; with prices surging, the risk of illegal gold entering supply chains remains high. The increasingly cost-effective opportunities for gold recovery from 'urban mining' may help to reduce demand for newly mined gold in the years to come.

7.2 Recommendations

Based on the report's findings, it is clear that diverse stakeholders influence the value chains threatening tropical rainforests. Urgent, coordinated action is **now** required to prevent locking the Amazon, Congo Basin, and Southeast Asia-Oceania rainforests into another decade of pressured expansion and irreversible loss of rainforests and the livelihoods that depend on them. Policymakers must create and implement enabling regulations. Private sector actors must implement deforestation- and conversion-free (DCF) supply chains, and financiers must shift their capital towards sustainable practices. These actions should be taken in tandem, with red lines and legal protections as the top priority. As the analysis examines broad trends that may shape future deforestation patterns, the resulting recommendations tend to be more generally applicable and overarching, rather than sector- or country-specific.

Governments in producer countries

Establish strong red lines and legal protections

- **Enforce strict 'no-go' zones:** No-go zones with buffer zones for the commercial extraction of natural resources should be defined and prohibitions enforced to minimise environmental and social harm. These should include, in particular, Indigenous Protected Areas (IPAs), Indigenous and Community Conserved Areas (ICCAs); World Heritage Areas, RAMSAR sites, UNESCO Global Geoparks and Biosphere Reserves and IUCN Protected Areas; High Conservation Value (HCV) areas and intact forest landscapes; High Carbon Stock (HCS) areas, including primary forests and peatlands; significant natural ecosystems, including the deep sea and small islands; Critical Water Bodies; and IP and LCs lands that do not have their free, prior, and informed consent (FPIC) for prospecting or mining (see below).

  No-go zones are particularly important where Indigenous Peoples living in isolation could be impacted by commercial activities.[952] As more than half of the 'critical' mineral resource base and many oil and gas concessions are situated on or near the lands of IPs and LCs, regulations to ban any exploration and exploitation activities in these areas, as well as sufficient resources to enforce them, are crucial to protecting tropical rainforests and Indigenous peoples' rights.[953]

- **Mandate free, prior, and informed consent (FPIC):** FPIC should be enshrined in national law with the binding right to say 'no' to ensure IPs' and LCs' rights to land, culture, self-determination, self-governance, a healthy environment, non-discrimination, and full and effective participation in the decisions that affect them. FPIC processes should ensure meaningful participation of different genders, youth, and intersectional groups throughout planning and oversight. Consent processes require at least 18-24 months for major projects and should provide independent facilitation and culturally appropriate decision-making. Rights violations are often linked to deforestation and land conversion dynamics, while securing the rights of Indigenous peoples and local communities has proven to help protect natural ecosystems.[954]

  Violations should result in an immediate halt to the project and be linked to legal sanctions for corporate executives and public officials. Restoration funds should be managed by affected communities. Early FPIC compliance should be honoured with preferential credit and premium payments.

- **Formalise land tenure:** Land tenure should be subject to regulation, avoiding situations of unclear or contested land rights and speculative clearing. Land tenure systems should explicitly recognise and enforce the land rights of IPs and LCs, and recognise and support titling for women.

Strengthen governance and justice

- **Strengthen legal frameworks and law enforcement**: Legal frameworks to protect forests should be reinforced, integrating both formal and customary laws through inclusive participation of relevant stakeholders. Equal participation opportunities for all stakeholders in policy processes should be ensured, and corporate lobbying should be limited. Law enforcement should receive robust and long-term funding. Transparency should be increased by ensuring public access to near-real-time deforestation alerts, which are also connected to defender community security protocols. This would enable rapid response through embargoes and seizures. Enforcement should lead to a remedy for damages already caused.

- **Protect defenders:** Environmental and human rights defenders should be subject to specific protection mechanisms, specifically addressing intersectional vulnerabilities. Defender protection assessments should be mandatory for all project approvals, financing decisions, and certification schemes. Parent company responsibility should apply to attacks on defenders in supply chains, with automatic suspension of financing in the event of violations.

  Safe grievance mechanisms for affected communities and workers should be mandatory. Systems should have low access thresholds and be based on secure, multi-language complaint channels with legal standing and whistleblower protections.

  Legislation to expedite dismissal procedures for frivolous SLAPP lawsuits (Strategic Lawsuits Against Public Participation) against defenders should be fast-tracked, with cost recovery and public reporting of corporate SLAPP attempts.

Provide social and economic safety

- **Create 'Just Transition' frameworks**: Countries should implement the UN's Fairness and Justice Recommendations to guide the global energy transition across value chains. It responds to calls from low-income countries for globally agreed guidance to ensure responsible, fair and just value chains, focusing on equity, benefit-sharing, grievance and remedy, and safeguards for human rights defenders.[955]
- **Support alternative livelihoods**: Assistance should be provided to help people involved in unsustainable commodity production in rainforest areas transition to alternative, more sustainable livelihoods. Examples include workers engaged in informal or illegal gold mining or cattle ranching. Community-led economic models, such as the 'sociobioeconomy' in the Amazon, should receive funding and support to offer livelihoods that protect the forest.

Regulate economic drivers of deforestation

- **Limit and monitor infrastructure expansion:** Obligations to minimise the deforestation impact of infrastructure development connected to economic activities should be implemented. New access corridors should be avoided where possible; where unavoidable, their footprint should be capped by choosing the least-impactful option regardless of cost. No-deforestation buffers should be enforced, indirect impacts closely monitored, and reforestation obligations should be enforced with the risk of fines for non-compliance.
- **Control commodity production**: The issuance of new concessions or permits should be halted while governance frameworks are strengthened. Where productive or extractive projects are proceeding, strict obligations should apply, including cumulative-impact EIAs and stringent environmental requirements during production to avoid negative outcomes for the environment and health. In the case of the mining industry, post-mining rehabilitation should be enforced. Benefit-sharing agreements with community oversight should be mandatory.
- **Phase out fossil fuels and unsustainable bioenergy:** No new fossil fuel projects should be approved, and already-granted concessions should be withdrawn. Existing production should be phased out, and all subsidies for the fossil fuel industry should be ended.

  Bioenergy development and use should be limited to truly sustainable alternatives, prioritising direct electrification and more sustainable alternatives. First-generation biofuels should be phased out immediately. Waste-based feedstock should be subject to sustainability safeguards to exclude fraud; the limited volumes and competing uses of feedstocks with proven environmental benefits need to be considered in bioenergy development. Subsidies for unsustainable feedstocks and their use, for example, in co-firing, should be halted.

Governments in producing countries

Establish strict market regulation

- **Enact mandatory due diligence and accountability laws**: Policymakers should implement strict human rights and environmental due diligence requirements and traceability obligations for products that are put on the market, requiring biodiversity and forest-risk disclosure. This entails a digital chain of custody and robust third-party audits from upstream to downstream. Particular attention should be paid to the unintended impacts of policy divergence among key markets and displacement effects resulting from narrow geographic definitions. Strong accountability mechanisms must be binding for both private actors, including financial institutions, and public sector actors, with meaningful participation from civil society in the oversight process. Implementation should be accompanied by targeted support for producing countries.
- **Limit corporate lobby influence**: Industry lobbyists' influence in shaping public policies should be limited and linked to high standards of public transparency. Equal participation opportunities for all stakeholders in policy processes should be ensured.

Create partnerships to protect forests

- **Provide support and share best practices**: In close cooperation with exporting countries, importing countries should provide financial and technical support as well as law enforcement cooperation, and align best practices to protect forests.

Shift economic incentives and consumption patterns

- **Tackle excessive resource use and consumption**: Policymakers should address the over-production and high resource use of low-quality, fast-turnover products linked to consumerism, excessive e-commerce, dumping, and waste colonialism. Measures could include a true-cost levy on fast-turnover goods to reflect environmental externalities, and enforcing extended producer responsibility (EPR) fees that penalise low-durability items.
- **Reduce product intensity and boost the circular economy:** High resource intensity should be designed out by setting product-level material-intensity targets and prioritising lower-intensity technologies (for example, energy-efficient battery technology using lower-risk materials, smaller cars). To this end, policymakers should promote a secondary raw materials market and fund research and development for next-generation technologies using low-impact materials. Durability, repair, refurbishment, parts availability, and extended guarantee should be mandated. Reuse models should be scaled to reduce new resource production.

  An enabling policy environment should be created to reduce the use of virgin raw materials while investing in widely implemented and efficient collection and recycling infrastructure to help close the loop and significantly increase recycling supplies.
- **Promote lower-impact, healthier diets:** Public health policies should give high priority to a transition to healthier and less resource-intensive diets, particularly in relation to animal proteins and ultra-processed foods. Subsidies benefiting meat production should be shifted to more sustainable plant and alternative proteins.

Supply chain companies, private and public financiers

Operationalise deforestation- and conversion-free (DCF) supply chains

- **Implement robust DCF and human rights policies**: Where legal obligations are not strict enough or not enforced sufficiently, robust DCF policies have proven to support transparency and a reduction in deforestation for forest-risk commodities. Relevant standards to consider in policy formulation related to ‘critical’ minerals, agricultural products, and other forest-risk commodities include, inter alia, the UN Guiding Principles on Business and Human Rights

(UNGP), ILO International Labour Standards, OECD Due Diligence Guidance on Minerals, UN Guidance for Action on Critical Energy Transition Minerals, and AFi Guidelines.

Commercial actors should implement policies that include comprehensive traceability, supported by robust socio-environmental monitoring (in the case of livestock, for example, this includes indirect cattle suppliers and feed suppliers), satellite monitoring, grievance & remedy mechanisms, and strict, time-bound cut-off dates.

Downstream buyers should implement strict contractual no-conversion clauses, suspend non-compliant suppliers, and respect human and labour rights, aligned with the consensus-based guidelines provided by the Accountability Framework initiative (AFi).[956] Market access should be contingent on credible deforestation and human rights due diligence. Meaningful engagement with suppliers should be initiated, including escalation strategies in the event of non-compliance. The implementation of time-bound restoration of deforested areas and transparency through public reporting should be obliged.

- **Adhere to the mitigation hierarchy:** Companies should follow the mitigation hierarchy of avoiding → minimising → restoring → offsetting.[957] Avoidance should be prioritised, while no-go zones should be set and respected. Independent, third-party audits should be conducted and included in a company's transparent reporting and disclosure. Transition pathways for energy-intensive industries must be developed and implemented with high priority.[958]
- **Support producer groups**: To reduce individual compliance costs, technical and financial support should be provided to smallholder cooperatives for collective traceability systems, GPS mapping, and documentation.

Ensure circularity

- **Design for durability and circularity:** Brands and retailers should switch to a model designed for longevity and repair. Information on durability, repairability, origin, and socio-environmental footprint should be clearly visible, allowing consumers to make informed buying decisions.
- **Prioritise low-impact options and technologies:** Public procurement and companies should prioritise low-impact options and technologies. To this end, research and development should focus on the less resource-intensive and lower deforestation-risk options. Producers should increase recycled content, and extended producer responsibility should be implemented.

Align capital with sustainability goals

- **Enforce strict lending criteria**: Access to finance should be contingent on credible DCF and human rights due diligence. In the event of non-compliance, meaningful engagement with investees should be initiated. Clear escalation strategies should be in place that should lead to the suspension of financing if violations persist.
- **Mobilise 'Just Transition' funds**: In general, funds should be shifted and scaled for a just transformation of supply chains and markets towards the 'resource-light' pathway and achieve a fundamental shift in resource use. Economic incentives should be transferred in favour of conserving and maintaining tropical rainforests, while respecting and promoting human rights, in particular the rights of IPs and LCs. This should include increased funding for IP and LC rights, as well as forest governance, particularly through more fit-for-purpose, IP and LC-led funding arrangements.

Appendix 1 Key sources and resource persons

Key sources consulted in the initial steps of the research included:

Main scientific journals

- Conservation Letters
- Environmental Research Letters
- Forest Policy and Economics
- Global Environmental Change
- Nature family: Nature Communications, Nature Sustainability, Nature Food, Scientific Reports
- PNAS (Proceedings of the National Academy of Sciences)

Main CSO sources

- Auriga Nusantara
- Earthsight
- Global Witness
- Greenpeace
- Mapbiomas
- Mighty Earth
- Monitoring of the Andes Amazon Project (MAAP)
- Observatório da Mineração
- Rainforest Foundation Norway
- Trase
- Trend Asia
- World Resources Institute (WRI) / Global Forest Watch
- WWF

Main other information source:

- OECD–FAO Agricultural Outlook
- FAO / FAOSTAT
- Government institutions in producing and consuming countries
- US Geological Survey

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