Research Paper -
Country Level Biodiversity Risks

February 2026

CRÉDIT AGRICOLE
CORPORATE & INVESTMENT BANK

Acknowledgements

LEAD AUTHOR:

Thomas MORIN, Crédit Agricole Corporate & Investment Bank

CO-AUTHORS:

Loïc MARCADET, Nexialog Consulting

Gisèle DUCROT, Crédit Agricole Corporate & Investment Bank

Diego MATALLANA ALBORNOZ, Crédit Agricole Corporate & Investment Bank

CONTRIBUTOR:

Joan RALAMBOARISON, Crédit Agricole Corporate & Investment Bank

Luc VERMOT-GAUCHY, Nexialog Consulting

CREDITS:

Cover image, © Thomas Morin

p.29, © Sanit Fuangnakhon on ShutterStock

p.31, © Bildagentur Zoonar GmbH on ShutterStock

p.32, © Ney Matsumura on ShutterStock

Contents

Abstract

This research paper introduces the Country Biodiversity Risk Index (CBRI), a proof-of-concept framework that tests whether freely available, open-source datasets can be compiled into a structured methodology to perform country-level biodiversity risk assessments. The CBRI combines 43 indicators across four dimensions: ecosystem health, species conservation status, anthropogenic pressures, and protection measures. All data derive from peer-reviewed sources and authoritative global monitoring initiatives, ensuring transparency and reproducibility. By evaluating the strengths and limitations of this approach, the research aims to inform the development of more sophisticated biodiversity risk assessment methodologies and to demonstrate the current capabilities and constraints of publicly available biodiversity data for financial risk analysis.

Results suggest that (1) it is possible to construct a detailed country-level risk framework from open-source and free datasets that captures most of biodiversity variability, and (2) that following the CBRI methodology, highest-risk countries cluster in rapidly developing megadiverse regions—China, India, Southeast Asia, tropical South America, and parts of Africa—where high species richness coincides with accelerating habitat conversion, industrial expansion, and insufficient conservation capacity. Conversely, lowest-risk countries include sparsely populated regions (Canada, Russia, Central Asia) and post-industrial nations with stabilized land use (European Union, Australia). In this regard, regions experiencing the most rapid economic growth and attracting the most investment simultaneously face the highest biodiversity-related risks.

Introduction

Loss of biodiversity

Recent research by the Stockholm Resilience Centre found that among nine processes that regulate the stability of the Earth system, six of them have reached a critical limit above which irreversible damage is due to happen[1]. This translates into major and increasing impact on biodiversity worldwide. The IPBES report of 2019 reveals the extent of the currently occurring loss, indicating that 85% of global wetlands vanished since 1870, 75% of terrestrial ecosystems[2], and 66% of marine ecosystems have been severely degraded by human activities. This impact on ecosystem extent and quality transfers on species. Populations of vertebrates have decreased by about 73% since 1970[3], and 25% of species in the well-studied taxonomic groups face a risk of extinction[4].

A vital dependency

This biodiversity loss poses significant risks because biodiversity underpins a wide array of ecosystem services -including the provision of food and raw materials, water cycle regulation, and carbon storage- that are indispensable to human well-being and economic performance. According to the World Economic Forum, 44 trillion dollars (more than half the world's GDP) are moderately (37%) or strongly (15%) dependent on nature[5], with sectors like construction, agriculture and food and beverages being the most reliant. Furthermore, global supply chains extend the risks to industries not directly reliant on natural resources. In this context, biodiversity acts as an "unseen stakeholder" vital to long-term viability of the economic system.

---

[1] Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S. E., Donges, J. F., ... & Rockström, J. (2023). Earth beyond six of nine planetary boundaries. Science advances, 9(37), eadh2458.

[2] IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673

[3] WWF (2024) Living Planet Report 2024 – A System in Peril. WWF, Gland, Switzerland.

[4] IUCN, S. (2020). The IUCN red list of threatened species.

[5] Herweijer, C., Evison, W., Mariam, S., Khatri, A., Albani, M., Semov, A., & Long, E. (2020). Nature risk rising: Why the crisis engulfing nature matters for business and the economy. In World Economic Forum and PwC. http://www3. weforum. org/docs/WEF_New_ Nature_Economy_Report_2020. pdf (Vol. 2).

A highly local phenomenon

Understanding these biodiversity-economy linkages requires recognizing that biodiversity functions simultaneously at global and local scales. While global biodiversity trends are important, the most critical impacts and dependencies remains at the local level. Each region hosts distinct combinations of flora and fauna that have co-evolved over millennia, creating intricate webs of interdependence that directly shape local social and economic systems. Global supply chains are thus built upon a mosaic of local biodiversity hotspots, each contributing unique resources or ecosystem services. [6]

Biodiversity national dynamics

National-level analysis is useful for understanding biodiversity state and its associated risks: government policies, legislative frameworks, and conservation initiatives fundamentally shape biodiversity outcomes within borders.[7] National-level analysis allows for a comprehensive understanding of these dynamics across supply chains which makes it possible to identify sectors and geographies at risk and develop more effective mitigation strategies.

A risk analysis framework still under development

Despite the clear economic stakes, the integration of biodiversity risks into financial risk assessment remains nascent. While frameworks such as the Task Force on Nature-related Financial Disclosures (TNFD) have emerged to guide corporate disclosure and risk management, their operationalisation is still ongoing. The ECB has for example published several papers reviewing nature related risks for the European financial system such as the *Nature at risk: Implications for the euro area economy and financial stability.* Yet, the lack of consistent, comparable data across jurisdictions throughout biodiversity variables and values hampers the ability of financial practitioners to conduct systematic risk analyses at scale. This research seeks to contribute to the evolving body of knowledge on biodiversity risk assessment for financial institutions by testing the viability of country-level data aggregation and presenting a transparent methodology.

---

[6] Ceglar, A., Jwaideh, M., O'Donnell, E., Danieli, F., Pasqua, C., Hutchinson, J., ... & Heemskerk, I. (2025). Nature at risk: Implications for the euro area economy and financial stability. *ECB Occasional Paper*, (2025/380).

[7] Whitehorn, P. R., Navarro, L. M., Schröter, M., Fernandez, M., Rotllan-Puig, X., & Marques, A. (2019). Mainstreaming biodiversity: A review of national strategies. Biological conservation, 235, 157-163.

Country Biodiversity Risk Index (CBRI)

Aim

The CBRI is a proof-of-concept methodology to assess biodiversity-related risks at the country level using exclusively free and open-source datasets. It investigates whether publicly available biodiversity data can provide useful insights for financial institutions and other stakeholders intending to integrate biodiversity into their risk assessment.

By combining country-level biodiversity indicators, the CBRI helps to identify potential economic impacts for countries and companies operating in or sourcing from specific regions. While biodiversity is inherently a localized phenomenon, country-level analysis offers a useful starting point - providing an overview of risks, highlighting key trends, and establishing a base for more granular analyses of corporate assets and supply chains.

The CBRI is developed to evaluate 1) a static approach with the current state of species and ecosystems in the countries. When ecosystems are damaged by human activities, the services they provide are disrupted, affecting business operations. For instance, degradation of coastal ecosystems results in a weaker protection against storms, hence increased risks for infrastructures and economic activities along the seaboard 2) a dynamic approach with the anticipated evolution of biodiversity viewed through information on pressure exerted on nature as well as protection measures implemented in the country.

Data

The CBRI framework incorporates 43 key performance indicators. Every indicator used in this methodology was created using public and free datasets, fulfilling the wish for a transparent and reproducible model. Additional details for the data and computation of indicators are provided in the Appendix. Most of them come from renowned public tools such as the Yale Environmental Performance Index (Yale

EPI)[8], the WWF Biodiversity Risk Filter (WWF BRF)[9] or IBAT (Integrated Biodiversity Assessment Tool)[10]. Other sources include intergovernmental organisations like the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Food and Agriculture Organization of the United Nations (FAO), governmental bodies with the Central Intelligence Agency (CIA) and scientific organisations like the International Union for Conservation of Nature (IUCN).

Furthermore, all data incorporated into the framework are either directly derived from peer-reviewed scientific papers or sourced from credible publications by global authorities in their respective fields.

Computation

The CBRI aggregates four composite sub-indicators, each capturing a distinct dimension of biodiversity risk and resilience:

Static approach

- Ecosystem health: Assesses the integrity and stability of national ecosystems. Healthy ecosystems provide critical services—water purification, climate regulation, coastal protection—that underpin economic activities
- Species state: Evaluates the conservation status and extinction risk across fauna, flora, and other taxonomic groups. Species loss serves as an early warning indicator of ecosystem dysfunction, as species declines often precede broader ecosystem collapse

Dynamic approach

- Anthropogenic pressures: Quantifies human-induced threats structured around the five primary drivers identified by IPBES:
    - Land-use change and habitat destruction – conversion of natural habitats for agriculture, urbanization, and infrastructure
    - Overexploitation of natural resources – unsustainable harvesting of species and extraction of resources

[8] Block, S., Emerson, J. W., Esty, D. C., de Sherbinin, A., Wendling, Z. A., et al. (2024). 2024 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

[9] WWF (2024) WWF Risk Filter Suite and ESRS Technical Guidance version 2.0, https://doi.org/10.5281/zenodo.13736021

[10] Protected Area and Key Biodiversity Area data used from the Integrated Biodiversity Assessment Tool (IBAT) (https://www.ibat-alliance.org). Provided by BirdLife International, Conservation International, IUCN and UNEP-WCMC.

  - Climate change – temperature shifts, precipitation changes, and extreme weather events
  - Pollution – contamination of air, water, and soil affecting ecosystem function
  - Invasive species – introduction of non-native species disrupting ecological balance

  Current pressures enable anticipation of future biodiversity state changes.
- Protection: Measures the extent and effectiveness of conservation initiatives, including protected area coverage, management quality, and policy implementation. Protection indicators reflect national commitment to halting biodiversity loss and provide information on whether current conservation efforts are sufficient to counterbalance current pressures

This allows to distinguish between countries facing immediate crises, those on worrying paths despite stable conditions, and those where conservation efforts are successfully reducing pressures.

1. Static Approach

Sub-indicator 1: Ecosystem Health

Ecosystems underpin economic activity by providing essential services across multiple sectors, including physical risk mitigation, water cycle regulation, food and raw material provision, carbon sequestration, and aesthetic and spiritual value. The capacity of ecosystems to deliver these benefits depends fundamentally on their functional integrity, connectivity, composition, and structure.

The ecosystem health sub-indicator evaluates several dimensions of ecosystem condition: The datasets included assess the connectivity and integrity of terrestrial, freshwater, and marine ecosystems using various indices such as the Biodiversity Intactness Index and the Ocean Health Index. Soil condition is measured by its carbon content. The quality of aquatic ecosystems is assessed by considering nutrient pollution, ocean acidification, and eutrophication. The impact on biodiversity due to habitat loss, degradation, and fragmentation is measured by the Biodiversity Habitat Index. Finally, the integrity of forest landscapes is evaluated by observing human disturbances and loss of connectivity.

However, this composite indicator remains limited due to the dataset coverage. It does not directly measure species diversity, interspecific interactions, or fine-scale ecological processes. Genetic diversity and the specific ecosystem services provided by different ecosystems are not explicitly captured. Additionally, there is a temporal bias: because most underlying datasets were established relatively recently, historical ecosystem degradation—particularly pre-industrial impacts—may be inadequately represented in current assessments.

This evaluation draws on the following datasets:

- Ecosystem condition (WWF BRF) measuring the connectivity and intactness of terrestrial ecosystems measured by the Biodiversity Intactness Index and the Functional Connectivity of the World's Protected Areas, the connectivity of freshwater ecosystems and the integrity of marine ecosystems measured by the Ocean Health Index Habitat Condition.
- Soil condition (WWF BRF) measured as the carbon content rate in soils.
- Water condition (WWF BRF) measuring the state of aquatic ecosystems measured as the quality of freshwater ecosystems and the quality of marine ecosystems by the average of three data points:
    - The Ocean Health Index Nutrient Pollution
    - Ocean acidification data from the Ocean Health Index
    - WRI's Eutrophication and Hypoxia
- Species Habitat Index (Yale EPI), providing information on the proportion of suitable habitats for a country's species weighted according to the proportion of their global range that is found within the country that remain intact, relative to a baseline set in the year 2001.
- Forest Landscape Integrity (Yale EPI) analysing the integrity of forest landscapes based on observed and inferred human disturbances and losses of forest connectivity.

Sub-indicator 2: Species State

Species rarity and extinction risk are critical biodiversity issues, crucial for assessing a country's environmental risks. Ecosystems with many threatened species can be vulnerable to collapse, potentially causing massive biodiversity loss and disrupting vital services with severe consequences on the ecological, economic and social benefits that it provides to its surroundings. Most human activities rely on services that are possible only thanks to the role that some species play in their territory, which explains the importance of species preservation.

The species state sub-indicator evaluates the abundance, diversity, and conservation status of species within a country. Species-level risk is quantified through five complementary datasets: total species count (IUCN) provides a proxy for national genetic diversity; total threatened species (IUCN) captures the absolute pressure on biodiversity and rare species; percentage of threatened species (IUCN) normalizes this pressure to reflect the proportional impact of human activities; density of threatened species per km^2 (IUCN) adjusts for country size to enable cross-national comparison; and range rarity (WWF BRF) identifies countries with disproportionate importance for global biodiversity conservation.

This indicator has several limitations. The included datasets do not directly assess population health, genetic diversity, interspecific interactions, or the ecological functions performed by different species. The focus on threatened species may overlook important dynamics within non-threatened populations. While the indicator provides a broad overview of species status, it lacks granular data on species-specific trends and population trajectories, limiting its capacity to fully capture the complexity of biodiversity dynamics at the species level.

Risk related to the abundance or extinction of species is measured using these datasets:

- Total species (IUCN)
- Total threatened species (IUCN)
- Percentage of threatened species (IUCN)
- Density of threatened species per km^2 (IUCN)
- Range rarity (WWF BRF)

2. Dynamic Approach

Sub-indicator 3: Anthropogenic pressures

The IPBES identifies five direct drivers of global biodiversity loss: land and sea use change, natural resource use and exploitation, climate change, pollution, and invasive alien species.

The land and sea use change sub-indicator, based on the IPBES report, addresses four major drivers: agricultural and urban expansion, fragmentation, landscape use intensification, and ecosystem degradation. The datasets used measure primary forest and intact forest landscape loss, weighted forest cover loss, wetland and grassland losses, human impact on landscape ecological integrity, river fragmentation, and projected urbanisation and cultivated area changes. These metrics assess impacts on biodiversity-rich ecosystems, the sustainability of forest changes, natural to anthropogenic area conversion, overall habitat fragmentation, and potential future land use pressures.

However, this sub-indicator has several limitations. It does not explicitly capture specific marine ecosystem changes, subtle alterations in landscape use intensity, or agricultural practice modifications that occur without area changes. The indicator also cannot precisely quantify cumulative and long-term impacts on ecological connectivity and ecosystem resilience. While providing a comprehensive overview of major land use transformations, it may underrepresent gradual degradation processes that do not result in complete habitat conversion.

Pressures associated with land and sea use change are evaluated using these datasets:

- Forests (Yale EPI)
  - Loss of Humid Tropical Primary Forests (30% of EPI Forests Indicator) measuring annual losses of tree cover in these critical ecosystems relative to their extent in 2001, using a 30 percent minimum tree cover canopy density.
  - Loss of Intact Forest Landscapes (30% of EPI Forests Indicator) measuring annual losses of tree cover in these critical expanses of pristine forests relative to their extent in 2000, using a 30 percent minimum tree cover canopy density.
  - Lasting Tree Cover Loss (25% of EPI Forests Indicator) measuring the lasting annual losses of tree cover relative to their extent in 2000, using a 30 percent minimum tree cover canopy density. Depending on what drives tree cover loss, forests have different likelihoods of regrowing in the short- to medium-term. With some drivers, such as urbanisation and commodity-driven deforestation, tree cover loss is typically permanent. With others,

such as wildfires and forestry operations, tree cover typically starts recovering almost immediately after being lost.

    - Net Tree Cover Change (10% of EPI Forests Indicator) measuring net percent change in tree cover between 2000 and 2020.
    - Forest Landscape Integrity Index (5% of EPI Forests Indicator) measuring integrity of forest landscapes based on observed and inferred human disturbances and losses of forest connectivity

- Grassland Loss (Yale EPI), translating a five-year moving average of percentage of gross losses in grassland areas compared to the 1992 reference year
- Wetland Loss (Yale EPI), measuring a five-year moving average of percentage of gross losses in wetland areas compared to the 1992 reference year
- Land River and Sea Use change (WWF BRF) measuring direct human impact on marine ecosystems, fragmentation of rivers and cropland expansion.
- Urbanisation rate (CIA) measuring the projected average rate of change of the size of the urban population over the 2020 and 2025 period[11].
- Cropland change (World Bank) measuring the change in the share of land area that is arable, under permanent crops and under permanent pastures between 2011 and 2021[12].

The IPBES report on sustainable use of wild species identifies five main pathways for natural resource exploitation: fishing, gathering, terrestrial animal hunting, logging, and non-extractive practices.

The overexploitation of natural resources sub-indicator evaluates resource extraction pressure through three complementary datasets. Marine exploitation is assessed through fisheries metrics (Yale EPI). Terrestrial extraction pressure is quantified through forestry metrics (FAO) calculated as the ratio of national timber production (2020-2022 mean) to forested area. Exploitation of endangered species is tracked through international trade data (CITES 2020-2023), compiled from records documenting fishing, gathering, hunting, logging, and non-extractive

[11] The World Factbook (2024). Washington, DC: Central Intelligence Agency, 2024. Urbanization rate. Urbanization - The World Factbook

[12] World Bank, World Development Indicators. (2024). Permanent Cropland (% of land area). World Development Indicators | DataBank

uses of protected species where country of origin and specimen numbers are available.

However, this sub-indicator remains limited. It provides minimal coverage of the "gathering" and "non-extractive practices" pathways identified by IPBES, and critically, it does not establish whether extraction rates exceed regenerative capacity—the fundamental criterion for overexploitation. The fisheries component is limited to exclusive economic zones, potentially underestimates illegal and unreported fishing, and aggregates across fish stocks, obscuring species-specific vulnerabilities. The forestry pressure indicator lacks context on regeneration rates and sustainable yield thresholds. The CITES trade database captures only threatened or protected species in legal international trade, missing domestic consumption and overexploitation of non-listed species. Consequently, while the sub-indicator provides valuable insights into certain exploitation pressures, it offers an incomplete assessment of resource extraction sustainability.

Pressures associated with overexploitation are evaluated using these datasets:

- Fisheries (Yale EPI):
  - Domestic Fish Stock Status (15% of EPI Fisheries Indicator) measuring percentage of a country's total catch that comes from collapsed fish stocks, based on an assessment of all fish stocks within a country's exclusive economic zone(s)
  - Domestic Marine Trophic Index (5% of EPI Fisheries Indicator) measuring decline of the trophic level of fish catches.
  - Fish Caught by Bottom Trawling and Dredging (60% of EPI Fisheries Indicator)
    - Domestic: The proportion of the total catch in a country's exclusive economic zone(s) caught by any country using bottom trawling and dredging. This indicator measures whether countries allow bottom trawling in the marine regions under their jurisdiction (25% of total EPI Fisheries Indicator).
    - Global Ocean: The proportion of a country's total catch across the global ocean caught by bottom trawling and dredging. This indicator measures how much countries use

bottom trawling, either in their own waters, those of other countries, or on the high seas (35% of total EPI Fisheries Indicator).

    - Fish Catch Discarded (20% of EPI Fisheries Indicator) measuring the proportion of a country's total catch in the global ocean that is discarded instead of landed and used. This indicator serves as a proxy of bycatch and thus of untargeted and wasteful fishing practices.

  - Forestry Pressure Indicator (FAO) computed using the Forestry National Production mean for 2020-2022[13] and the Forested Areas[14] datasets from the FAO, as a proxy for the pressure on the national forested ecosystems.
  - Endangered species trades (CITES), the fishing, gathering, terrestrial animal hunting, logging, and non-extractive practices of endangered or protected species. We used CITES Trade database for the year 2020-2023 and compiled the occurrence of species use when country of origin and number of specimens was available for any kind of purpose.[15]

The climate change sub-indicator adopts a multidimensional approach to assess its impacts on biodiversity, in line with the approach of the joint IPBES and IPCC report[16]:

- Acute impacts: Measurement of changes in the frequency and intensity of extreme weather events, which can have immediate and significant effects on ecosystems and species.
- Long-term impacts: Assessment of the effects of rising temperatures and changes in global climate conditions on the state of ecosystems and their resilience, reflecting gradual habitat modifications.
- Greenhouse gas emissions: Inclusion of an indicator related to national GHG emissions, recognising their dual impact on global and local biodiversity.

[13] FAO. FAOSTAT. [2020-2022]. Industrial roundwood production. FAOSTAT
[14] FAO. Global Forest Resources Assessment. (2024). Extent of forest and other wooded land. FRA Platform | Global Forest Resources Data | Food and Agriculture Organization of the United Nations
[15] CITES Trade Database [2020-2023]. Compiled by UNEP-WCMC for the CITES Secretariat. Available at: trade.cites.org. Accessed [10-12-2024].
[16] Pörtner, H.O et al. 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. DOI:10.5281/zenodo.4782538.

This approach allows for capturing both direct and indirect effects of climate change on biodiversity, offering an overview of the pressures exerted by this global phenomenon.

Pressures associated with climate change are evaluated using these datasets:

- Bioclimatic Ecosystem Resilience (Yale EPI), the ecosystems' capacity to retain species diversity under climate change as a function of ecosystem area, connectivity, and integrity. It reflects how well locations are connected to areas of intact habitat in the surrounding landscape that are projected to support a similar composition of species in future climates.
- Climate change (Yale EPI) composed of 11 indicators: Adjusted emission growth rates for four greenhouse gases (CO_2, CH_4, F-gases, and N_2O) and one climate pollutant (black carbon); adjusted emission growth rates of carbon dioxide with country-specific targets based on their allocated share of the remaining carbon budget, projected greenhouse gas emissions in 2050 and projected cumulative emissions to 2050 relative to countries' allocated share of the remaining carbon budget; net carbon fluxes from land cover change; and GHG growth rate adjusted by either emissions intensity or by per capita emissions.
- Regulating services – Mitigating (WWF BRF) the occurrence of natural hazards such as landslides, fires, heatwaves and storms that can disturb or disrupt ecosystems, kill organisms or populations and alter habitats and landscapes, in some cases resulting in severe damage to biodiversity.

The pollution sub-indicator measures contamination across its diversity: Atmospheric pollution is assessed through datasets on six key pollutants: fine particulate matter (PM2.5), ground-level ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, and volatile organic compounds—each with distinct sources and ecological impacts. Aquatic pollution is quantified through datasets on agricultural nutrient loading (nitrogen and phosphorus runoff), wastewater production volumes, and plastic pollution metrics. Soil contamination is measured via datasets on agricultural nitrogen and phosphorus inputs that can alter soil chemistry and microbial communities. Multi-modal pollutant exposure is tracked through datasets on lead contamination data, pesticide application rates, and waste production statistics. These complementary datasets provide a multi-dimensional assessment of pollution pressures.

As pollution is inherently complex, often highly localized, temporally variable, and extremely diverse in nature and impact, this assessment also represents a simplified view. Despite the breadth of this approach, many pollution types remain difficult to quantify or lack sufficient global, standardized data. Emerging pollutants such as endocrine disruptors and nanoparticles are not captured. Heavy metal contamination is limited to lead, excluding mercury, cadmium, arsenic, and other toxic metals. Region-specific pollutants (such as mining effluents) and industry-specific contaminants may be systematically underrepresented. Consequently, while the indicator offers valuable insights into major pollution pressures, it should be interpreted as a partial assessment of the full spectrum of environmental contamination affecting biodiversity.

Pressures associated with pollution are evaluated using these datasets:

- Air Pollution (Yale EPI), the countries' contribution and exposure to air pollution with two indicators regarding the emissions of acid rain precursors (sulphur dioxide and nitrogen oxides), and two indicators measuring exposure to ground-level ozone in a country's croplands and Key Biodiversity Areas.
- Air Quality (Yale EPI), the combination of seven indicators: anthropogenic PM2.5 exposure, household solid fuels, ozone exposure, nitrogen oxides exposure, sulphur dioxide exposure, carbon monoxide exposure, and volatile organic compound exposure.
- Heavy Metals (Yale EPI), the direct impacts of heavy metal pollution exposure on human health in each country. It is expected that impacts on human health significantly correlates with impacts on biodiversity.
- Agriculture (Yale EPI), the impact on biodiversity from the agricultural related pollution based on four indicators: the Sustainable Nitrogen Management Index (SNMI), Relative Yield Index, pesticide pollution risk, and phosphorus surplus.
- Solid Waste (Yale EPI), the threats of solid waste to human and environmental health. It is based on three indicators: municipal solid waste generation per capita, controlled solid waste, and recovery of energy and materials from waste.

- Water Resources (Yale EPI), the extent to which humans are mitigating damages to aquatic ecosystems through the generation and mismanagement of wastewater. It consists of four indicators: wastewater generation, collection, treatment, and reuse.
- Pollution (WWF BRF), measuring terrestrial nutrient load and pesticide pollution, freshwater nutrient pollution and plastic pollution, marine nutrient pollution, pesticide pollution and plastic pollution as well as PM2.5 air pollution

The invasive alien species sub-indicator evaluates invasion pressure through two complementary datasets. Regional presence of the world's 100 most invasive species (based on an internationally recognized list) identifies areas particularly affected by the most problematic invaders at a global scale. Total invasive species number by country, normalized by native species richness, provide a broader overview of the pressure exerted by invasive species on national ecosystems, beyond just the most notorious species. Together, these metrics capture both the presence of high-impact invaders and the overall magnitude of biological invasions.

However, there are again many limits to the sub-indicator. The data may not reflect current invasion dynamics, as the situation may have evolved since collection. Critically, the indicator measures presence and classification rather than actual ecological impact: it does not capture effects on native species populations, changes in ecosystem structure and function, disruption of ecological processes, or the long-term economic and ecological consequences of invasions. Invasion pathways, establishment rates, and spread dynamics are similarly not quantified. Consequently, while the indicator identifies regions facing invasion pressure, it does not assess the severity of biodiversity impacts or ecosystem transformation resulting from these invasions.

Pressures associated with invasive alien species are evaluated using these datasets:

- Invasive species (WWF BRF), measuring the presence of one of the 100 worst invasive species in each country. Species were selected for the list according to two criteria: their serious impact on biological diversity and/or human activities and their illustration of important issues surrounding biological invasion.

- Invasive alien species asymmetry index[17] from Turbelin et al. (2017) evaluating the asymmetry between the number of invasive species coming from a country and the number of invasive species in the country.

Sub-indicator 4: Protection

To comprehensively assess biodiversity risks in a country, it is crucial to examine the protection measures implemented at the national level. These measures play a fundamental role in preserving species and various ecosystem components. Effective protected areas are particularly important for several reasons:

- They allow the country to maintain a sufficient level of ecosystem services to support its economic activity.
- When they have sufficient ecological connectivity, they allow individuals to migrate across the national territory. This is essential for:
    a) Enabling certain species to continue their biological migration cycle.
    b) Facilitating species movement to adapt to the effects of climate change.

The Global Biodiversity Framework (GBF) adopted at COP15 in Kunming-Montreal sets ambitious goals for global biodiversity protection. It stipulates that 30% of the planet's terrestrial and marine areas must be protected by 2030. To achieve this goal, most signatory countries will need to establish many new protected areas. However, not all protected areas are equivalent. Their effectiveness varies considerably depending on their initial objectives and the means implemented to achieve them.

In our study, we will focus on four essential data points to assess the effectiveness of territorial protection in each country:

- The coverage of protected areas, both terrestrial and marine, as well as the presence of sites of international interest (Ramsar sites, recognised for their importance as wetlands, and UNESCO World Heritage sites). This measure will allow to assess the quantitative extent of protection implemented by each nation.

[17] Turbelin, A. J., Malamud, B. D., & Francis, R. A. (2017). Mapping the global state of invasive alien species: patterns of invasion and policy responses. *Global Ecology and Biogeography*, *26*(1), 78-92.

- The ecological representativeness of protected areas. This crucial indicator will help determine whether established conservation areas accurately reflect the diversity of species, ecosystems, and landscapes present in the country. Good ecological representativeness ensures that protection is not limited to a few emblematic areas or species but encompasses the entire biological richness of the territory.
- The protection of Key Biodiversity Areas (KBAs). This aspect will inform about the country's ability to effectively protect areas of its territory considered by international experts as vital for global biodiversity conservation. The protection of KBAs demonstrates the alignment of national conservation efforts with global biodiversity preservation priorities.
- The actual effectiveness of protected areas, both marine and terrestrial. For marine areas, we will examine the fishing intensity within these protected areas, which will give us an insight into the concrete impact of protection on marine biomass and aquatic ecosystem health. Regarding terrestrial areas, we will analyse the extent and nature of urban and agricultural development in these protected spaces.

The combined analysis of these four indicators will provide a relatively complete and nuanced picture of the effectiveness of biodiversity protection measures in each studied country.

The protection sub -indicator is constructed using these datasets:

- Protected areas coverage
  - Terrestrial Protected Area Coverage (IBAT), measuring the coverage of the countries' territories against global target from the Global Biodiversity Framework targets of 30%
  - Marine Protected Area Coverage (IBAT), measuring the coverage of the countries' territories against global target from the Global Biodiversity Framework targets of 30%
  - Sites of international interest (WWF BRF), comprising of RAMSAR and World Heritage sites

To be noted that IBAT Protected Area coverage of a country is assessed by eliminating all overlaps between Protected Areas to avoid double counting.

The overlap between protected areas and Ramsar/World Heritage sites is common and expected due to their shared conservation goals and aligned criteria for designation. Protected areas are generally candidates for international recognition, as they typically have existing management structures in place. The dual designation can provide enhanced protection and visibility for these important sites[18].

- Protected areas representativeness
    - Terrestrial biome protection (Yale EPI), measuring the proportions of the area of each of a country's biome types that are covered by protected areas and then constructing a weighted sum of the protection percentages for all biomes within that country.
    - Species protection index (Yale EPI), evaluating the species-level ecological representativeness of each country's protected area network. The SPI metric uses remote sensing data, global biodiversity informatics, and integrative models to map suitable habitat for over 30,000 terrestrial vertebrate, invertebrate, and plant species at high resolutions.
    - Marine and coastal habitat protection (Yale EPI), measuring the percentage of important marine and coastal habitats — mangroves, salt marshes, seagrasses, coral reefs, cold corals, sea mounts, and knolls — under protection in a country's exclusive economic zone.
    - Protected area representativeness index (Yale EPI), analysing the proportion of national biodiversity included in a country's terrestrial protected areas. The measure relies on remote sensing, biodiversity informatics, and global modelling of fine-scaled variation in biodiversity composition for plant, vertebrate, and invertebrate species.
- Key Biodiversity Ares (KBA) protection. KBA are places of particular importance for global the persistence of biodiversity.
    - KBA Protected area and Other effective area-based conservation measure (OECM) coverage (IBAT)
    - Terrestrial KBA protection (Yale EPI), translating the percentage of terrestrial Key Biodiversity Areas within a country's territory that falls within protected areas.

[18] Deguignet, Marine, et al. "Measuring the extent of overlaps in protected area designations." *PloS one* 12.11 (2017): e0188681.

    - Marine KBA protection (Yale EPI) translating the percentage of marine Key Biodiversity Areas within a country’s territory that falls within protected areas.
- Efficiency of protected areas
    - Marine protection stringency (Yale EPI), estimating the stringency of marine protected areas (MPAs) by comparing total fishing effort on a given year inside versus outside MPAs within a country's exclusive economic zone(s).
    - Protected area effectiveness (Yale EPI), measuring the percentage of a country's terrestrial protected areas in which the area of croplands and buildings is increasing by more than 0.5% per year.

Results

The CBRI framework provides a structured approach to examining key biodiversity variables and assessing biodiversity state and dynamics at the country level. While individual datasets have inherent limitations and certain data gaps exist, the framework represents in our view an advancement over existing approaches by enabling comprehensive, biodiversity-specific country-level analysis using freely available data.

Results are presented in two stages: first examining each sub-indicator individually to reveal specific dimensions of biodiversity risk, then synthesizing these components into the integrated CBRI score to identify overall country-level risk profiles.

Ecosystem health

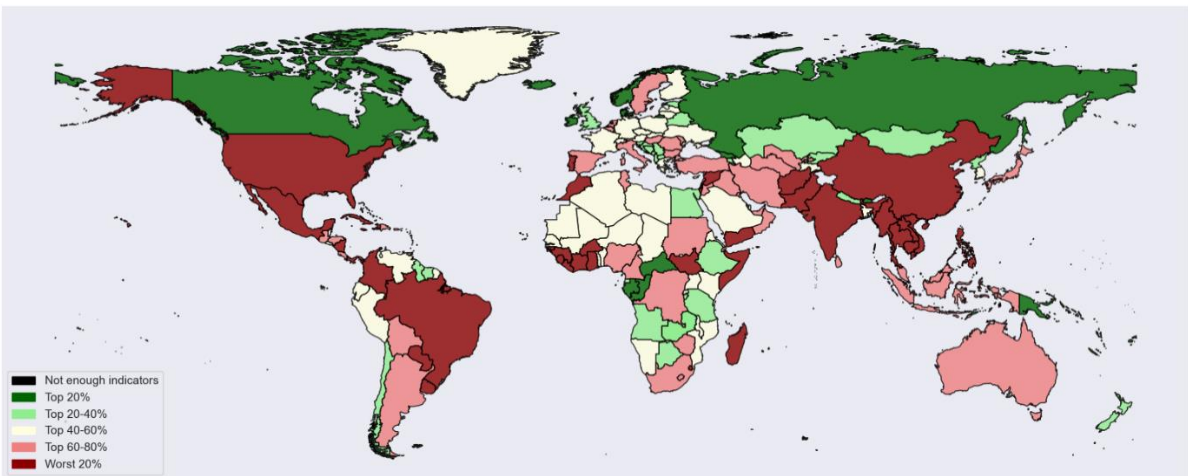

Figure 1 - Ecosystem Health Sub-Indicator: Global Distribution

Ecosystem health scores reveal a clear inverse relationship with population density and agricultural intensity. The most intact ecosystems persist in sparsely populated regions: boreal forests of Canada and Russia, Central Asian steppes (Mongolia, Kazakhstan), and remote tropical forests (Central African Republic, Gabon, Republic of Congo). These areas benefit from low human population density and limited infrastructure development, preserving ecosystem functionality despite varying levels of formal protection.

The most degraded ecosystems concentrate in regions experiencing intensive land conversion: the United States (extensive agricultural and urban development), China and India (supporting 36% of global population), Southeast Asia (rapid deforestation for palm oil and agriculture), Brazil and Paraguay (agricultural frontier expansion), and densely populated African nations. Notably, even wealthy nations like the USA show significant ecosystem degradation—a legacy of historical land conversion that predates modern conservation efforts.

A critical limitation of ecosystem health datasets used in this framework must be acknowledged: most ecosystem health datasets establish baselines from relatively recent periods (typically 1970s-2000s), meaning the indicator primarily captures *recent trends in ecosystem change* rather than absolute ecosystem integrity relative to pre-industrial conditions. Consequently, regions like the European Union—which underwent extensive agricultural conversion and industrialization centuries ago—may score favorably because their ecosystems have stabilized at a degraded baseline, with limited further deterioration in recent decades. Conversely, countries currently experiencing rapid land-use change show poor scores even if their ecosystems remain more intact in absolute terms than Europe's heavily modified landscapes. This temporal bias means the indicator effectively measures *current trajectory* (ongoing degradation vs. stabilization) rather than *historical ecosystem loss*, privileging regions that completed their intensive development phase before modern monitoring began.

Species state

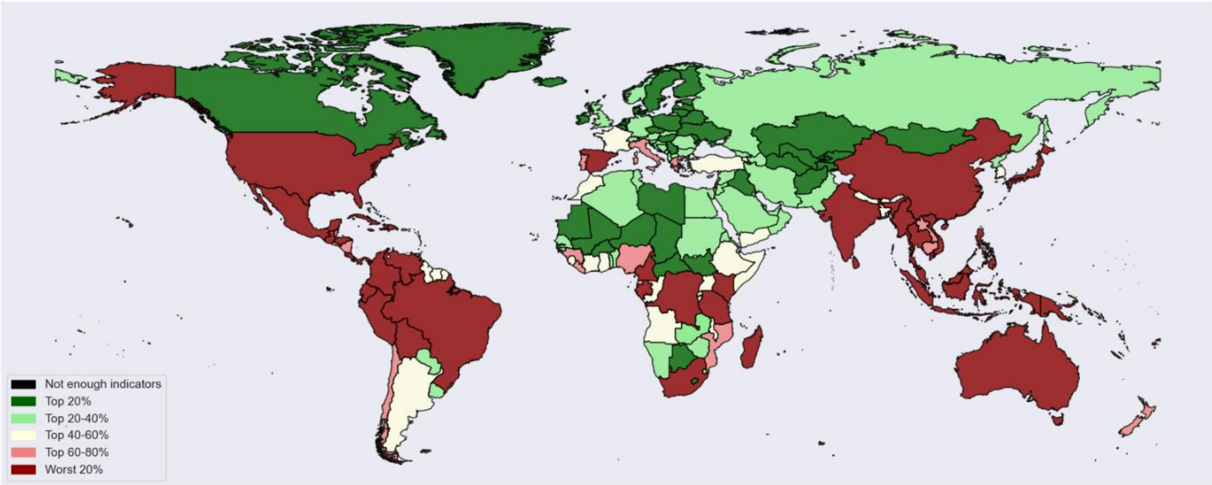

Figure 2 - Species State Sub-Indicator: Global Distribution

The highest-risk countries cluster in megadiverse regions experiencing severe threats: the USA, Mexico, Central and South America (particularly Brazil, Colombia, Ecuador, Peru), China, India, Southeast Asia (Indonesia, Malaysia, Philippines, Vietnam, Thailand), Madagascar, Australia, South Africa, Democratic Republic of Congo, Tanzania, and Kenya. These nations combine exceptional species diversity with high numbers of threatened species, creating acute ecosystem collapse risk. Small island nations also score high despite modest absolute species counts, as they harbor disproportionate numbers of endemic species with restricted ranges, making them exceptionally vulnerable to localized extinction events.

The lowest-risk countries fall into species-poor environments where limited biodiversity that also reduces absolute extinction risk: desert regions surrounding the Sahara (Egypt, Libya, Algeria, Niger, Mali, Mauritania) and Arabian Peninsula (Saudi Arabia, Yemen, Oman), Central Asian deserts (Kazakhstan, Turkmenistan, Uzbekistan), and high-latitude zones (northern Canada, Russia, Scandinavia). This pattern reveals a fundamental biodiversity paradox: the world's most species-rich regions face the highest extinction risk precisely because they contain more endemic species vulnerable to habitat loss and human pressures.

Anthropic pressures

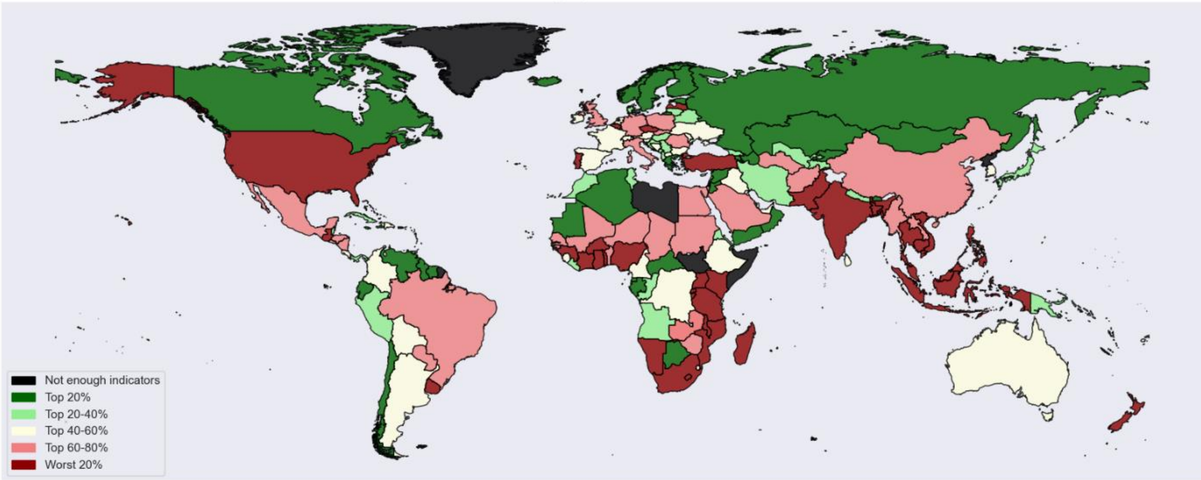

Figure 3 - Anthropogenic Pressure Sub-Indicator: Global Distribution

Pressure indicators reveal a clear correlation with economic development stage and population density. Countries experiencing lowest pressures—Canada, Russia, Northern Europe, Mongolia, Kazakhstan, and desert nations (Algeria, Morocco, Oman, Yemen)—share sparse populations and either completed their intensive development phase (Northern Europe) or maintain low-density economies with limited industrial activity.

Highest pressure concentrations occur in countries undergoing rapid industrialization and agricultural intensification: India, Southeast Asia, China, Pakistan, much of Africa, Brazil, USA, and Mexico. This pattern reflects several overlapping dynamics:

- Rapid development economies (China, India, Southeast Asia): Accelerating infrastructure expansion, industrial growth, and agricultural intensification
- High population density (India, Pakistan, Southeast Asia): Intense competition for land and resources
- Resource extraction economies (parts of Africa, Brazil): Deforestation, mining, and agricultural expansion for export markets

The USA's presence among high-pressure countries despite being a developed economy reflects its exceptionally high per-capita consumption and continued land-use intensity, distinguishing it from European nations that have stabilized land use.

Protection

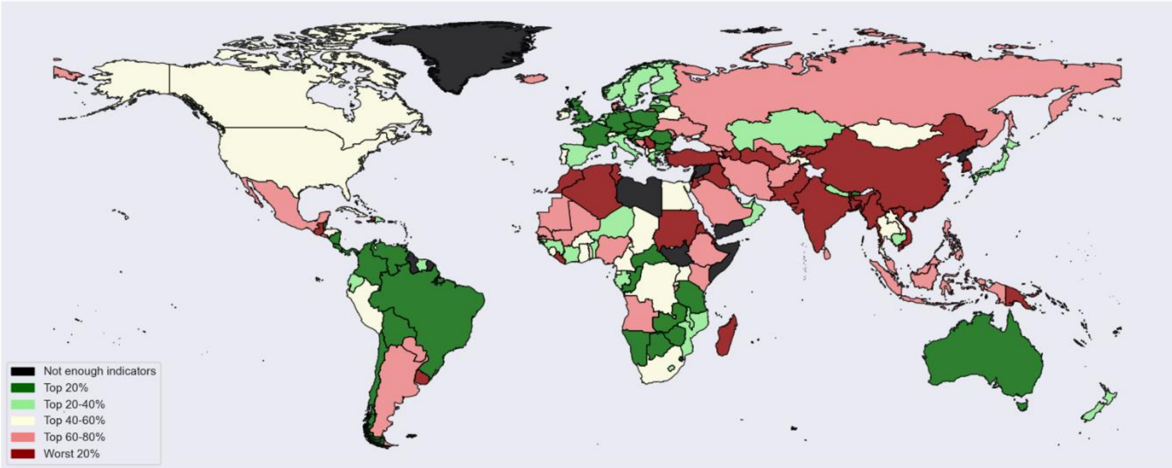

Figure 4 - Protection Sub-Indicator: Global Distribution

Protection scores reveal a strong correlation with governance capacity, economic development, and democratic institutions. Highest protection scores occur in the European Union, Australia, New Zealand, and select countries in Africa and South America—regions with either strong institutional capacity (EU, Australia) or recent conservation investments (parts of Africa and South America benefiting from international conservation funding).

Lowest protection scores concentrate in Asia and the Middle East, suggesting a correlation with governance structures. Democratic nations with strong civil society and environmental movements (EU, Australia, New Zealand) demonstrate higher protection effectiveness, while countries with weaker democratic institutions or competing development priorities show lower protection scores.

CBRI

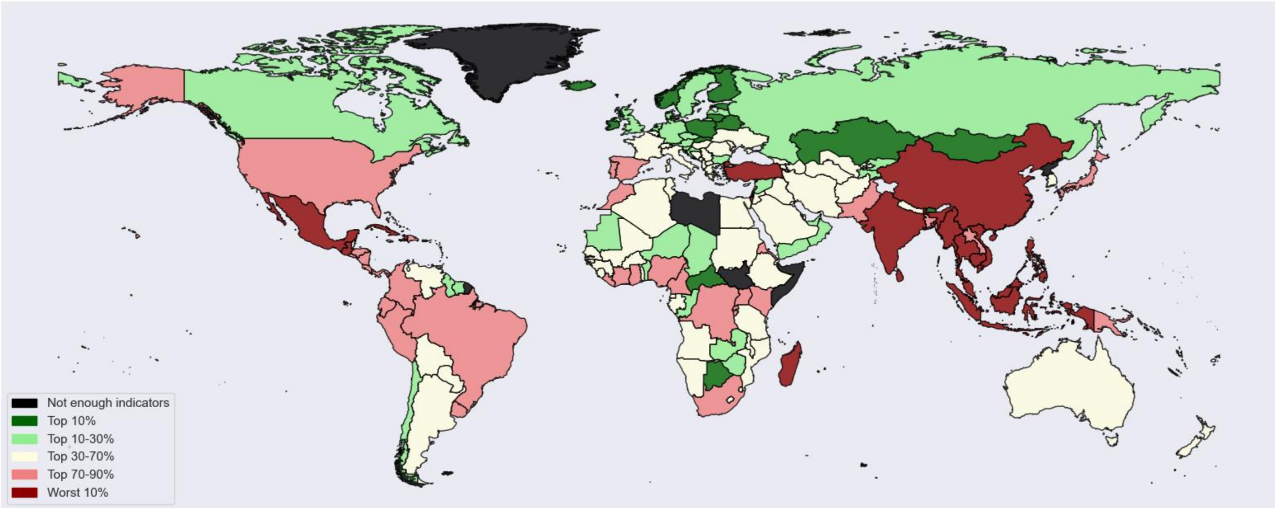

Figure 5 – Country Biodiversity Risk Index: Global Distribution

The CBRI results reveal that biodiversity risk is not randomly distributed but follows predictable patterns driven by:

1. Biogeographic specificities: Megadiverse regions face higher absolute risk due to greater species richness
2. Development stage: Countries in rapid economic transition face peak biodiversity risk
3. Population density: Human presence intensity fundamentally constrains biodiversity outcomes
4. Governance capacity: Democratic institutions and strong civil society correlate with conservation effectiveness

China, India, Southeast Asia, and parts of Africa and South America are simultaneously experiencing peak rates of habitat conversion for agriculture and infrastructure, rapid industrial expansion and associated pollution, increasing per-capita consumption and resource extraction and insufficient conservation capacity relative to development pace.

Sparsely populated countries (Canada, Russia, Mongolia, Kazakhstan, Central African Republic, Niger, Mali, Mauritania) consistently show lower risk regardless of governance quality or economic development level. This reflects the fundamental constraint that low human presence limits anthropogenic pressures.

Conversely, densely populated regions (India, Southeast Asia, parts of China, Nigeria) face inherent biodiversity challenges from competition for land and resources, regardless of conservation efforts. This suggests that biodiversity conservation in high-density regions requires fundamentally different strategies—focusing on intensive land-use efficiency and ecosystem restoration rather than preservation of intact wilderness.

The strong correlation between democratic governance and protection effectiveness illustrates that biodiversity conservation depends not only on economic capacity but also on political systems that enable environmental prioritization. The EU's relatively strong performance despite high historical development reflects decades of environmental policy development, while Asia's weak protection despite rapid economic growth suggests that wealth alone does not guarantee conservation investment.

These patterns suggest that biodiversity risk assessment must account for development trajectories and governance structures, not merely current biodiversity status.

For financial institutions, these results indicate that biodiversity risk is highest in regions experiencing rapid economic growth—precisely the regions attracting the most investment. This creates a potential misalignment between capital flows and biodiversity risk, suggesting the need for enhanced due diligence in high-growth emerging markets.

Accounting for uncertainty

Because some indicators used in the computation of the CBRI can be missing, special care is needed not to bias the score because of some aspects of biodiversity being given a weight that is too important. As a baseline, when a sub-indicator is missing, the composite indicator is computed using only the weights of the valid sub-indicators. Given the tree-like structure, these missing weights can be aggregated to obtain a measure of uncertainty for all the indicators in the assessment. However, it is unwise to only evaluate a composite indicator with few data. Consider the case where 90% of weights are missing for the pressures risk indicator. Should the score be computed as usual, the 10% of pressure data would get a huge influence on the pressure score and therefore the final indicator. Therefore, a threshold of missing sub-weights can be set, above which an indicator is not computed and is “deactivated” in the CBRI. For instance, with the initial threshold of 50%, if more than half the data are missing, the CBRI is not computed for the country (a problem which occurs only in rare occasions).

Discussion

The CBRI framework demonstrates its relevance through its ability to synthesise diverse, scientifically sourced biodiversity metrics. This integrated approach facilitates a comprehensive overview of biodiversity status while simultaneously offering a structure for detailed country-level analysis. The integration of multiple data sources enhances the robustness of the assessment, allowing for a more nuanced understanding of biodiversity-related challenges and opportunities at the national scale.

While the CBRI methodology provides a perspective on the state and trajectory of biodiversity within a given country, it is subject to several inherent limitations. The reliance on open-source data restricts the scope of biodiversity aspects that can be assessed, leaving certain ecological dimensions underrepresented. Furthermore, the use of several non-commercial use datasets restricts the use of results for direct applicability on corporate risk assessment. Additionally, pressure indicators serve only as proxies for underlying drivers of biodiversity loss, lacking a direct and consistent correspondence with the actual causal mechanisms. Moreover, genetic biodiversity and international waters are not accounted for in the computation because of missing data.

The process of aggregating biodiversity indicators necessitates the assignment of relative weights based on expert knowledge. The determination of these weights is influenced by the importance attributed to different indicators by data sources and authoritative bodies such as the IPBES. However, while such organisations provide guidance on the relevance of individual indicators in relation to specific conservation stakes, there is no universally accepted methodology for defining their relative importance.

Finally, as previously discussed, biodiversity is inherently a localised phenomenon and should ideally be assessed at the most granular level possible. The CBRI, however, operates as a country-level assessment, given that its underlying data is aggregated at the national scale. Consequently, while the CBRI offers a high-level overview of biodiversity trends across different regions, it may not accurately reflect site-specific variations. Localised anthropogenic activities can exert severe ecological impacts that remain undetected within a national-level framework. This score will be highly improved with GIS and geospatial data that allow to evaluate more finely the biodiversity for any km^2 of territory in a country.

Nevertheless, we deem that the existence of a national level biodiversity score provides a good first-order approximation, facilitating the identification of priority regions for more detailed analysis.

Conclusion

This study underscores two critical aspects of biodiversity assessment: the necessity for localised analysis using multiple indicators, and the importance of a global perspective in light of interconnected supply chains.

The CBRI methodology addresses some of these needs by providing both an overview and a structured framework to review the complexity of biodiversity dynamics. By proposing a way to aggregate multiple indicators - including ecosystem conditions, species endangerment status, current anthropogenic pressures, and existing protection measures - this methodology enables a more detailed evaluation of biodiversity risks than traditional single-metric approaches.

The practical implications of the CBRI methodology are also significant in the context of global value chains and international trade. By providing a standardised risk assessment tool applicable across countries, the CBRI enables stakeholders to begin a first assessment of biodiversity risks throughout complex, multinational supply chains. This capability is increasingly vital in today's interconnected global economy, where the environmental impacts of production and consumption often span multiple countries and ecosystems.

Bibliography

- Block, S., Emerson, J. W., Esty, D. C., de Sherbinin, A., & Wendling, Z. A. (2024). *2024 Environmental Performance Index*. Yale Center for Environmental Law & Policy. https://epi.yale.edu
- Ceglar, A., Jwaideh, M., O'Donnell, E., Danieli, F., Pasqua, C., Hutchinson, J., ... & Heemskerk, I. (2025). Nature at risk: Implications for the euro area economy and financial stability. *ECB Occasional Paper*, (2025/380).
- Central Intelligence Agency. (2024). Urbanization rate. In *The World Factbook*. https://www.cia.gov/the-world-factbook/
- Deguignet, M., Arnell, A., Juffe-Bignoli, D., Shi, Y., Bingham, H., MacSharry, B., & Kingston, N. (2017). Measuring the extent of overlaps in protected area designations. *PLoS ONE, 12*(11), e0188681. https://doi.org/10.1371/journal.pone.0188681
- Food and Agriculture Organization of the United Nations. (2024a). *Global Forest Resources Assessment*. FRA Platform. FRA Platform | Global Forest Resources Data | Food and Agriculture Organization of the United Nations
- Food and Agriculture Organization of the United Nations. (2024b). Industrial roundwood production [2020-2022]. *FAOSTAT*. https://www.fao.org/faostat/
- Herweijer, C., Evison, W., Mariam, S., Khatri, A., Albani, M., Semov, A., & Long, E. (2020). *Nature risk rising: Why the crisis engulfing nature matters for business and the economy*. World Economic Forum and PwC. http://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf
- Integrated Biodiversity Assessment Tool. (n.d.). Protected Area and Key Biodiversity Area data. Provided by BirdLife International, Conservation International, IUCN and UNEP-WCMC. https://www.ibat-alliance.org
- IPBES. (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (E. S. Brondizio, J. Settele, S. Díaz, & H. T. Ngo, Eds.). IPBES Secretariat. https://doi.org/10.5281/zenodo.3831673
- IUCN. (2020). *The IUCN Red List of Threatened Species* (Version 2020). https://www.iucnredlist.org

- Pörtner, H.O et al. 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. DOI:10.5281/zenodo.4782538.
- Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S. E., Donges, J. F., Drüke, M., Fetzer, I., Bala, G., von Bloh, W., Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W., Kummu, M., Mohan, C., Nogués-Bravo, D., ... Rockström, J. (2023). Earth beyond six of nine planetary boundaries. *Science Advances, 9*(37), eadh2458. https://doi.org/10.1126/sciadv.adh2458
- Secretariat of the Convention on Biological Diversity. (2022). *Kunming-Montreal Global Biodiversity Framework*. https://www.cbd.int/gbf/
- Turbelin, A. J., Malamud, B. D., & Francis, R. A. (2017). Mapping the global state of invasive alien species: Patterns of invasion and policy responses. *Global Ecology and Biogeography, 26*(1), 78-92. https://doi.org/10.1111/geb.12517
- UNEP-WCMC. (2024). *CITES Trade Database* [2020-2023]. Compiled for the CITES Secretariat. https://trade.cites.org (Accessed December 10, 2024)
- United Nations University. (2024, May 16). *Understanding humanity's role in biodiversity loss: 5 elements of accelerating species extinctions*. https://unu.edu/
- Whitehorn, P. R., Navarro, L. M., Schröter, M., Fernandez, M., Rotllan-Puig, X., & Marques, A. (2019). Mainstreaming biodiversity: A review of national strategies. *Biological Conservation, 235*, 157-163. https://doi.org/10.1016/j.biocon.2019.04.016
- World Bank. (2024). Permanent cropland (% of land area). *World Development Indicators*. https://databank.worldbank.org/
- World Wildlife Fund. (2024a). *Living Planet Report 2024: A system in peril*. WWF International.
- World Wildlife Fund. (2024b). *WWF Risk Filter Suite and ESRS Technical Guidance* (Version 2.0). https://doi.org/10.5281/zenodo.13736021
- Yale Center for Environmental Law and Policy & Center for International Earth Science Information Network, Columbia University. (2023). *2022 Environmental Performance Index (EPI)* (Version 2022.00) [Dataset]. NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/DWT2-9K25

Appendix – Technical details

Computation of the indicators

To compute indicators from raw data, several statistical techniques were used. The common procedure involves a Min-Max normalisation so that all indicators are on the same scale, with a high value corresponding to a high risk. However, for some data, extreme values can shift the score distribution and lead to a high imbalance. To alleviate this phenomenon, a correction based on the kurtosis of the distribution was implemented. Kurtosis measures the concentration of values around the mean or in the tails of the distribution.

When there is kurtosis excess, the distribution is heavy-tailed. To avoid low scores, only values between the 5^{th} and 95^{th} percentile are considered in the Min-Max normaliation, instead of all the values. Values below the 5^{th} percentile are attributed the lowest score while values above the 95^{th} percentile are attributed the highest score. That way, scores are better spread out avoiding a concentration of values squished because of extreme values.

Besides, indicators with several orders of magnitude require specific treatment, as with CITES trade data. Before applying the kurtosis correction and the Min-Max normalisation, a logarithmic scale was therefore applied to the raw values, to have a score distribution more adapted to the scale of the values while keeping the relative country order.

Datasets descriptions

Dataset	Source	License type	URL/DOI
WWF Biodiversity Risk Filter	WWF	Specific	https://riskfilter.org/
Yale Environmental Performance Index	Yale University	CC-BY-NC-SA	https://epi.yale.edu/

IUCN Red List	IUCN	CC-BY-NC	https://www.iucnredlist.org/
Country Profiles	IBAT	Specific	https://www.ibat-alliance.org/
CITES Trade Database	CITES	Specific	https://trade.cites.org/
World Development Indicators	World Bank	CC-BY 4.0	World Development Indicators | DataBank
Global State of Invasive Species	Turbelin et al. (2017)	CC-BY 4.0	https://doi.org/10.1111/geb.12517
The World Factbook	CIA	Public domain	https://www.cia.gov/the-world-factbook/
FAOSTAT	FAO	CC-BY 4.0	https://www.fao.org/faostat/en/#data/FO/visualize
Global Forest Resources Assessment	FAO	CC-BY 4.0	https://fra-data.fao.org/assessments/fra/2025

Data Availability and Licensing

This research utilizes publicly available datasets, some of which are licensed under Creative Commons Attribution-NonCommercial-ShareAlike (CC BY-NC-SA) terms. We acknowledge and comply with these licensing requirements. This paper does not redistribute the original datasets but presents only derived analyses, aggregated results, and visualizations. In accordance with the CC BY-NC-SA terms of the source data, this research paper is made available under the same CC BY-NC-SA 4.0 License. Full dataset attributions and sources are provided in the Appendix.

Indicators descriptions

Descriptions for indicators in the WWF Country Biodiversity Risk Filter and Yale Environmental Performance Index come directly from the data sources.

- WWF Country Biodiversity Risk Filter

Title	Abbreviation	Description
Ecosystem Condition	EC	Ecosystem condition indicates whether the natural environment is intact and connected. Poor ecosystem condition can result in businesses having restricted access in the long-term to the quantity and quality of resources and enablers needed for their activities as well as other ecosystem services they rely on. The preservation and restoration of terrestrial, freshwater and marine habitat is a key

		component in addressing biodiversity risk, and to achieve the Sustainable Development Goals (SDG).
Soil Condition	SC	Soil condition indicates whether soil can perform basic functions to benefit human use and ecosystems alike. This indicator is based on soil organic carbon (SOC) content. SOC is the main component of soil organic matter and is a prerequisite for soil functions and food production, mitigation and adaptation to climate change, and the achievement of the Sustainable Development Goals (SDGs).
Water Condition	WC	Water condition indicates whether water resources are fit for use by humans and ecosystems alike. Poor water condition – water pollution – can impact a company indirectly by destabilising ecosystems or by causing serious health issues, as well as directly through increased operating costs and a reduction in production or growth.
Range Rarity	RR	Reputational risk will likely be highest where corporate actions cause or contribute significantly to a species extinction. Range-size rarity is a measure of species endemism – a state of a species being found in a single and/or restricted geographic range. This indicator specifies those areas where impact on a species might more easily cause or contribute to an extinction. It is calculated from the area of the pixel divided by the area of the range for each species, i.e. the proportion of the species' range contained within the given pixel. These values are summed across all species to show the aggregate importance of each pixel to the species occurring there.
Land, Freshwater and Sea use change	LFS	Land-use change is the major human influence on habitats and can include the conversion of land cover (e.g. expansion of cropland), changes in the spatial configuration of the landscape (e.g. fragmentation of habitats) or changes in the management of the ecosystem or agro-ecosystem (e.g. through the intensification of agricultural management or forest harvesting). Here, we only include metrics for the first two, as there is currently no available global data set for changes in the management of ecosystems or agro-ecosystems.
Regulating Services – Mitigating	BCC	The occurrence of natural hazards such as landslides, fires and storms can disturb or disrupt projects, operations, or entire value chains, and in some cases can result in severe damage to or loss of assets. Intact ecosystems can help to mitigate the impact of some natural hazards. Note: Herbicide resistance was removed from this composite indicator.
Pollution	POL	Pollution is an important driver of biodiversity and ecosystem change throughout all biomes, with particularly devastating direct effects on freshwater and marine habitats. The WWF BRF focuses on nutrient, pesticide, plastic and air pollution.
Invasive Species	INV	Invasive species may be indigenous and/or exotic or alien. They can occur in terrestrial and aquatic ecosystems, both marine and freshwater, and can disrupt the ecological functioning of natural systems. Invasive species can out-compete local and indigenous

		species for natural resources, with negative implications for biodiversity. Invasive and alien species have been reported around the world, resulting in loss of biodiversity at local and regional scales and causing significant economic damage
Sites of international Interest	SI	The sites of international interest comprise RAMSAR and World Heritage sites. Wetlands are among the most diverse and productive ecosystems. They provide essential services and supply all our fresh water. RAMSAR sites highlight important wetlands and encourage their wise use. World Heritage sites are a collection of unique and diverse places that encourage nature conservation and the preservation of cultural properties
Media Scrutiny	MSC	Media scrutiny indicates whether there has been documented negative news (e.g., incidents, criticism or controversies) related to environmental and social issues that can affect a company's reputational risk.

- Yale Environmental Performance Index

Nom	Abréviation	Descriptif
Species Habitat Index	SHI	The Species Habitat Index (SHI) measures the proportion of suitable habitats for a country's species that remain intact, relative to a baseline set in the year 2001. While the SHI can be calculated for single species, Map of Life aggregates these metrics into a single score, with each species weighted according to the proportion of their global range that is found within the country. This weighting scheme encourages countries to take special care to ensure the protection of rare or endemic species. The SHI serves as a proxy for potential population losses and the extinction risk to individual species. A score of 100 indicates that a country has experienced no habitat loss since the year 2001, and a score of 0 indicates the worst levels of habitat loss.
Forest Lanscape Integrity	FLI	Going beyond measuring changes in tree cover, this indicator estimates the integrity of forest landscapes based on observed and inferred human disturbances and losses of forest connectivity.
Agriculture	AGR	The Agriculture issue category measures efforts to produce food and other agricultural products while minimising the threats of agriculture to the environment. It is based on four indicators: the Sustainable Nitrogen Management Index (SNMI), Relative Yield Index, pesticide pollution risk, and phosphorus surplus.
Water Resources	WRS	The Water Resources issue category measures the extent to which humans are mitigating our threats to aquatic ecosystems through the generation and mismanagement of wastewater. It consists of four indicators: wastewater generation, collection, treatment, and reuse.
Fisheries	FSH	The Fisheries issue category measures the health and sustainability of the world's fisheries. It is made up of five

		indicators: fish stock status, fish catch discarded, fish caught by bottom trawling and dredging (domestically and across the global ocean), and the marine trophic index. Since data is only available for marine fisheries, landlocked countries are not scored in these indicators.
Forests	ECS	The Forests issue category (previously called "Ecosystem Services") measures trends in area and integrity of countries' forests. It includes five indicators: loss of humid tropical primary forests, loss of intact forest landscapes, lasting tree cover loss, net change in tree cover, and the Forest Landscape Integrity Index. Only countries that had more than 10 percent tree cover in 2000 are scored in these indicators.
Bioclimatic Ecosystem Resilience	BER	The Bioclimatic Ecosystem Resilience Index (BERI) measures the capacity of natural ecosystems to retain species diversity in the face of climate change, as a function of ecosystem area, connectivity and integrity. This metric is calculated by CSIRO based on land use maps and species occurrence data.
Climate Change	PCC	The Climate Change Mitigation issue category measures progress to combat global climate change, which exacerbates other environmental threats and imperils human health and safety. It is composed of 11 indicators: adjusted emission growth rates for four greenhouse gases (CO2, CH4, F-gases, and N2O) and one climate pollutant (black carbon); adjusted emission growth rates of carbon dioxide with country-specific targets based on their allocated share of the remaining carbon budget, projected greenhouse gas emissions in 2050 and projected cumulative emissions to 2050 relative to countries' allocated share of the remaining carbon budget; net carbon fluxes from land cover change; and GHG growth rate adjusted by either emissions intensity or by per capita emissions.
Air Pollution	APO	The Air Pollution issue category (previously called "Acid Rain") measures countries' contribution and exposure to air pollution. It consists of two indicators measuring trends in the emissions of acid rain precursors (sulfur dioxide and nitrogen oxides), and two pilot indicators measuring exposure to ground-level ozone in a country's croplands and Key Biodiversity Areas.
Solid Waste	WMG	The Waste Management issue category recognises the threats of solid waste to human and environmental health. It is based on three indicators: municipal solid waste generation per capita, controlled solid waste, and recovery of energy and materials from waste.
Air Quality	AIR	The Air Quality issue category measures the impacts of air pollution on human health in each country. It consists of seven indicators: anthropogenic PM2.5 exposure, household solid fuels, ozone exposure, nitrogen oxides exposure, sulphur

		dioxide exposure, carbon monoxide exposure, and volatile organic compound exposure.
Heavy Metals	HMT	The Heavy Metals issue category measures the direct impacts of heavy metal pollution exposure on human health in each country. It is based on one indicator, lead exposure.
Terrestrial Biome Protection	TBN	We derive the terrestrial biome protection indicator by first calculating the proportion of each biome in a country that lies within a protected area. We then give greater weight to biomes that are relatively rare within a country – and less weight to prevalent biomes – before aggregating the proportions. A score of 100 indicates that a country protects at least 30% of each of its biome types, corresponding to Aichi Target 11 of the Convention on Biological Diversity. Data for this indicator come from the World Database on Protected Areas.
Terrestrial KBA Protection	TKP	Percentage of area designated as "Key Biodiversity Areas" (KBA) within a country's territory that is covered by protected areas. Protected Area data comes from the March 2024 release of the World Database on Protected Areas (https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA). Data on KBAs, compiled by BirdLife International in partnership with other major conservation organisations, is available at: https://www.keybiodiversityareas.org/
Marine KBA Protection	MKP	Percentage of area designated as "Key Biodiversity Areas" (KBA) within a country's exclusive economic zone(s) that is covered by marine protected areas. Marine Protected Area data comes from the March 2024 release of the World Database on Protected Areas (https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA). Data on KBAs, compiled by BirdLife International in partnership with other major conservation organisations, is available at: https://www.keybiodiversityareas.org/
Marine Habitat Protection	MHP	Percentage of important marine and coastal habitats -- coral reefs, cold-water corals, sea grasses, salt marshes, mangroves, knolls, and seamounts -- within a country's exclusive economic zone(s) that is covered by marine protected areas.
Species Protection Index	SPI	The Species Protection Index (SPI) measures how well a country's terrestrial protected areas overlap with the ranges of its vertebrate, invertebrate, and plant species. Map of Life calculates this index using remote sensing data, global biodiversity informatics, and integrative models to map suitable habitat for over 30,000 terrestrial species at high resolutions. A score of 100 indicates full coverage of all species' ranges by a country's protected areas, and a score of 0 indicates no overlap.

Protected Areas Representativeness Index	PAR	The Protected Areas Representativeness Index (PARI) indicator measures how well terrestrial protected areas represent the ecological diversity of a country. This metric is calculated by CSIRO (https://geobon.org/ebvs/indicators/protected-area-representatives-connectedness-indices/) using high-resolution remote sensing data and biological records of species' locations. A score of 100 indicates that a country's terrestrial protected areas nearly perfectly represent the country's ecosystem diversity, and a score of 0 indicates very low representativeness (≤5th-percentile of PARI values).
Marine Protection Stringency	MPE	This pilot indicator estimates the stringency of marine protected areas (MPAs) by comparing total fishing effort on a given year inside versus outside MPAs within a country's exclusive economic zone(s). A score of 100 indicates that fishing efforts inside a country's MPAs is 1% or less than the fishing effort outside MPAs, and a score of 0 indicates that fishing effort inside MPAs is 100 times more intense than outside. Fishing effort data, from Global Fishing Watch, is based on satellite tracking of fishing boats.
Protected Area Effectiveness	PAE	This pilot indicator measures the percentage of a country's terrestrial protected areas in which the area of croplands and buildings is increasing by more than 0.5% per year.
Grassland loss	GRL	We measure grassland loss as a proportion: the average annual loss in grassland area over the past five years, divided by the total extent of grassland area in the year 1992. This metric only looks at gross losses, not net. A score of 100 indicates virtually no grassland loss, and a score of 0 indicates the worst levels of loss. Annual land cover data come from the European Union's Copernicus Earth observation program.
Wetland loss	WTL	We measure wetland loss as a proportion: the average annual loss in wetland area over the past five years, divided by the total extent of wetland area in the year 1992. This metric only looks at gross losses, not net. A score of 100 indicates virtually no wetland loss, and a score of 0 indicates the worst levels of loss. Annual land cover data come from the European Union's Copernicus Earth observation program.

- Other

Nom	**Abréviation**	**Descriptif**
Urbanisation Rate	URB	Projected average rate of change of the size of the urban population over the 2020 and 2025 period
Cropland Change	CRO	Share of land area that is arable, under permanent crops and under permanent pastures
Endangered Species Trades	TRA	Number of threatened specimens traded during the period 2020-2023

Forestry Pressure Indicator	FPI	Production and trade in roundwood and primary wood normalised by area of forests
Terrestrial Protected Areas Coverage (%)	TPA	Percentage of the country's land covered by protected areas
Marine Protected Areas Coverage (%)	MPA	Percentage of the country's seas covered by protected areas
All KBAs Protected Areas and OECMs (%)	KBAC	Percentage of the country's Key Biodiversity Areas covered by protected areas and OECMs (Other Effective Area-Based Conservation Measures)
Total species	TOT	Number of species in the country (animals, plants, mushrooms and chromists)
Total threatened species	THT	Number of threatened species in the country
Threatened species (%)	THTP	Proportion of threatened species in the country
Threatened species density	THTD	Density of threatened species per square kilometer of territory
Invasive Species Assymetry Index	IAS	Input-output of invasive species in the country

CRÉDIT AGRICOLE
CORPORATE & INVESTMENT BANK